EXHIBIT A:

Declaration of James B. DeMocker

IN THE UNITED STATES DISTRICT COURT FOR THE NORTHERN DISTRICT OF WEST VIRGINIA
Wheeling

MURRAY ENERGY CORPORATION, et al., Plaintiffs, v. GINA McCARTHY, Administrator, UNITED STATES ENVIRONMENTAL PROTECTION AGENCY, acting in her official capacity, Defendants.	**Civil Action No. 5:14-CV-00039** **Judge Bailey**

DECLARATION OF JAMES DEMOCKER IN SUPPORT OF THE UNITED STATES' MOTION FOR SUMMARY JUDGMENT

1. My name is James B. DeMocker. I am Director of the Office of Policy Analysis and Review, Office of Air and Radiation, United States Environmental Protection Agency (EPA). In this position I am responsible for conducting, overseeing, and coordinating cross-agency policy and program development efforts that support and inform the policy and programmatic decisions of the Assistant Administrator for Air and Radiation, particularly with respect to economics, science policy, rule-and-program tracking and management, stakeholder engagement, intergovernmental partnerships, international policies and programs, and priority efforts of the Administrator of EPA and the Assistant Administrator for Air and Radiation, including Environmental Justice, Sustainability, and Innovative Technology initiatives. I have held this position for approximately three years. Prior to that I was the Senior Economics Policy Advisor to the Assistant Administrator for the Office of Air and Radiation.

2. The following exhibits, submitted in pertinent parts with this Declaration, demonstrate EPA's evaluation of potential loss or shifts of employment which may result from

the administration or enforcement of the Clean Air Act (CAA) and applicable implementation plans. While EPA is continuing to evaluate the potential employment impacts of its forthcoming rules and to refine its analytical methods, to the best of my knowledge, EPA has completed no other evaluations of potential employment impacts of the Act at this time. Because many of the exhibits are voluminous, I have provided a brief summary of the documents. Section I identifies and summarizes documents in which EPA evaluated the potential employment impacts associated with specific regulatory actions. Section II identifies and summarizes documents in which EPA evaluated employment impacts associated with EPA's overall administration and enforcement of the CAA. Section III identifies documents and summarizes EPA's guidance on performing employment analyses and its ongoing research to improve its employment analyses.

I. EPA's Evaluations of Employment Impacts Associated with Specific Regulatory Actions Authorized by the CAA

Exhibits 1-39 are Regulatory Impact Analyses (RIAs), Economic Impact Assessments (EIAs), and related memoranda prepared by EPA as official agency records in connection with recent CAA rulemakings.[1] The regulatory actions are listed below, with a brief summary of the evaluation of potential employment impacts included in the individual RIA, EIA, or memorandum.

A. Proposed Carbon Pollution Guidelines for Existing Power Plants and Emission Standards for Modified and Reconstructed Power Plants (Clean Power Plant Rule) (Ex. 1)

In Chapter 6 and Appendix 6A of the RIA for the proposed Clean Power Plant Rule, proposed on June 20, 2014 (Ex. 1), EPA provided an overview of the proposed guidelines and summarized relevant economic theory, peer-reviewed literature, and recent employment trends.

[1] The RIAs, EIAs, and related Memoranda are also available at http://www.epa.gov/ttnecas1/ria.html and http://www.epa.gov/otaq/.

EPA provided illustrative estimates of demand-side energy efficiency employment impacts, relying on government data on energy efficiency activities. *Id.* at 6-1 to 6-39; *see also id.* at 6A-1 to 6A-10 (discussing employment impacts in the electric power industry and related supply-side industries). For implementation of demand-side energy efficiency activities, EPA estimated projected employment impacts ranging from 57,000 to 78,800 full or part-time employees in 2020 in response to the proposed rule, and ranging from 76,200 to 112,000 employees in 2025. *Id*. at 6-31, tbl. 6-6.

Using the Integrated Planning Model (IPM or Model),[2] EPA also identified illustrative projections of potential employment shifts for the electric power industry and coal and natural gas sectors, accounting for differences in regional and state-specific compliance approaches. EPA recognized that initial net increases in power plant employment due to heat rate improvements and construction and operation of new generating capacity would eventually yield to longer-term reductions in the need for additional capacity and fuel supplies, including "the loss of operating and fuel-related jobs arising from the retirement of existing coal generating capacity." *Id.* at 6-23. In its supply-side industry evaluation, for the electric power industry and coal and natural gas production, EPA estimated an initial increase ranging between 25,900 and 29,800 full-time employee (FTE) job-years in 2017-2020, followed by an overall reduction of

[2] The IPM is a detailed model of the U.S. electric power sector. EPA uses the model to project changes in the power sector and related upstream industries from the effect of air emission rules. *See* http://www.epa.gov/powersectormodeling/. IPM includes a detail-rich representation of fuel supply and consumption for the power sector, including coal supply and consumption. EPA's latest report on the assumptions, updates, and enhancements in IPM includes a chapter on coal that details how the coal sector is modeled within IPM, including the bottom-up, mine-by-mine approach used to develop coal supply curves. *See* http://www.epa.gov/airmarkets/documents/ipm/Chapter9.pdf; full table of contents at http://www.epa.gov/airmarkets/programs/ipm/psmodel.html. The chapter also includes detailed discussion of coal transportation, coal supply regions, coal demand regions, coal quality, coal imports, exports, and non-electric sector demand. In addition, Chapter 9 has three online appendices, Appendix 9-3, Appendix 9-4 Data, and Appendix 9-4 Graphics, which provide more information.

between 49,200 and 77,900 FTE job-years for 2021-2025. *Id.* at 6-26 to 6-27, tbls. 6-4 & 6-5. Appendix 6A, "Estimating Supply-side Employment Impacts of the Proposed EGU GHG Existing Source Guidelines," describes how EPA used IPM to estimate employment impacts in the coal, natural gas, and natural gas pipeline sectors. *See id.* at 6A-1 to 6A-10. The RIA also estimated monetized climate and health benefits between 55 and 89 billion dollars by 2030 (in 2011 dollars), *id.* at ES-18, and illustrative compliance costs of 4.5 to 5.5 billion dollars in 2025 and 7.3 to 8.8 billion dollars in 2030 (all in 2011 dollars). *Id.* at ES-8.

In Chapter 6, EPA also included two graphs depicting the national trends in employment for the coal mining sector (Figure 6.2), and the oil and gas extraction sector (Figure 6.3). *Id.* at 6-14 to 6-15. Figure 6.2 shows that employment in the coal mining sector has been more or less constant over the past 10 years, with the exception of a small temporary increase in 2011. On the other hand, Figure 6.3 shows that there has been a sharp increase in employment in the oil and gas extraction sector over the past decade.

EPA anticipates issuing a final rule in the summer of 2015.[3] EPA anticipates that the final rule will also be accompanied by an RIA that will include an assessment of employment impacts that may result from the rule.

B. Carbon Pollution Emission Guidelines Supplemental Proposal for Indian Country and U.S. Territories (Ex. 2)

In Chapter 4.3 of this RIA for the supplemental Clean Power Plant Rule proposal dated October 28, 2014 (Ex. 2), EPA estimated that power plants in Indian country would meet the requirements of the proposed rule with existing actions, therefore resulting in no estimated employment impacts. For the U.S. territories of Guam and Puerto Rico, EPA qualitatively

[3] *See* http://www2.epa.gov/carbon-pollution-standards/fact-sheet-clean-power-plan-carbon-pollution-standards-key-dates.

discussed economic and employment impacts, acknowledged the difficulties of quantifying impacts at power plants and other supply-side industries due to various uncertainties, and confirmed its expectation of an increase in employment in energy efficiency-related industries. *Id.* at 28-30.

C. Mercury and Air Toxics Standards (Exs. 3 & 4)

In the RIA for the proposed Mercury and Air Toxics Standards (MATS), dated March 2011 (Ex. 3), EPA quantified employment impacts under three separate approaches. *Id.* at 9-1 to 9-16. For impacts to the affected electric utility sector, EPA estimated impacts at a range of 17,000 losses to 35,000 job gains, with a central estimate of plus 9,000 jobs. *Id.* at 9-7 to 9-10, tbl. 9-3. EPA estimated the rule would support or create roughly 31,000 one-time job-years in the environmental protection sector. *Id*. at 9-10 to 9-13. In addition, the RIA discusses employment impacts in the coal, natural gas, and other upstream or related sectors. For example, EPA estimated a decrease of 5,630 job-years from "Changes due to Coal Capacity Retirements" as well as employment shifts from "Changes in Fuel Use," including losses of job-years in the coal sector (2,200), and employment increases in natural gas (1,090) and new natural gas pipeline (300). *Id*. at 9-13 to 9-16, tbl. 9-6. Results from the IPM informed calculation of these employment estimates.

EPA continued its evaluation during the rulemaking process, using the same three-tiered approach for the RIA supporting the final rule (Ex. 4). First, in Chapter 6 of the RIA, "Employment and Economic Impact Analysis," and Appendix 6A, EPA estimated that net employment effects in the regulated electric utility sector would range from a loss of 15,000 to a gain of 30,000 jobs, with a central estimate of plus 8,000 jobs. *Id.* at 6-12, tbl. 6-6. Second, for the "MATS-Pollution Control Sector," EPA estimated the addition of approximately 46,120 one-time job-years driven by pollution control retrofit requirements. *Id.* at 6A-2, tbl. 6A. Finally, EPA identified employment shifts for other sectors, including an increase of 4,320 job-years from operating pollution control equipment, changes due to increased demand for pollution control materials (lime, 280 job-years, activated carbon, 460 job-years, trona, 3,130 job-years, and baghouse material, 20 job-years), a decrease of 2,500 job-years from retirements of existing coal capacity, a decrease of 430 job-years from changes in coal demand, and an increase of 670 job-years from changes in natural gas demand. *Id.* at 6-11, tbl. 6-5. Appendix 6A, "Employment Estimates of Direct Labor in Response to the Mercury and Air Toxics Standards in 2015," describes how EPA used IPM to estimate employment impacts in the coal, natural gas, and natural gas pipeline sectors. *See id.* at 6A-1 to 6A-16. Using data provided by the Energy Information Agency on regional coal-mining productivity, EPA projected coal-mining employment impacts by region, and estimated a loss of 1,950 job-years in Appalachia, a gain of 1,990 job-years in the Interior region, and a loss of 420 job-years in the West. *Id.* at 6A-10, tbl. 6A-6. The RIA also estimated that MATS would yield annual monetized benefits (in 2007 dollars) of 37 to 90 billion dollars using a 3% discount rate, reflecting, among other things, 4,200 to 11,000 fewer premature mortalities; the RIA estimated annual monetized social costs, approximated by the compliance costs, of 9.6 billion dollars (in 2007 dollars). *Id.* at ES-1.

D. National Emission Standards for Hazardous Air Pollutants for Industrial, Commercial, and Institutional Boilers and Process Heaters (Boiler MACT) (Exs. 5- 8)

In the April 2010 RIA for the proposed Boiler MACT rule (Ex. 5), proposed on May 6, 2010, EPA estimated employment shifts for major and area sources, using two approaches. *See* Ex. 5 at 4-1, 4-6 to 4-9 (Section 4, "Economic Impact Analysis," and Section 4.1.2.4, "Job Effects"). EPA found that "[n]ear-term employment changes associated with the proposed major source rule are estimated to be less than 8,000 job losses; over a longer time period, net employment effects range between 6,000 job losses to 12,000 job gains. For the area source rule, near-term employment changes . . . are estimated to be less than 1,000 job losses; over a longer time period, net employment effects also range between 1,000 job losses to 3,000 job gains." *Id.* at 1-2.

EPA continued its evaluation during the rulemaking process. In the RIA accompanying the final rule dated February 23, 2011 (Ex. 6), EPA estimated "the net employment effect for major and areas sources to range from -4,100 to +8,500 jobs in the directly affected sectors with a central estimate of +2,200." *Id.* at 4-9 to 4-10. For major source boilers, EPA estimated "employment changes range between −3100 to 6,500 employees, with a central estimate of +1,700 employees." *Id.* at 1-2.

EPA continued to analyze the employment impacts in response to a petition for reconsideration of the adopted standards. In its December 1, 2011 memorandum (Ex. 7), prepared to support the proposed reconsideration decision dated February 2, 2012, EPA concluded that there were no changes to area source impact estimates. EPA estimated, for major sources, that "the market impact results are very similar to the results in the final rule in the RIA." *Id.* at 1. EPA adjusted its estimate for major source impacts to between a loss of 3,000 jobs and a gain of 6,300 jobs, with a central estimate of plus 1,600 jobs. *Id*. at 2.

For the final reconsideration decision dated December 19, 2012 (Ex. 8), EPA identified factors that warranted adjustment of its estimate for major source boilers to a range of 2,600 job losses to 5,400 job gains, with a central estimate of plus 1,400 jobs. *Id.* at 4. The RIA also estimated the total monetized benefits to be 27 to 67 billion dollars and annual engineering costs to be 1.4 to 1.6 billion dollars in 2015 (in 2008 dollars), using a 3% discount rate. *Id.* at 3, tbl 2.

E. Standards of Performance for New Stationary Sources and Emission Guidelines for Existing Sources: Commercial and Industrial Solid Waste Incineration Units (Exs. 9-12)

The April 2010 RIA (Ex. 9) for the proposed rule dated May 6, 2010 includes Chapter 4, "Economic Impact Analysis," and sub-section 4.1.2.4, "Job Effects." *Id.* at 4-1 to 4-9. Using two approaches, EPA estimated that the "[n]ear-term employment changes associated with the proposed rule are estimated to be less than 500 job losses; over a longer time period, net employment effects range between 400 job losses to 800 job gains." *Id*. at 1-1.

EPA continued its evaluation during the administrative process and prepared a subsequent RIA dated February 23, 2011 (Ex. 10) for the final regulation, including Section 3, "Economic Impact Analysis," and sub-section 3.1.2.3, "Job Effects." EPA estimated that longer-term "employment changes range between −500 to 1,000 employees, with a central estimate of +300 employees." *Id.* at 1-2, 3-10, tbl. 3-5.

EPA continued to analyze the employment impacts in response to a petition for reconsideration of the adopted standards. In its memorandum dated November 7, 2011, prepared to support the proposed reconsideration decision dated March 5, 2012, EPA concluded that "[t]he market impact results are very similar to the results in the final rule RIA," and EPA adjusted its estimate for major source impacts to a range of a loss of 400 employees to a gain of 900 employees with a central estimate of plus 200 employees. Ex. 11 at 1-2.

EPA continued its evaluation during the reconsideration process and, in a memorandum dated December 20, 2012 supporting the final reconsideration decision dated December 21, 2012, EPA further adjusted its impact estimate for major sources to between -400 employees and +800 employees, with a central estimate of plus 200 employees. Ex. 12 at 4. The RIA also estimated the total monetized benefits to be 420 million to 1 billion dollars and annual engineering costs to be 258 million dollars in 2015 (in 2008 dollars), using a 3% discount rate. *Id*. at 3, tbl 2.

F. Proposed New Source Performance Standards and Amendments to the National Emissions Standards for Hazardous Air Pollutants for the Oil and Natural Gas Industry (Exs. 13-14)

The July 2011 RIA (Ex. 13), prepared for the proposed rule dated July 28, 2011, estimated employment impacts for the regulated industry, and for the installation, operation, and maintenance of pollution control equipment, as described in Chapter 7, "Economic Impact Analysis and Distributional Assessments," and sub-section 7.3, "Employment Impact Analysis." *Id.* at 7-1, 7-20 to 7-28. EPA estimated that the labor requirements to comply with the proposed standards would result in approximately 350 up-front FTE job-years and 2,502 ongoing FTE job-years. *Id*. at 7-21 to 7-26, tbls. 7-13 & 7-14. For the regulated industry, EPA weighed the costs of compliance against potential new revenues resulting from compliance (i.e., from additional natural gas recovery), the potential market impact of the small increase in natural gas production, and predicted a "slight stimulative effect on employment in industries that consume natural gas." *Id*. at 7-28.

EPA continued its evaluation during the administrative process and revisited the analysis of employment impacts. In Chapter 7, sub-section 7.3 "Employment Impact Analysis" of the April 2012 RIA (Ex. 14) supporting the final rule dated April 18, 2012, EPA adjusted its total estimate of employment impacts to about 54 FTE job-years for up-front labor requirements and ongoing labor requirements of about 600 FTE job-years, and re-iterated the "small production increase and price decrease may have a slight stimulative effect on employment in industries that consume natural gas." *Id.* at 7-19 to 7-27. The RIA also estimated the annualized engineering costs of the final NSPS to be -15 million dollars in 2015 (in 2008 dollars), using a 7% discount rate, based on the assumption of a wellhead natural gas price of 4 dollars per thousand cubic feet and condensate price of 70 dollars per barrel. *Id.* at 1-3 to 1-5, tbl. 1-1.

G. Federal Implementation Plans to Reduce Interstate Transport of Fine Particulate Matter and Ozone in 27 States (Cross-State Air Pollution Rule or CSAPR) (Ex. 15)

In the 2011 RIA (Ex. 15) for the final rule dated July 12, 2011, EPA assessed employment shifts under three methods. *Id.* at 286. EPA estimated impacts to the affected electricity sector at between 1,000 job losses and 3,000 job gains, with a central estimate of plus 700 jobs. *Id.* at 287-91, tbls. 8-3 & 8-7. For impacts to the environmental protection sector, EPA estimated the rule would support or create 2,230 job-years by 2014. *Id.* at 291-99, tbl. 8-7. EPA also provided an estimate for non-regulated entities that includes an increase of 2,650 jobs-years from "Changes to Demand in Materials," an increase of 2,320 job-years from ongoing annual retrofit operations, a decrease of 2,710 job-years from "Coal Capacity Retirements," and a net loss of 990 job-years from changes in fuel use, including an accounting for losses of job-years in the coal sector. *Id*. at 295-98, tbl. 8-6, app. D. Appendix D, "Employment Estimates of Direct Labor in Response to the Final Transport Rule in 2014," describes how EPA used IPM to project employment shifts in the coal, natural gas, and natural gas pipeline sectors. *See id.* at 371-90. The RIA also estimated monetized annual health benefits in 2014 to be 120 to 280 billion dollars (in 2007 dollars), using a 3% discount rate, reflecting, among other things, the prevention of 13,000 to 34,000 premature deaths; the RIA estimated annual monetized social costs of 810 million dollars using a 3% discount rate (also in 2007 dollars). *Id.* at 1-2.

H. Tier 3 Motor Vehicle Emission and Fuel Standards (Exs. 16-17)

In Chapter 9, "Economic Impact Analysis," of the RIA for the proposed rule dated March 2013 (Ex. 16), EPA presented both a qualitative and quantitative employment analysis for the motor vehicle manufacturing sector as well as a qualitative employment analysis for the petroleum refining sector. Due to data limitations, EPA was only able to produce a partial estimate of the job impacts on the motor vehicle manufacturing sector. For that partial employment impact, EPA estimated an increase of 200 to 900 job-years in 2017 and up to 400 to 2,100 job-years in 2025 in the regulated sector of motor vehicle manufacturing. *Id*. at tbl. 9-2, 9-1 to 9-11. EPA noted that the overall effect of the proposed rule would depend on impacts EPA could not estimate; however, EPA expected employment impacts in the motor vehicle manufacturing sector to be small. For less directly affected sectors, including auto parts manufacturers and the retail sector, EPA provided general assessments of employment impacts. EPA also acknowledged potential employment impacts in the petroleum refining sector due to decreases in fuel sales. *Id.* at ES-10.

In Chapter 9, "Economic Impact Analysis," of the March 2014 RIA for the final rule (Ex. 17), EPA continued to provide both a partial quantitative and qualitative analysis for impacts on motor vehicle manufacturing, motor vehicle sales and parts, and petroleum refining. *See id.* at 9-1 to 9-12. For a partial estimate of impacts in the motor vehicle manufacturing sector, EPA estimated an employment impact of between 100 and 400 job-years in 2017 and up to a range of 200 to 700 job-years annually through 2025. *Id*. at 9-7 to 9-8, tbl. 9-2. Again, EPA noted that the overall effect of the proposed rule would depend on impacts EPA could not estimate, but EPA expected the overall effect to be small. For petroleum refinery employment, EPA's qualitative analysis concluded that the standards "will not have major employment consequences for this sector." *Id.* at ES-11, and 9-9 to 9-11.

I. Final Rulemaking for 2017-2025 Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards (Ex. 18)

In the RIA for the final rule dated August 2012 (Ex. 18), in Chapter 8.2 "Employment Impacts," EPA presents both a qualitative and quantitative employment analysis for the motor vehicle manufacturing sector as well as a qualitative employment analysis for closely related sectors. Due to data limitations, EPA was only able to produce a partial estimate of the job impacts on the motor vehicle manufacturing sector. For that partial employment impact, EPA estimated an increase of 700 to 3,200 job-years in the first year of the standard, 2017, *id.* at 8-32, and up to an increase of 6,300 to 31,100 job-years in 2025 in the regulated sector of motor vehicle manufacturing, *id.* at tbl. 8.2-3, 8-18 to 8-32. For less directly affected sectors, including auto parts manufacturers and the retail sector, EPA provided general assessments of employment increases. EPA also acknowledged a potential decrease in employment in the petroleum sector due to reduced production and noted that this impact may be offset by increases in employment related to providing infrastructure for alternative fuels. *Id.* at 8-32. The RIA also estimated monetized annualized benefits to be 5.46 billion dollars, annualized fuel savings of 20.5 billion dollars, and annualized costs of 6.49 billion dollars (all in 2010 dollars), when using a 3% discount rate. *Id.* at 1-2.

J. Proposed Revisions to the National Ambient Air Quality Standard for Ground-Level Ozone (Ex. 19)

In Chapter 10 of this RIA for the proposed rule dated November 26, 2014, EPA provided a three-part evaluation of the potential employment impacts of the proposed standard. First, EPA discussed the economic theory that provides a framework for analyzing the impacts of environmental regulation on employment. Ex. 19 at 10-1 to 10-6. Next, EPA evaluated the empirical literature and concluded that, overall, there is no evidence that environmental regulation has a large impact on net employment (either negative or positive) in the long run across the whole economy. *Id.* at 10-6. Finally, EPA evaluated the employment impacts related to the installation and maintenance of nitrogen oxide (NO_X) control equipment in various industries where facilities may be required, through state implementation plans approved pursuant to the revised standard, to install and operate various NO_X control devices. EPA estimated that 145 existing coal-fired electric generating units (EGUs) may need to apply a selective-catalytic reduction (SCR) system. *Id.* at 10-10. In an illustrative analysis based on engineering data, EPA estimated that short-term FTEs required to install the equipment over a period of two to three years would range from approximately 160 job-years at a 300 MW "model plant" to approximately 530 job-years at a 1000 MW "model plant," and that the ongoing FTEs required to operate and maintain the equipment annually would range from roughly two job-years at a 300 MW "model plant" to roughly five job-years at a 1000 MW "model plant." *Id.* at 10-11 to 10-12, tbls. 10-1 & 10-2. EPA made a similar assessment of employment impacts for individual industrial, commercial, and institutional (ICI) boilers, *id.* at 10-14, tbl. 10-3, and for installation and operation of selective non-catalytic reduction (SNCR) units applied to mid-sized cement kilns, *id*. at 10-15, tbl. 10-4.

K. Proposed Brick and Structural Clay Products National Emissions Standards for Hazardous Air Pollutants (Ex. 20)

In Chapter 5.2, "Employment Impacts of the Proposed Rule," of this July 2014 RIA (Ex. 20) for the proposed rule dated November 25, 2014, EPA used a market analysis to assess employment impacts under two alternative standards. *Id.* at 5-2 to 5-14. EPA estimated that under the proposed standards, one-to-two brick manufacturing facilities were at significant risk of closure; under the alternative standards, EPA estimated that two-to-six brick manufacturing facilities were at significant risk of closure. *Id.* at ES-2. EPA assessed the impacts on employment in the brick industry through a qualitative discussion and a quantitative analysis. *Id.* at 5-1. EPA estimated that the regulation would require an additional 133,000 labor hours per year to operate pollution control devices, which is equivalent to about 64 additional FTE job-years or an approximate 1.1% increase. *Id.* at 5-13 to 5-14. EPA also estimated that, based on average employment at a facility, the likely closure of one or two affected facilities would result in a loss of 37 to 74 jobs. *Id.* at 5-14. The RIA also estimated monetized annual human health benefits of 52 to 120 million dollars using a 3% discount rate for the proposed standards and 78 to 180 million dollars using a 3% discount rate for the alternate standards, reflecting, among other things, reduced cases of morbidity and premature mortality among populations exposed to PM2.5, and annual monetized social costs (in 2011 dollars) of 21 million dollars for the proposed standards and 31 million dollars for the alternate standards. *Id.* at ES-1.

L. Amendments to the National Emission Standards for Hazardous Air Pollutants and New Source Performance Standards (NSPS) for the Portland Cement Manufacturing Industry (Ex. 21)

The August 9, 2010 RIA for this September 9, 2010 rule includes Chapter 3, "Economic Impacts Analysis," and sub-section 3.2.3.3, "Job Effects." Ex. 21 at 3-1 to 3-18. Using two approaches, EPA estimated 1,500 job losses from output changes in the Portland cement industry, and a range of a net loss of 600 to a net gain of 1,300 jobs of other employment impacts. *Id*. at 3-15 to 3-18, tbl. 3-10; *see also id.* at 1-2. The RIA also estimated total monetized benefits of the final NESHAP and NSPS in the year of full implementation (2013) of 7.4 billion to 18 billion dollars at a 3% discount rate (in 2005 dollars for the year 2013) and total annualized costs with the final NESHAP and NSPS based on engineering analysis of 466 million dollars (in 2005 dollars); the estimated social cost is 926 to 950 million dollars (2005 dollars), which is higher due to assumptions about existing market structure. *Id.* at 1-2 and 1-3.

M. Standards of Performance for Greenhouse Gas Emissions for New Stationary Sources: Electric Utility Generating Units (Exs. 22-23)

In the RIA for the proposed rule dated March 27, 2012 (Ex. 22), EPA considered potential impacts of the proposed rule on employment and concluded that "since the EPA does not forecast a change in behavior relative to the baseline in response to this proposed rule, there are no notable macroeconomic or employment impacts expected as a result of this proposed rule." *See id.* at 5-37. EPA reconfirmed this evaluation in a subsequent RIA in September 2013. Ex. 23 at 5-54.

N. Petroleum Refineries New Source Performance Standards (Ex. 24)

In Chapter 4, "Economic Impact Analysis," of the June 2012 RIA for the final rule dated June 18, 2012 (Ex. 24), EPA determined: "For this rule, based on our [market] analysis and an estimated annual cost savings of 79 million dollars (in 2006 dollars) expected in the fifth year, no national-level negative economic impacts are expected." *Id.* at 4-1.

O. Petroleum Refineries Proposed Amendments to the National Emissions Standards for Hazardous Air Pollutants and New Source Performance Standards (Ex. 25)

In this related refineries-sector rulemaking, EPA prepared a February 2014 EIA (Ex. 25) for proposed amendments to the rule dated May 15, 2014. This EIA includes Chapter 4.3 "Discussion of Employment Impacts," which "provides a conceptual framework for considering the potential influence of environmental regulation on employment in the U.S. economy and discusses the limited empirical literature that is available." *Id.* at 4-9. The ensuing qualitative analysis reviewed relevant economic theory and peer-reviewed literature and then described considerations for evaluating employment impacts on the regulated sector, the environmental protection sector, labor supply in general, and overall net employment. *See id*. at 4-9 to 4-19.

P. Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles (Ex. 26)

EPA and the National Highway Safety Traffic Administration (NHSTA) jointly prepared the RIA for this final rule in August 2011 (Ex. 26). In Chapter 9, "Economic and Other Impacts" and sub-section 9.9, "Employment Impacts," EPA and NHSTA presented a qualitative employment impact analysis, considering impacts to affected sectors, and generally concluded that:

> Given the job creation as a result of the $1.2B (2009$) in fuel savings in 2014 and the possible employment increases in the manufacturing and parts sectors, we find it highly unlikely that there would be significant net job losses related to this policy. Given the current level of unemployment, net positive employment effects are possible, especially in the near term, due to the potential hiring of idle labor resources by the regulated sector to plan for and meet new requirements. In the future, when full employment is expected to return, any changes in employment levels in the regulated sector due to this program are mostly expected to be offset by changes in employment in other sectors.

Id. at 9-54 to 9-61. The RIA estimated that the rule would yield annualized monetized benefits (in 2009 dollars) of 2.6 billion dollars using a 3% discount rate and annualized monetized costs of 0.4 billion dollars (in 2009 dollars) using a 3% discount rate. *Id.* at ES-1 to ES-2, tbl. 1.

Q. Proposed National Emission Standards for Hazardous Air Pollutants (NESHAP) for Mercury Emissions from Mercury Cell Chlor Alkali Plants (Ex. 27)

In Chapter 4, "Economic Impact Analysis," and sub-section 4.3, "Impact on Employment," of the November 2010 RIA for this proposed rule dated June 29, 2011 (Ex. 27), EPA considered methodologies and other factors that might allow EPA to quantify employment impacts, but ultimately concluded that it "does not have enough information to estimate whether individual plants will convert or close and therefore no estimate of changes in employment [is] provided." *Id.* at 4-4; *see also id.* at 1-2, 4-1 to 4-14. EPA also considered local employment data in relation to the four affected plants and concluded that "[p]redicting whether, [sic] no plant, one plant, two plants, three plants, or all four plants will close or convert is not possible with the available data." *Id.* at 4-8. The RIA estimated that the rule would yield, in 2013, monetized energy co-benefits (in 2007 dollars) of 22 million to 43 million dollars using a 3% discount rate, and annualized monetized costs of 13 million to 25 million dollars (in 2007 dollars). *Id.* at 1-3 to 1-4, tbl. 1-1.

R. Cost and Benefit Changes Since Proposal for Standards of Performance for New Stationary Sources and Emission Guidelines for Existing Sources: Sewage Sludge Incineration Units (Exs. 28-29)

The September 2010 RIA for the proposed rule (Ex. 28) provided estimates of labor costs for testing, monitoring, and recordkeeping, as one component of compliance costs. *Id.* at 3-4 to 3-6. In the January 2011 analysis of cost and benefit changes since the rule proposal (Ex. 29), EPA's evaluation of employment impacts concluded that insufficient information precluded a quantified assessment of potential employment impacts. *See id.* at 2.

S. Proposed Manganese Ferroalloys Risk and Technology Review (Exs. 30-31)

The November 2011 RIA for the proposed rule dated November 8, 2011 (Ex. 30) includes Chapter 5.7, "Employment Impacts Analysis." *Id.* at 5-9 to 5-12. In a sub-section on "Employment Impacts from Pollution Control Requirements," EPA estimated employment impacts of 27 FTE job-years for up-front, one-time labor requirements and an additional four FTE job-years on an ongoing basis. *Id.* at 5-6 to 5-9, tbl. 5-1. EPA did not further quantify employment impacts for the regulated ferroalloy industry due to various uncertainties. *Id*. at 5-9 to 5-12.

EPA issued a supplemental proposal in September 2014 (Ex. 31), with an accompanying EIA that included a qualitative employment analysis in Chapter 5. The 2011 RIA estimated that the proposed rule would yield, in 2015, monetized benefits (in 2010 dollars) of 71 million to 170 million dollars using a 3% discount, and annualized costs of 4 million dollars (in 2010 dollars). Ex. 30 at 1-1 to 1-3, tbl. 1-1.

T. Existing Stationary Spark Ignition Reciprocating Internal Combustion National Emission Standards for Hazardous Air Pollutants (Exs. 32-33)

EPA's May 2012 RIA for the proposed reconsideration rule dated May 23, 2012 (Ex. 32) estimated employment impacts of approximately 200 up-front and 400 ongoing FTE job-years for pollution control requirements and recordkeeping, reporting, and testing, as detailed in Chapter 5.7, "Employment Impact Analysis." *Id.* at 5-11. EPA did not further quantify impacts within the regulated sector due to various uncertainties. *Id.* at 5-11 to 5-18.

EPA re-evaluated these conclusions during the final reconsideration dated January 15, 2013 and confirmed earlier conclusions. *See* Ex. 33 at 5-11 to 5-18. The 2013 RIA estimated that the final reconsideration would yield, in 2013, monetized benefits of 62 million to 150 million dollars (in 2010 dollars) using a 3% discount rate, and annualized costs of approximately 115 million dollars per year (2009 or 2010 dollars) in the year of full implementation of the rule (2013). *Id.* at 1-1 to 1-3, tbl. 1-1.

U. Existing Stationary Compression Ignition Engines National Emission Standards for Hazardous Air Pollutants (Exs. 34-35)

Chapter 5.7, "Employment Impact Analysis," of EPA's May 2012 RIA for the proposed reconsideration rule dated May 23, 2012 (Ex. 34), estimated employment impacts of about 1,300 one-time FTE job-years for installation of equipment and about 2,000 FTE job-years as ongoing labor for compliance with the proposed rule, *id.* at 5-15, and again refrained from further quantifying employment impacts within the regulated sector due to uncertainties, *id.* at 5-12 to 5-19, *see also id.* at 1-3.

EPA affirmed its estimates during the final reconsideration dated January 15, 2013 *See* Ex. 35 at 1-4 ("We estimate that 1,300 full-time equivalents (FTEs) will be required as one-time labor for installation of equipment, and 2,000 FTEs will be required as ongoing labor for compliance with the proposed rule. The results are presented and explained in detail in Section 5 of this RIA."); *see also id*. at 5-12 to 5-19 (Section 5.7 "Employment Impact Analysis"). The 2013 RIA estimated that the final reconsideration would yield, in 2013, monetized co-benefits of 770 million to 1.9 billion dollars (2010 dollars) using a 3% discount rate, and annualized costs of approximately 372 million dollars (2008 dollars) or 373 million dollars (2010 dollars) in the year of full implementation of the rule (2013). *Id.* at 1-1.

V. Residential Wood Heaters New Source Performance Standards Revision (Exs. 36-37)

In Chapter 5.7, "Employment Impacts," of its RIA for the proposal dated January 8, 2014 (Ex. 36), EPA presented a qualitative employment analysis for the regulated industry and cited various uncertainties and data limitations as a basis for not quantifying employment impacts. *See id.* at 5-24 to 5-30. For the final rule, in Chapter 5.7 of the February 2015 RIA (Ex. 37), the employment analysis is unchanged from the proposal. *See id.* at 5-30 to 5-36.

W. Revisions to the National Ambient Air Quality Standards for Particulate Matter (Exs. 38-39)

In Chapter 11 of its RIA for the proposed rule dated June 29, 2012 (Ex. 38), EPA noted that:

> Estimating specific employment impacts from a new NAAQS standard is particularly challenging for two reasons. First, the NAAQS is a target level of public health protection that individual areas have flexibility to meet in a variety of ways, and the primary regulatory activity and implementation occur at the state or local level.

Id. at 11-1. As a result of this aspect of the NAAQS and the long time-frame of implementation, the RIA discussed employment impacts qualitatively and did not include quantitative projections of shifts in employment. *Id.* at 11-2. EPA concluded that:

> [D]eriving estimates of how regulations will impact economy-wide net employment is a difficult task, especially in the case of setting a new NAAQS, given that economic theory predicts that the net effect of an environmental regulation on regulated sectors and the overall economy is indeterminate (not necessarily positive or negative). Peer-reviewed econometric studies that use a structural approach, applicable to overall net effects in the regulated sectors, converge on the finding that any net employment effects of environmental regulation in general, whether positive or negative, have been small and have not affected employment in the economy in a significant way.

Ex. 38 at 11-7; *see also generally id.* at 11-1 to 11-8. EPA confirmed its approach in Chapter 10 of the RIA for the final rule dated December 14, 2012. Ex. 39 at 10-7.

II. EPA's Evaluations of Employment Impacts with Respect to Administration and Enforcement of the CAA

The following official agency documents, attached as Exhibits 40-45, demonstrate EPA's evaluations of the potential employment impacts of EPA's administration and enforcement of the Clean Air Act.

A. EPA's 2011 White Paper: "Empirical evidence regarding the effects of the Clean Air Act on jobs and economic growth" (Ex. 40)[4]

In 2011, EPA prepared a White Paper, "Empirical evidence regarding the effects of the Clean Air Act on jobs and economic growth," evaluating the most recent economics literature on "the connection between environmental regulation — specifically, the Clean Air Act — and employment and economic growth in the United States." Ex. 40 at 1.

[4] EPA, *Empirical evidence regarding the effects of the Clean Air Act on jobs and economic growth* (2011), *available at* http://www.epa.gov/ocir/pdf/hottopics/2011_0208_white_paper.pdf.

The White Paper includes a section specifically addressing the "Impacts of the Clean Air Act on Employment," in which EPA evaluated economic research. *Id*. at 3-4. One study examined four heavily regulated industries (pulp and paper, refining, iron and steel, and plastic) and concluded that:

> increased environmental spending generally does *not* cause a significant change in employment. Our average across all four industries is a net gain of 1.5 jobs per $1 million in additional environmental spending . . . . These small positive effects can be linked to labor-using factor shifts and relatively inelastic estimated demand.

Id. at 4 (citing Morgenstern et al. at 412) (emphasis in original).[5] Another study concluded that:

> EP [environmental protection], economic growth, and jobs creation are complementary and compatible: Investments in EP create jobs and displace jobs, but the net effect on employment is positive. Second, environment protection has grown rapidly to become a major sales-generating, job-creating industry -- $300 billion/year and 5 million jobs in 2003. Third, most of the 5 million jobs created are standard jobs for accountants, engineers, computer analysts, clerks, factory workers, etc, and the classic environmental job (environmental engineer, ecologist, etc.) constitutes only a small portion of the jobs created. . . . Fourth, at the state level, the relationship between environmental policies and economic/job growth is positive, not negative. . . . Finally, environmental jobs are concentrated in manufacturing and professional, information, scientific, and technical service, and are thus disproportionately the types of jobs all states seek to attract.

Ex. 40 at 4 (citing Bezdek et al. at 63).[6]

In another section of the White Paper, EPA evaluated data demonstrating that CAA regulations stimulate investment in innovative technologies to solve a broad spectrum of pollution problems and create jobs in the growing market for pollution control. *Id.* at 4. The data show that the environmental technology and services sector has experienced dramatic growth since the early 1970s, following the passage of the CAA. By 2008, the industry was

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[5] Richard D. Morgenstern, William A. Pizer & Jhih-Shih, *Jobs Versus the Environment: An Industry-Level Perspective*, 43 J. Envtl. Econ. & Mgmt. 412-36 (2002).

[6] Roger H. Bezdek, Robert M. Wendling & Paul DiPerna, *Environmental Protection, the Economy, and Jobs: National and Regional Analysis*, 86 J. Envtl. Mgmt. 63-79 (2008)

generating approximately 300 billion dollars in revenues and supporting nearly 1.7 million jobs. Air pollution control equipment alone generated revenues of 18 billion dollars in 2007. *Id*. at 5 (citing U.S. Department of Commerce International Trade Administration, *Environmental Technologies Industries: FY2010 Industry Assessment*).[7] The White Paper notes that the innovations helped U.S. companies become a world leader in pollution control technologies, *id*. at 5 (citing *The Clean Air Act Amendments: Spurring Innovation and Growth While Cleaning the Air*),[8] and the field is also growing rapidly as an international market, *id*. at 5 (citing Network of Heads of the European Environment Protection Agencies, *The Contribution of Good Environmental Regulation to Competitiveness*).[9] EPA found that the growth in the environmental protection industry translated to increased employment in those sectors. EPA also concluded that jobs related to CAA implementation are widely dispersed throughout the states and occur in many sectors of the economy, and many of the created jobs are high-tech, such as engineering and computer-aided design; others involve traditional manufacturing, transport, and communication. *Id*. at 5.

In addition to the jobs created in the pollution control sector, EPA also recognized that compliance with environmental regulations requires the purchase and installation of new pollution-reduction technologies, and that also creates employment, including work installing,

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[7] U.S. Department of Commerce, International Trade Administration, *Environmental Technologies Industries: FY2010 Industry Assessment* (2010), *available at* http://web.ita.doc.gov/ete/eteinfo.nsf/068f3801d047f26e85256883006ffa54/4878b7e2fc08ac6d85256883006c452c/$FILE/Full%20Environmental%20Industries%20Assessment%202010.pdf.

[8] ICF Consulting and EPA, *Clean Air Act Amendments: Spurring Innovation and Growth While Cleaning the Air* (2005), *available at* http://www.ntis.gov/Search/Home/titleDetail/?abbr=PB2006102110.

[9] Network of Heads of European Environment Protection Agencies, *The Contribution of Good Environmental Regulation to Competitiveness* (Nov. 2005), *available at* http://epanet.pbe.eea.europa.eu/fol249409/our-publications/prague-statement-folder/PragueStatement_1.pdf/download/en/1/PragueStatement_1.pdf.

operating, and maintaining pollution controls, which must be done domestically. *Id*. at 4; *see also id*. at 6, tbl. 1 (illustrating the average employment impacts associated with the manufacture, installation and operation of one example of air pollution abatement technology). The Institute for Clean Air Companies estimated that implementation of just one rule — the Clean Air Interstate Rule Phase 1 — resulted in 200,000 jobs in the air pollution control industry. *Id*. at 6. *See also* http://www.icac.com/?page=Jobs.

After evaluating the overall economic effects of the CAA, including the impacts of the Act on employment as described in the economics literature, EPA concluded that "the costs of pollution abatement are a very small fraction of total manufacturing costs and research has found that they play a negligible part in plant location decisions and have a very small impact on employment." Ex. 40 at 1.

B. EPA's 2001 Report, "Impacts of the Acid Rain Program on Coal Industry Employment" (Ex. 41)

In 2001, EPA published a report, "Impacts of the Acid Rain Program on Coal Industry Employment" (Ex. 41).[10] The report was externally peer-reviewed by four economists. *See id.*, app. F ("Peer Review Process").

The report projected the impact of the Clean Air Act Title IV Acid Rain Program on coal mining employment through 2010. The report calculated regional shifts in coal production that could be attributed to Title IV, relying on the IPM Model to generate results. *See id.* at 1. Productivity estimates for coal mining in different portions of the country were then used to translate changes in coal demand into changes in coal industry employment. *Id.* The report

[10] EPA, *Impacts of the Acid Rain Program on Coal Industry Employment* (2001), *available at* http://www.epa.gov/airmarkt/resource/docs/coalemployment.pdf.

projected that by 2010, Title IV could result in "a gross loss of 7,700 job slots" with a net loss of "4,100 coal miner job slots because 3,600 new job slots would be created."[11] *See id.* The report further noted that "98 percent of the projected [coal mining] job loss between 1978 and 2010 is related to productivity gains and only two percent of the net decrease in coal miner job slots is due to Title IV." *Id.* at ii. The report revisited an earlier prospective employment analysis of the Acid Rain Program from 1990, discussing the changes in assumptions and data availability between the different analyses and noting that the more recent analysis projected only about half the job losses estimated by the 1990 analysis. *See id.* at 1, app. C.

C. EPA's Economic Analyses of the Benefits and Costs of the Clean Air Act (Exs. 42-45)

EPA has prepared multi-decade economic impact analyses evaluating the impact of the CAA on the U.S. economy. These analyses focus on overall monetized costs and benefits attributable to the CAA, and thus cover a variety of economic topics beyond impacts on employment.

The first of these multi-decade reports evaluated the benefits and costs of the CAA during its first two decades of implementation. *See The Benefits and Costs of the Clean Air Act: 1970 to 1990* (Ex. 42).[12] The study was designed as a first step in answering the overarching question, "How do the overall health, welfare, ecological, and economic benefits of Clean Air Act programs compare to the costs of these programs?" *Id.* at ES-1. The study concluded that the impact of CAA implementation on employment varied by sector, finding that CAA implementation was associated with decreasing employment in some sectors and increasing

[11] "Job slots" were defined as "the number of workers needed to produce the industry's projected output of coal at projected productivity levels."

[12] EPA, *The Benefits and Costs of the Clean Air Act: 1970-1990* (1997), *available at* http://www.epa.gov/cleanairactbenefits/copy.html.

employment by "similar magnitudes" in other sectors. *Id.* at 9. EPA estimated that the total monetized benefits of the CAA, from 1970 to 1990, range from 5.6 to 49.4 trillion dollars (in 1990 dollars) with compliance costs over the same time period of 0.5 trillion dollars (in 1990 dollars); the central estimate of 22.2 trillion dollars in benefits may be a significant underestimate due to the exclusion of large numbers of benefits from the monetized benefit estimate (e.g., all air toxics effects, ecosystem effects, and numerous human health effects). *Id.* at ES-8.

As part of the development of this report, EPA funded a study led by Harvard Professor Dale Jorgenson that looked exclusively at the costs of CAA implementation. Dale W. Jorgenson, Richard J. Goettle, Daniel E. Gaynor, Peter J. Wilcoxen, & Daniel T. Slesnick, *The Clean Air Act and the U.S. Economy: Final Report of Results and Findings* (1993) (Ex. 43).[13] This study's more detailed evaluation of employment impacts examined changes in labor employment due to compliance costs in different sectors. The analysis concluded that:

> Twenty sectors experience reductions in the use of labor services. Of these, eight also show output reductions while substitution effects dominate output effects in the remaining twelve. Fourteen sectors show increases in labor input. Here, the output effects dominate so labor input rises while labor output ratios decline.

Id. at 4-12.

In November 1999, EPA issued a prospective study estimating the benefits and costs of the CAA Amendments of 1990 through the year 2010. *See The Benefits and Costs of the Clean Air Act: 1990 to 2010* (1999) (Ex. 44).[14] In that study, EPA acknowledged that changes in employment constitute an indirect impact of compliance, but focused on direct, monetized costs

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[13] *Available at* http://yosemite.epa.gov/ee/epa/eerm.nsf/vwAN/EE-0349-01.pdf/$file/EE-0349-01.pdf.

[14] EPA, *The Benefits and Costs of the Clean Air Act: 1990-2010* (Nov. 1999), *available at* http://yosemite.epa.gov/ee/epa/eerm.nsf/vwan/ee-0295a-01.pdf.

and benefits as an "initial measure" of the effect of the CAA Amendments of 1990 on the U.S. economy. *Id.* at iii. EPA estimated that the annual economic value of the human health and environmental benefits of the CAA Amendments, in the year 2010, ranges from 26 to 270 billion dollars (in 1990 dollars) with annualized costs of 27 billion dollars (in 1990 dollars). *Id.* at iii to iv, Table ES-1.

In 2001, EPA issued a revision to the 1993 Jorgensen analysis. *See* Dale W. Jorgenson & Richard J. Goettle, *An Economic Analysis of the Benefits and Costs of the Clean Air Act 1970 to 1990: Revised Report of Results and Findings* (Aug. 2001) (Ex. 45).[15] The revised study included more detail on labor and employment impacts, concluding that:

> The net benefits of the CAA combine the early capital and productivity losses of compliance with the subsequent labor and capital gains associated with fewer deaths and workdays lost. In the short run, the Clean Air Act proves costly to the economy. A lower capital stock and reduced productivity more than offset the induced and benefit-driven gains from labor. However, over time, the benefits continue to mount while the compliance costs stabilize. Ultimately, under the CAA, the economy is larger with a larger population, a larger pool of labor and a greater capital stock.

Id. at 25.

III. Additional Documents Demonstrating EPA's Guidance and Continuing Research to Improve its Evaluation of Potential Employment Impacts Associated with Administration and Enforcement of the CAA

Exhibits 46-53 demonstrate EPA's continuing efforts to refine its methodology for evaluation of employment impacts resulting from the administration and enforcement of the CAA. Those projects are summarized below.

[15] *Available at* http://yosemite.epa.gov/ee/epa/eerm.nsf/vwAN/EE-0565-01.pdf/$file/EE-0565-01.pdf.

A. EPA's Guidelines for Preparing Economic Analyses (Ex. 46)

EPA's *Guidelines for Preparing Economic Analyses* (*Guidelines*) (Ex. 46)[16] provide direction to all EPA economists and analysts developing economic analyses, including RIAs prepared during the development of regulations. *Id.* at 1-1 to 1-2. The Guidelines are "part of a continuing effort" by EPA to improve its decision-making process and have been revised and updated several times to reflect new developments. *Id.* at 1-1.

The *Guidelines* include a section regarding "Impacts on employment," which evaluates the methodology used to evaluate employment impacts in past EIAs and discusses preferred approaches. *Id.* at 9-8 to 9-9. The *Guidelines* identify weaknesses in the methodology used for certain employment evaluations in the past:

> Many analyses only present the employment effect on the regulated industry as a result of higher regulatory compliance costs. In doing so, these analyses make simplifying assumptions that employment in a given industry is proportional to output, i.e., if production goes down by 1 percent, employment goes down by 1 percent. These limited assessments on employment impacts from regulation examine how higher manufacturing costs lead to fewer sales and therefore lower employment in that sector. However, empirical and theoretical modeling suggests that these simplified relationships are faulty and should not be used.

Ex. 46 at 9-8. The *Guidelines* counsel against such limited assessments of employment impacts from regulation and recommend that "the analyst needs to quantify all of the employment impacts, positive and negative, to present a complete picture of the effects" and thus should evaluate "shifts of employment," as opposed to just losses. *Id.* at 9-8 to 9-9. The impacts described include a demand effect, cost effect, and factor-shift effect on the regulated industry, as well as employment effects on pollution control industries and industries that make substitute products. *Id.*

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[16] EPA, *Guidelines for Preparing Economic Analyses* (Dec. 17, 2010, updated May 2014)), *available at* http://yosemite.epa.gov/ee/epa/eerm.nsf/vwAN/EE-0568-50.pdf/$file/EE-0568-50.pdf.

B. EPA Workshops and Seminars for the Evaluation of the Employment Impacts of CAA Regulations (Exs. 47-50)

In order to advance the available methods for understanding the employment effects of environmental regulation, EPA's National Center for Environmental Economics (NCEE), in consultation with Dr. V. Kerry Smith (W. P. Carey Professor of Economics at Arizona State University), convened a scientific workshop with academic experts in October 2012 titled "Advancing the Theory and Methods for Understanding Employment Effects of Environmental Regulation." The full agenda and all papers presented are available on NCEE's website.[17]

The purpose of the workshop was to spur research and develop more rigorous methods to capture the employment effects of regulations. Academic experts with backgrounds in macroeconomics, labor economics, and environmental economics presented a variety of technical papers on specific opportunities to refine and improve employment analyses. For example, one of the papers submitted for discussion at the workshop was "Can Sorting Models Help Us Evaluate the Employment Effects of Environmental Regulations?"

In 2012, EPA economists also participated in a series of workshops hosted by the University of Pennsylvania law school that resulted in a published conference volume. *Does Regulation Kill Jobs?* (Cary Coglianese, Adam M. Finkel, & Christopher Carrigan eds., 2012). The effort aimed to support research to "understand better which regulations have which specific effects on jobs and what are the conditions under which these effects occur." Excerpt from *Does Regulation Kill Jobs?*, U. Pa. Press, http://www.upenn.edu/pennpress/book/toc/15183.html. The Preface of the conference volume (Ex. 47) explained:

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[17] Description of Workshop: Advancing the Theory and Methods for Understanding Employment Effects of Environmental Regulation, NECC, http://yosemite.epa.gov/ee/epa/eed.nsf/82A1EF3ABDDDBFC085257600006BB562/F118D6A5DCEF3EE685257B570078FA3E?OpenDocument.

> Despite the obvious reasons for wanting to understand better whether regulation helps or hurts employment, neither regulatory analysts nor academic researchers have yet to develop the kind of evidentiary foundation needed to provide solid answers. Partly this is because the empirical relationship between regulation and employment is harder to untangle than it might seem at first glance. Intuitively it might seem obvious that regulation adversely affects employment. When regulation increases the cost of doing business, it drives up the cost of products and services, reducing demand and thereby shrinking employers' need for workers and the capacity to retain them. But just as intuitively, it might seem obvious that regulation can promote jobs. After all, one of the ways regulation increases the cost of doing business is by increasing the demand for goods and services needed to comply with the law, thus creating additional demand for labor associated with installing and operating required equipment and implementing mandated protocols. Of course, it is also highly plausible that both intuitions have validity and that the same regulations that increase jobs for some individuals decrease them for others.

Ex. 47 at vii. The Preface concluded that "[g]iven the economy's complexity and dynamism, combined with regulation's heterogeneity and expansiveness, more work is needed to produce firm, generalizable answers. This book seeks to help in filling this need." *Id.* at viii.

EPA economists co-authored several chapters of the conference volume, including: *Do the Job Effects of Regulation Differ with the Competitive Environment?* by Wayne B. Gray and Ronald J. Shadbegian (Ex. 48); *Environmental Regulatory Rigidity and Employment in the Electric Power Sector* by Rolf Färe, Shawna Grosskopf, Carl A. Pasurka, Jr., and Ronald J. Shadbegian (Ex. 49); and *A Research Agenda for Improving the Treatment of Employment Impacts in Regulatory Impact Analysis* by Ann E. Ferris and Al McGartland (Ex. 50). Gray and Shadbegian found that more stringent regulation, as measured by total abatement costs relative to output, were associated with statistically significant, but quantitatively very small job losses. Ex. 48 at 66. More specifically, they found that a 10-percent increase in regulatory stringency was associated with a decline of only 30 jobs in the average industry with 40,000 employees, such that the overall effect of regulation on employment in a typical industry was very small. *Id.* Färe et al. found that more efficient regulations, in particular, cap-and-trade programs, would allow industry to achieve more emission reductions and output with the same level of employment. Ex. 49 at 100-01. Ferris and McGartland, in suggesting a research agenda to strengthen the rigor of employment analysis, contended "that additional research is needed in a number of areas to resolve the theoretical treatment of jobs within [benefit-cost analysis] and to improve economists' ability to estimate and value the employment impacts from regulations." Ex. 50 at 172.

C. EPA Research on Employment Impacts Associated with Environmental Regulation (Exs. 51-52)

EPA economists have conducted research on the employment impacts of specific environmental regulations and policies, and this research has been published in recent peer-reviewed scholarly articles. Three EPA economists examined panel data on fossil fuel-fired power plants to assess the impact of Phase I of the CAA's Acid Rain Program on electric utility employment. *See* Ann E. Ferris, Ronald J. Shadbegian & Ann Wolverton, *The Effect of Environmental Regulation on Power Sector Employment: Phase I of the Title IV SO2 Trading Program*, 1 J. Ass'n Envtl. & Resource Economists 521-53 (2014) (Ex. 51). The paper concluded that there was little evidence that power plants had significant decreases in employment during Phase I relative to non–Phase I power plants. *Id.* at 521.

In addition, one EPA economist, along with three academic economists, examined the employment impacts of environmental regulation on the pulp and paper industry. Wayne Gray, Ronald J. Shadbegian, Chunbei Wang & Merve Meral, *Do EPA Regulations Affect Labor Demand? Evidence from the Pulp and Paper Industry*, 68 J. Envtl. Econ. & Mgmt. 188-202 (2014) (Ex. 52). This study used establishment-level Census Bureau data from 1992-2007 to examine employment impacts to the pulp and paper industry from a set of EPA water and air regulations promulgated in 1998. *Id.* at 189. The study found some evidence of employment declines (on the order of 3%-7%) associated with the regulations, which were sometimes statistically significant. *Id.* at 201. These declines were concentrated in plants covered by water-pollution standards; employment effects at plants covered only by the air regulations were more often positive than negative, though generally not statistically significant. *Id.*

D. EPA Science Advisory Board Panel on Use of Economy-Wide Modeling (Ex. 53)

In its continuing effort to advance the evaluation of costs, benefits, and economic impacts associated with environmental regulation, EPA formed a panel of experts as part of EPA's Science Advisory Board (SAB) to advise EPA on the technical merits and challenges of using economy-wide economic models to evaluate the impacts of its regulations. The panel of experts will consider a variety of issues related to the use of economy-wide modeling, including their technical appropriateness for assessing employment impacts. On February 5, 2014, EPA requested public comment on specific questions for the panel to address. *See* "Comment Request; Draft Supporting Materials for the Science Advisory Board Panel on the Role of Economy-Wide Modeling in U.S. EPA Analysis of Air Regulations," 79 Fed. Reg. 6899 (Feb. 5, 2014). The revised "charge" questions were presented to the SAB on February 26, 2015 (Ex. 53).[18] The charge seeks advice on, among other things, the extent to which various models are technically appropriate to shed light on the economic impacts of an air regulation, including consideration of "[s]ectoral impacts (including price and quantity changes, plant openings and closures)"; "[t]ransition costs in capital or labor markets"; and "[e]quilibrium impacts on labor

[18] Memorandum from Al McGartland, Director, National Center for Environmental Economics, Office of Policy, EPA to Holly Stallworth, Designated Federal Office, Science Advisory Board Staff Office, EPA, Regarding Transmittal of Charge to the Science Advisory Board Advisory Panel on Economy-Wide Modeling of the Benefits and Costs of Environmental Regulation (Feb. 26, 2015), *available at* http://yosemite.epa.gov/sab/sabproduct.nsf/368203f97a15308a852574ba005bbd01/07E67CF77B54734285257BB0004F87ED/$File/Charge+Questions+2-26-15.pdf.

productivity, supply or demand (e.g., labor market outcomes)." *Id.* at 9. Answers from the panel of experts will help EPA assess whether economy-wide models can be used to evaluate employment and other economic impacts.

I declare under penalty of perjury that the foregoing is true and correct to the best of my knowledge, information, and belief.

Date: 4/10/15

James B. DeMocker

EXHIBIT 1

United States
Environmental Protection
Agency

Regulatory Impact Analysis for the Proposed Carbon Pollution Guidelines for Existing Power Plants and Emission Standards for Modified and Reconstructed Power Plants

EPA-452/R-14-002

June 2014

Regulatory Impact Analysis for the Proposed Carbon Pollution Guidelines for Existing Power Plants and Emission Standards for Modified and Reconstructed Power Plants

U.S. Environmental Protection Agency
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Health & Environmental Impacts Division
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DEDICATION

This Regulatory Impact Analysis is dedicated to the memory of Lillian Grace Bradley who made substantial contributions to this analysis and report. Lillian freely expressed her fundamental belief that everyone has an inherent right to be treated with dignity and respect, regardless of their position or background, and she was a recognized leader in Environmental Justice and Tribal issues at EPA. She expressed her deep regard for others through individual acts of kindness as well as her dedication to increasing social awareness and emotional intelligence in the workplace. Her caring, integrity, and outspokenness were a gift to us all. Lillian challenged us to lead our very best life. She will be greatly missed.

EXECUTIVE SUMMARY

This Regulatory Impact Analysis (RIA) discusses potential benefits, costs, and economic impacts of the proposed Emission Guidelines for Greenhouse Gas Emissions from Existing Stationary Sources: Electric Utility Generating Units (herein referred to EGU GHG Existing Source Guidelines). This RIA also discusses the potential benefits, costs and economic impacts of the proposed Standards of Performance for Greenhouse Gas Emissions from Reconstructed and Modified Stationary Sources (EGU GHG Reconstructed and Modified Source Standards).

ES.1 Background and Context of Proposed EGU GHG Existing Source Guidelines

Greenhouse gas pollution threatens Americans' health and welfare by leading to long-lasting changes in our climate that can have a range of severely negative effects on human health and the environment. Carbon Dioxide (CO_2) is the primary greenhouse gas pollutant, accounting for nearly three-quarters of global greenhouse gas emissions and 84 percent of U.S. greenhouse gas emissions. Fossil fuel-fired electric generating units (EGUs) are, by far, the largest emitters of GHGs, primarily in the form of CO_2, among stationary sources in the U.S.

In this action, the EPA is proposing emission guidelines for states to use in developing plans to address greenhouse gas emissions from existing fossil fuel-fired EGUs. Specifically, the EPA is proposing state-specific rate-based goals for carbon dioxide emissions from the power sector, as well as emission guidelines for states to use in developing plans to attain the state-specific goals. This rule, as proposed, would set in motion actions to lower the carbon dioxide emissions associated with existing power generation sources in the United States.

ES.2 Summary of Proposed EGU GHG Existing Source Guidelines

Under Clean Air Act (CAA) section 111(d), state plans must establish standards of performance that reflect the degree of emission limitation achievable through the application of the “best system of emission reduction” (BSER) that, taking into account the cost of achieving such reduction and any non-air quality health and environmental impact and energy requirements, the Administrator determines has been adequately demonstrated.[1] Consistent with CAA section 111(d), this proposed rule contains state-specific goals that reflect the EPA's calculation of the emission reductions that a state can achieve through the application of BSER. The EPA is using the following four building blocks to determine state-specific goals:

1. Reducing the carbon intensity of generation at individual affected EGUs through heat-rate improvements.

2. Reducing emissions from the most carbon-intensive affected EGUs in the amount that results from substituting generation at those EGUs with generation from less carbon-intensive affected EGUs (including natural gas combined cycle [NGCC] units that are under construction).

3. Reducing emissions from affected EGUs in the amount that results from substituting generation at those EGUs with expanded low- or zero-carbon generation.

4. Reducing emissions from affected EGUs in the amount that results from the use of demand-side energy efficiency that reduces the amount of generation required.

The proposed rule also contains emission guidelines for states to use in developing plans that set their standards of performance. The EPA recognizes that each state has different policy considerations, including varying emission reduction opportunities and existing state programs and measures, and characteristics of the electricity system (e.g., utility regulatory structure, generation mix, electricity demand). The proposed emission guidelines provide states with options for establishing standards of performance in a manner that accommodates a diverse range of state approaches. The proposed guidelines would also allow states to collaborate and to demonstrate emission performance on a multi-state basis, in recognition of the fact that electricity is transmitted across state lines, and local measures often impact regional EGU CO_2

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[1] Under CAA sections 111(a)(1) and (d), the EPA is authorized to determine the BSER and to calculate the amount of emission reduction achievable through applying the BSER; and the state is authorized to identify the standard(s) of performance that reflects that amount of emission reduction. In addition, the state is required to include in its state plan the standards of performance and measures to implement and enforce those standards. The state must submit the plan to the EPA, and the EPA must approve the plan if the standards of performance and implementing and enforcing measures are satisfactory.

emissions.

While the EPA must establish BSER and is proposing goals and guidelines that reflect BSER, CAA section 111(d) also provides the EPA with the flexibility to design goals and guidelines that recognize, and are tailored to, the uniqueness and complexity of the power generation sector and CO_2 emissions. And, importantly, CAA section 111(d) allows the states flexibility in designing the measures for their state plans in response to the EPA's guidelines. States are not required to use each of the measures that the EPA determines constitute BSER, or use those measures to the same degree of stringency that the EPA determines is achievable at a reasonable cost; rather, CAA section 111(d) allows each state to determine the appropriate combination of, and the extent of its reliance on, measures for its state plan, by way of meeting its state-specific goal. Given the flexibilities afforded states in complying with the emission guidelines, the benefits, cost and economic impacts reported in this RIA are not definitive estimates, but are instead illustrative of compliance actions states may take.

ES.3 Control Strategies for Existing EGUs

States will ultimately determine approaches to comply with the goals established in this regulatory action. The EPA is proposing a BSER goal approach referred to as Option 1 and taking comment on a second approach referred to as Option 2. Each of these goal approaches use the four building blocks described above at different levels of stringency. Option 1 involves higher deployment of the four building blocks but allows a longer timeframe to comply (2030) whereas Option 2 has a lower deployment over a shorter timeframe (2025).

Table ES-1 shows the proposed state goals for Options 1 and 2. This RIA depicts illustrative rate-based compliance scenarios for the goals set for Options 1 and 2, as well as regional and state compliance approaches for each option. With the state compliance approach, states are assumed to comply with the guidelines by implementing measures solely within the state and emissions rate averaging occurs between affected sources on an intrastate basis only. In contrast under the regional approach, groups of states are assumed to collaboratively comply with the guidelines. States have the discretion of choosing between a regional or state compliance approach, and this RIA reports the economic consequences of compliance under two sets of assumptions: one that assumes all states individually take a rate-based compliance approach and the other that assumes certain groups of states take regional rate-based approaches. The analysis in the illustrative scenarios does not assume that states use any specific policy mechanism to achieve the state goals. The distributions of emissions and electricity generation reflected in the Integrated Planning Model (IPM) analysis of the illustrative scenarios could be achieved by various policy mechanisms. Alternative compliance approaches are also possible. For example, the guidance allows flexibility of compliance, including the possibility of using a mass-based approach. While IPM finds a least cost way to achieve the state goals implemented through the rate-based constraints imposed in the illustrative scenarios, individual states or multi-state regional groups may develop more cost effective approaches to achieve their state goals.

Table ES-1. Proposed State Goals (Adjusted MWh-Weighted-Average Pounds of CO_2 per Net MWh from all Affected Fossil Fuel-Fired EGUs) for Options 1 and 2

State[2]	Option 1		Option 2	
	Interim Goal (2020-2029)	Final Goal (2030 Forward)	Interim Goal (2020-2024)	Final Goal (2025 Forward)
Alabama	1,147	1,059	1,270	1,237
Alaska	1,097	1,003	1,170	1,131
Arizona *	735	702	779	763
Arkansas	968	910	1,083	1,058
California	556	537	582	571
Colorado	1,159	1,108	1,265	1,227
Connecticut	597	540	651	627
Delaware	913	841	1,007	983
Florida	794	740	907	884
Georgia	891	834	997	964
Hawaii	1,378	1,306	1,446	1,417
Idaho	244	228	261	254
Illinois	1,366	1,271	1,501	1,457
Indiana	1,607	1,531	1,715	1,683
Iowa	1,341	1,301	1,436	1,417
Kansas	1,578	1,499	1,678	1,625
Kentucky	1,844	1,763	1,951	1,918
Louisiana	948	883	1,052	1,025

[2] The EPA has not developed goals for Vermont and the District of Columbia because current information indicates those jurisdictions have no affected EGUs. Also, as noted in Chapter 3, EPA is not proposing goals for tribes or U.S. territories at this time.

Table ES-1. Continued

Maine	393	378	418	410
Maryland	1,347	1,187	1,518	1,440
Massachusetts	655	576	715	683
Michigan	1,227	1,161	1,349	1,319
Minnesota	911	873	1,018	999
Mississippi	732	692	765	743
Missouri	1,621	1,544	1,726	1,694
Montana	1,882	1,771	2,007	1,960
Nebraska	1,596	1,479	1,721	1,671
Nevada	697	647	734	713
New Hampshire	546	486	598	557
New Jersey	647	531	722	676
New Mexico *	1,107	1,048	1,214	1,176
New York	635	549	736	697
North Carolina	1,077	992	1,199	1,156
North Dakota	1,817	1,783	1,882	1,870
Ohio	1,452	1,338	1,588	1,545
Oklahoma	931	895	1,019	986
Oregon	407	372	450	420
Pennsylvania	1,179	1,052	1,316	1,270
Rhode Island	822	782	855	840
South Carolina	840	772	930	897
South Dakota	800	741	888	861
Tennessee	1,254	1,163	1,363	1,326
Texas	853	791	957	924
Utah *	1,378	1,322	1,478	1,453
Virginia	884	810	1,016	962
Washington	264	215	312	284
West Virginia	1,748	1,620	1,858	1,817
Wisconsin	1,281	1,203	1,417	1,380
Wyoming	1,808	1,714	1,907	1,869

* Excludes EGUs located in Indian country.

Table ES-2 shows the emission reductions associated with the compliance scenarios for the proposed Option 1 regional and state compliance approaches and Table ES-3 reports emission reductions associated with Option 2. In 2020, the EPA estimates that CO_2 emissions will be reduced by 371 million metric tons under the regional compliance approach and by 383 million metric tons assuming a state specific compliance approach compared to base case levels. CO_2 emission reductions for Option 1 increase to 545 and 555 million metric tons annually in 2030 when compared to the base case emissions for Option 1 regional and state compliance approaches, respectively. Tables ES-2 and ES-3 also show emission reductions for criteria air pollutants.

Table ES-2. Summary of Climate and Air Pollutant Emission Reductions Option 1[1]

	CO_2 (million metric tons)	SO_2 (thousands of tons)	NO_X (thousands of tons)	$PM_{2.5}$ (thousands of tons)
2020 Regional Compliance Approach				
Base Case	2,161	1,476	1,559	212
Proposed Guidelines	1,790	1,184	1,213	156
Emissions Change	-371	-292	-345	-56
2025 Regional Compliance Approach				
Base Case	2,231	1,515	1,587	209
Proposed Guidelines	1,730	1,120	1,166	150
Emissions Change	-501	-395	-421	-59
2030 Regional Compliance Approach				
Base Case	2,256	1,530	1,537	198
Proposed Guidelines	1,711	1,106	1,131	144
Emission Change	-545	-424	-407	-54
2020 State Compliance Approach				
Base Case	2,161	1,476	1,559	212
Proposed Guidelines	1,777	1,140	1,191	154
Emissions Change	-383	-335	-367	-58
2025 State Compliance Approach				
Base Case	2,231	1,515	1,587	209
Proposed Guidelines	1,724	1,090	1,151	146
Emission Change	-506	-425	-436	-63
2030 State Compliance Approach				
Base Case	2,256	1,530	1,537	198
Proposed Guidelines	1,701	1,059	1,109	142
Emissions Change	-555	-471	-428	-56

Source: Integrated Planning Model, 2014.

[1] CO_2 emission reductions are used to estimate the climate benefits of the guidelines. SO_2, NOx, and directly emitted $PM_{2.5}$ emission reductions are relevant for estimating air pollution health co-benefits of the proposed guidelines.

Table ES-3. Summary of Climate and Air Pollutant Emission Reductions Option 2[1]

	CO_2 (million metric tons)	SO_2 (thousands of tons)	NO_X (thousands of tons)	$PM_{2.5}$ (thousands of tons)
2020 Regional Compliance Approach				
Base Case	2,161	1,476	1,559	212
Option 2	1,878	1,231	1,290	166
Emissions Change	-283	-244	-268	-46
2025 Regional Compliance Approach				
Base Case	2,231	1,515	1,587	209
Option 2	1,862	1,218	1,279	165
Emissions Change	-368	-297	-309	-44
2020 State Compliance Approach				
Base Case	2,161	1,476	1,559	212
Option 2	1,866	1,208	1,277	163
Emissions Change	-295	-267	-281	-49
2025 State Compliance Approach				
Base Case	2,231	1,515	1,587	209
Option 2	1,855	1,188	1,271	161
Emissions Change	-376	-327	-317	-48

Source: Integrated Planning Model, 2014.

[1] CO_2 emission reductions are used to estimate the climate benefits of the guidelines. SO_2, NOx, and directly emitted $PM_{2.5}$ emission reductions are relevant for estimating air pollution health co-benefits of the guidelines.

ES.4 Costs of Existing EGU Guidelines

The ‘‘compliance costs’’ of this proposed action are represented in this analysis as the change in electric power generation costs between the base case and illustrative compliance scenario policy cases. The compliance scenario policy cases reflect the pursuit by states of a distinct set of strategies, which are not limited to the technologies and measures included in the BSER to meet the EGU GHG emission guidelines, and include cost estimates for demand side energy efficiency. The compliance assumptions, and therefore the projected "compliance costs" set forth in this analysis, are illustrative in nature and do not represent the full suite of compliance flexibilities states may ultimately pursue.

The EPA projects that the annual incremental compliance cost of the proposed Option 1 ranges from $5.4 to $7.4 billion in 2020 and from $7.3 to $8.8 billion in 2030 ($2011), excluding the costs associated with monitoring, reporting, and recordkeeping. The estimated cost of Option 2 is between $4.2 and $5.4 billion in 2020 and between $4.5 and $5.5 billion in 2025 (2011$). The estimated monitoring, reporting and recordkeeping costs for both options are $68.3 million in 2020, $8.9 million in 2025, and $8.9 million in 2030 (2011$). The annual incremental cost is the projected additional cost of complying with the proposed rule in the year analyzed and includes the net change in the annualized cost of capital investment in new generating sources and heat rate improvements at coal steam facilities,[3] the change in the ongoing costs of operating pollution controls, shifts between or amongst various fuels, demand-side energy efficiency measures, and other actions associated with compliance. Costs for both options are reflected in Table ES-4 below and discussed more extensively in Chapter 3 of this RIA.

Table ES-4. Summary of Illustrative Compliance Costs

	Incremental Cost from Base Case (billions of 2011$)		
	2020	2025	2030
Option 1			
State Compliance	$7.4	$5.5	$8.8
Regional Compliance	$5.4	$4.6	$7.3
Option 2			
State Compliance	$5.4	$5.5	n/a
Regional Compliance	$4.2	$4.5	n/a

Source: Integrated Planning Model, 2014, with post-processing to account for exogenous demand-side management energy efficiency costs. See Chapter 5 of the GHG Abatement Measures TSD for a full explanation. Compliance costs shown here do not include monitoring, reporting, and recordkeeping costs.

The costs reported in Table ES-4 represent the estimated incremental electric utility generating costs changes from the base case, plus end-use energy efficiency program costs (paid by electric utilities) and end-use energy efficiency participant costs (paid by electric utility consumers). For example in 2020 for the proposed Option 1 regional compliance approach, end-use energy efficiency program costs are estimated to be $5.1 billion and end-use efficiency participant costs are $5.1 billion using a 3% discount rate (see Table 3-4). This estimate for end-use energy efficiency costs of $10.2 billion is combined with the costs generated by the IPM that include the costs of states' compliance with state goals associated with changes to reduce the carbon-intensity of electricity production and the energy demand decreases expected from end-use energy efficiency assumed in the illustrative scenarios. In order to reflect the full cost

[3] See Chapter 8 of EPA's Base Case using IPM (v5.13) documentation, available at: http://www.epa.gov/powersectormodeling/BaseCasev513.html

attributable to the policy, it is necessary to include this incremental -$4.8 billion (see Table 3-9) in electricity supply expenditure with the annualized expenditure needed to secure the end-use energy efficiency improvements. As a result, this analysis finds the cost of the Option 1 regional scenario in 2020 to be $5.4 billion (the sum of incremental supply-related and demand-related expenditures). Note that when monitoring, reporting and recordkeeping costs of $68.3 million are added to this estimate, compliance costs become $5.5 billion in 2020.

The compliance costs reported in Table ES-4 are not social costs. These costs represent the illustrative real resources costs for states to comply with the BSER goals for Options 1 and 2. Electric sector compliance costs and monitoring, recordkeeping and reporting costs are compared to social benefits in Tables ES-8, ES-9 and ES-10 to derive illustrative net benefits of the guidelines. For a more extensive discussion of social costs, see Chapter 3 of this RIA.

ES.5 Monetized Climate Benefits and Health Co-benefits for Existing EGUs

Implementing the proposed guidelines is expected to reduce emissions of CO_2 and have ancillary emission reductions (i.e., co-benefits) of SO_2, NO_2, and directly emitted $PM_{2.5}$, which would lead to lower ambient concentrations of $PM_{2.5}$ and ozone. The climate benefits estimates have been calculated using the estimated values of marginal climate impacts presented in the *Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866*, henceforth denoted as the 2013 SCC TSD.[4] Also, the range of combined benefits reflects different concentration-response functions for the air pollution health co-benefits, but it does not capture the full range of uncertainty inherent in the health co-benefits estimates. Furthermore, we were unable to quantify or monetize all of the climate benefits and health and environmental co-benefits associated with the proposed emission

[4] Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866, Interagency Working Group on Social Cost of Carbon, with participation by Council of Economic Advisers, Council on Environmental Quality, Department of Agriculture, Department of Commerce, Department of Energy, Department of Transportation, Environmental Protection Agency, National Economic Council, Office of Energy and Climate Change, Office of Management and Budget, Office of Science and Technology Policy, and Department of Treasury (May 2013, Revised November 2013). Available at: http://www.whitehouse.gov/sites/default/files/omb/assets/inforeg/technical-update-social-cost-of-carbon-for-regulator-impact-analysis.pdf

guidelines, including reducing exposure to SO_2, NO_x, and hazardous air pollutants (e.g., mercury and hydrogen chloride), as well as ecosystem effects and visibility impairment. These unquantified benefits could be substantial, but it is difficult to approximate the potential magnitude of these unquantified benefits and previous quantification attempts have been incomplete. The omission of these endpoints from the monetized results should not imply that the impacts are small or unimportant. Table ES-5 provides the list of the quantified and unquantified environmental and health benefits in this analysis.

Table ES-5. Quantified and Unquantified Benefits

Benefits Category	Specific Effect	Effect Has Been Quantified	Effect Has Been Monetized	More Information
Improved Environment				
Reduced climate effects	Global climate impacts from CO_2	—	✓	SCC TSD
	Climate impacts from ozone and black carbon (directly emitted PM)	—	—	Ozone ISA, PM ISA[1]
	Other climate impacts (e.g., other GHGs such as methane, aerosols, other impacts)	—	—	IPCC[1]
Improved Human Health (co-benefits)				
Reduced incidence of premature mortality from exposure to $PM_{2.5}$	Adult premature mortality based on cohort study estimates and expert elicitation estimates (age >25 or age >30)	✓	✓	PM ISA
	Infant mortality (age <1)	✓	✓	PM ISA
Reduced incidence of morbidity from exposure to $PM_{2.5}$	Non-fatal heart attacks (age > 18)	✓	✓	PM ISA
	Hospital admissions—respiratory (all ages)	✓	✓	PM ISA
	Hospital admissions—cardiovascular (age >20)	✓	✓	PM ISA
	Emergency room visits for asthma (all ages)	✓	✓	PM ISA
	Acute bronchitis (age 8-12)	✓	✓	PM ISA
	Lower respiratory symptoms (age 7-14)	✓	✓	PM ISA
	Upper respiratory symptoms (asthmatics age 9-11)	✓	✓	PM ISA
	Asthma exacerbation (asthmatics age 6-18)	✓	✓	PM ISA
	Lost work days (age 18-65)	✓	✓	PM ISA
	Minor restricted-activity days (age 18-65)	✓	✓	PM ISA
	Chronic Bronchitis (age >26)	—	—	PM ISA[1]
	Emergency room visits for cardiovascular effects (all ages)	—	—	PM ISA[1]
	Strokes and cerebrovascular disease (age 50-79)	—	—	PM ISA[1]
	Other cardiovascular effects (e.g., other ages)	—	—	PM ISA[2]
	Other respiratory effects (e.g., pulmonary function, non-asthma ER visits, non-bronchitis chronic diseases, other ages and populations)	—	—	PM ISA[2]
	Reproductive and developmental effects (e.g., low birth weight, pre-term births, etc)	—	—	PM ISA[2,3]
	Cancer, mutagenicity, and genotoxicity effects	—	—	PM ISA[2,3]
Reduced incidence of mortality from exposure to ozone	Premature mortality based on short-term study estimates (all ages)	✓	✓	Ozone ISA
	Premature mortality based on long-term study estimates (age 30–99)	—	—	Ozone ISA[1]
Reduced incidence of morbidity from exposure to ozone	Hospital admissions—respiratory causes (age > 65)	✓	✓	Ozone ISA
	Hospital admissions—respiratory causes (age <2)	✓	✓	Ozone ISA
	Emergency department visits for asthma (all ages)	✓	✓	Ozone ISA
	Minor restricted-activity days (age 18–65)	✓	✓	Ozone ISA
	School absence days (age 5–17)	✓	✓	Ozone ISA
	Decreased outdoor worker productivity (age 18–65)	—	—	Ozone ISA[1]
	Other respiratory effects (e.g., premature aging of lungs)	—	—	Ozone ISA[2]
	Cardiovascular and nervous system effects	—	—	Ozone ISA[2]
	Reproductive and developmental effects	—	—	Ozone ISA[2,3]

Table ES-5. Continued

Reduced incidence of morbidity from exposure to NO_2	Asthma hospital admissions (all ages)	—	—	NO_2 ISA[1]
	Chronic lung disease hospital admissions (age > 65)	—	—	NO_2 ISA[1]
	Respiratory emergency department visits (all ages)	—	—	NO_2 ISA[1]
	Asthma exacerbation (asthmatics age 4–18)	—	—	NO_2 ISA[1]
	Acute respiratory symptoms (age 7–14)	—	—	NO_2 ISA[1]
	Premature mortality	—	—	NO_2 ISA[1,2,3]
	Other respiratory effects (e.g., airway hyperresponsiveness and inflammation, lung function, other ages and populations)	—	—	NO_2 ISA[2,3]
Reduced incidence of morbidity from exposure to SO_2	Respiratory hospital admissions (age > 65)	—	—	SO_2 ISA[1]
	Asthma emergency department visits (all ages)	—	—	SO_2 ISA[1]
	Asthma exacerbation (asthmatics age 4–12)	—	—	SO_2 ISA[1]
	Acute respiratory symptoms (age 7–14)	—	—	SO_2 ISA[1]
	Premature mortality	—	—	SO_2 ISA[1,2,3]
	Other respiratory effects (e.g., airway hyperresponsiveness and inflammation, lung function, other ages and populations)	—	—	SO_2 ISA[1,2]
Reduced incidence of morbidity from exposure to methylmercury	Neurologic effects—IQ loss	—	—	IRIS; NRC, 2000[1]
	Other neurologic effects (e.g., developmental delays, memory, behavior)	—	—	IRIS; NRC, 2000[2]
	Cardiovascular effects	—	—	IRIS; NRC, 2000[2,3]
	Genotoxic, immunologic, and other toxic effects	—	—	IRIS; NRC, 2000[2,3]
Reduced incidence of morbidity from exposure to HAP	Effects associated with exposure to hydrogen chloride	—	—	ATSDR, IRIS[1,2]
Improved Environment (co-benefits)				
Reduced visibility impairment	Visibility in Class 1 areas	—	—	PM ISA[1]
	Visibility in residential areas	—	—	PM ISA[1]
Reduced effects on materials	Household soiling	—	—	PM ISA[1,2]
	Materials damage (e.g., corrosion, increased wear)	—	—	PM ISA[2]
Reduced PM deposition (metals and organics)	Effects on Individual organisms and ecosystems	—	—	PM ISA[2]
Reduced vegetation and ecosystem effects from exposure to ozone	Visible foliar injury on vegetation	—	—	Ozone ISA[1]
	Reduced vegetation growth and reproduction	—	—	Ozone ISA[1]
	Yield and quality of commercial forest products and crops	—	—	Ozone ISA[1]
	Damage to urban ornamental plants	—	—	Ozone ISA[2]
	Carbon sequestration in terrestrial ecosystems	—	—	Ozone ISA[1]
	Recreational demand associated with forest aesthetics	—	—	Ozone ISA[2]
	Other non-use effects			Ozone ISA[2]
	Ecosystem functions (e.g., water cycling, biogeochemical cycles, net primary productivity, leaf-gas exchange, community composition)	—	—	Ozone ISA[2]
Reduced effects from acid deposition	Recreational fishing	—	—	NO_x SO_x ISA[1]
	Tree mortality and decline	—	—	NO_x SO_x ISA[2]
	Commercial fishing and forestry effects	—	—	NO_x SO_x ISA[2]
	Recreational demand in terrestrial and aquatic ecosystems	—	—	NO_x SO_x ISA[2]
	Other non-use effects			NO_x SO_x ISA[2]
	Ecosystem functions (e.g., biogeochemical cycles)	—	—	NO_x SO_x ISA[2]

Table ES-5. Continued

Reduced effects from nutrient enrichment	Species composition and biodiversity in terrestrial and estuarine ecosystems	—	—	NO_x SO_x ISA[2]
	Coastal eutrophication	—	—	NO_x SO_x ISA[2]
	Recreational demand in terrestrial and estuarine ecosystems	—	—	NO_x SO_x ISA[2]
	Other non-use effects			NO_x SO_x ISA[2]
	Ecosystem functions (e.g., biogeochemical cycles, fire regulation)	—	—	NO_x SO_x ISA[2]
Reduced vegetation effects from exposure to SO_2 and NO_x	Injury to vegetation from SO_2 exposure	—	—	NO_x SO_x ISA[2]
	Injury to vegetation from NO_x exposure	—	—	NO_x SO_x ISA[2]
Reduced ecosystem effects from exposure to methylmercury	Effects on fish, birds, and mammals (e.g., reproductive effects)	—	—	Mercury Study RTC[2]
	Commercial, subsistence and recreational fishing	—	—	Mercury Study RTC[1]

[1] We assess these co-benefits qualitatively due to data and resource limitations for this analysis.

[2] We assess these co-benefits qualitatively because we do not have sufficient confidence in available data or methods.

[3] We assess these co-benefits qualitatively because current evidence is only suggestive of causality or there are other significant concerns over the strength of the association.

ES.5.1 Estimating Global Climate Benefits

We estimate the global social benefits of CO_2 emission reductions expected from this rulemaking using the SCC estimates presented in the 2013 SCC TSD. We refer to these estimates, which were developed by the U.S. government, as “SCC estimates” for the remainder of this document. The SCC is a metric that estimates the monetary value of impacts associated with marginal changes in CO_2 emissions in a given year. It includes a wide range of anticipated climate impacts, such as net changes in agricultural productivity and human health, property damage from increased flood risk, and changes in energy system costs, such as reduced costs for heating and increased costs for air conditioning. It is typically used to assess the avoided damages as a result of regulatory actions (i.e., benefits of rulemakings that have an incremental impact on cumulative global CO_2 emissions).

The SCC estimates used in this analysis have been developed over many years, using the best science available, and with input from the public. The EPA and other federal agencies have considered the extensive public comments on ways to improve SCC estimation received via the notice and comment period that was part of numerous rulemakings since 2006. In addition, OMB’s Office of Information and Regulatory Affairs recently sought public comment on the approach used to develop the SCC estimates. The comment period ended on February 26, 2014, and OMB is reviewing the comments received.

An interagency process that included the EPA and other executive branch entities used three integrated assessment models (IAMs) to develop SCC estimates and selected four global values for use in regulatory analyses. The SCC estimates represent global measures because of the distinctive nature of the climate change problem. Emissions of greenhouse gases contribute to damages around the world, even when they are released in the United States, and the world's economies are now highly interconnected. Therefore, the SCC estimates incorporate the worldwide damages caused by carbon dioxide emissions in order to reflect the global nature of the problem, and we expect other governments to consider the global consequences of their greenhouse gas emissions when setting their own domestic policies. See RIA Chapter 4 for more discussion.

The federal government first released the estimates in February 2010 and updated them in 2013 using new versions of each IAM. The general approach to estimating the SCC values in 2010 and 2013 was to run the three integrated assessment models (DICE, FUND, and PAGE)[5] using the following three inputs in each model: a probabilistic distribution for climate sensitivity; five scenarios capturing economic, population, and emission trajectories; and constant annual discount rates. The 2010 SCC Technical Support Document (SCC TSD) provides a complete discussion of the methodology and the 2013 SCC TSD presents and discusses the updated estimates. The four SCC estimates, updated in 2013, are as follows: $13, $46, $68, and $137 per metric ton of CO_2 emissions in the year 2020 (2011$), and each estimate increases over time. These SCC estimates are associated with different discount rates. The first three estimates are the model average at 5 percent discount rate, 3 percent, and 2.5 percent, respectively, and the fourth estimate is the 95th percentile at 3 percent.

The 2010 SCC TSD noted a number of limitations to the SCC analysis, including the incomplete way in which the IAMs capture catastrophic and non-catastrophic impacts, their

[5] The full models names are as follows: Dynamic Integrated Climate and Economy (DICE); Climate Framework for Uncertainty, Negotiation, and Distribution (FUND); and Policy Analysis of the Greenhouse Gas Effect (PAGE).

incomplete treatment of adaptation and technological change, uncertainty in the extrapolation of damages to high temperatures, and assumptions regarding risk aversion. Current integrated assessment models do not assign value to all of the important physical, ecological, and economic impacts of climate change recognized in the climate change literature because of a lack of precise information on the nature of damages and because the science incorporated into these models understandably lags behind the most recent research. In particular, the IPCC Fourth Assessment Report concluded that "It is very likely that [SCC estimates] underestimate the damage costs because they cannot include many non-quantifiable impacts." Nonetheless, these estimates and the discussion of their limitations represent the best available information about the social benefits of CO_2 emission reductions to inform the benefit-cost analysis.

ES 5.2 Estimating Air Pollution Health Co-Benefits

The proposed guidelines would reduce emissions of precursor pollutants (e.g., SO_2, NOx, and directly emitted particles), which in turn would lower ambient concentrations of $PM_{2.5}$ and ozone. This co-benefits analysis quantifies the monetized benefits associated with the reduced exposure to these two pollutants.[6] Unlike the global SCC estimates, the air pollution health co-benefits are only estimated for the contiguous U.S.[7] The estimates of monetized $PM_{2.5}$ co-benefits include avoided premature deaths (derived from effect coefficients in two cohort studies [Krewski et al. 2009 and Lepeule et al. 2012] for adults and one for infants [Woodruff et al. 1997]), as well as avoided morbidity effects for ten non-fatal endpoints ranging in severity from lower respiratory symptoms to heart attacks (U.S. EPA, 2012). The estimates of monetized ozone co-benefits include avoided premature deaths (derived from the range of effect coefficients represented by two short-term epidemiology studies [Bell et al. (2004) and Levy et al. (2005)]), as well as avoided morbidity effects for five non-fatal endpoints ranging in severity from school absence days to hospital admissions (U.S. EPA, 2008, 2011).

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[6] We did not estimate the co-benefits associated with reducing direct exposure to SO_2 and NOx.

[7] We do not have emission reduction information or air quality modeling available to estimate the air pollution health co-benefits in Alaska and Hawaii anticipated from implementation of the proposed guidelines.

We used a "benefit-per-ton" approach to estimate the health co-benefits. To create the benefit-per-ton estimates for $PM_{2.5}$, this approach uses an air quality model to convert emissions of $PM_{2.5}$ precursors (e.g., SO_2, NO_x) and directly emitted particles into changes in ambient $PM_{2.5}$ concentrations and BenMAP to estimate the changes in human health associated with that change in air quality. We then divide these health impacts by the emissions in specific sectors at the regional level (i.e., East, West, and California). We followed a similar process to estimate benefit-per-ton estimates for the ozone precursor NO_x. To calculate the co-benefits for the proposed guidelines, we then multiplied the regional benefit-per-ton estimates for the EGU sector by the corresponding emission reductions. All benefit-per-ton estimates reflect the geographic distribution of the modeled emissions, which may not exactly match the emission reductions in this rulemaking, and thus they may not reflect the local variability in population density, meteorology, exposure, baseline health incidence rates, or other local factors for any specific location.

Our estimate of the monetized co-benefits is based on the EPA's interpretation of the best available scientific literature (U.S. EPA, 2009) and methods and supported by the EPA's Science Advisory Board and the NAS (NRC, 2002). Below are key assumptions underlying the estimates for $PM_{2.5}$-related premature mortality, which accounts for 98 percent of the monetized $PM_{2.5}$ health co-benefits:

1. We assume that all fine particles, regardless of their chemical composition, are equally potent in causing premature mortality. This is an important assumption, because $PM_{2.5}$ varies considerably in composition across sources, but the scientific evidence is not yet sufficient to allow differentiation of effect estimates by particle type. The PM ISA concluded that "many constituents of $PM_{2.5}$ can be linked with multiple health effects, and the evidence is not yet sufficient to allow differentiation of those constituents or sources that are more closely related to specific outcomes" (U.S. EPA, 2009b).

2. We assume that the health impact function for fine particles is log-linear without a threshold in this analysis. Thus, the estimates include health co-benefits from reducing fine particles in areas with varied concentrations of $PM_{2.5}$, including both

areas that do not meet the fine particle standard and those areas that are in attainment, down to the lowest modeled concentrations.

3. We assume that there is a "cessation" lag between the change in PM exposures and the total realization of changes in mortality effects. Specifically, we assume that some of the incidences of premature mortality related to $PM_{2.5}$ exposures occur in a distributed fashion over the 20 years following exposure based on the advice of the SAB-HES (U.S. EPA-SAB, 2004c), which affects the valuation of mortality co-benefits at different discount rates.

Every benefits analysis examining the potential effects of a change in environmental protection requirements is limited, to some extent, by data gaps, model capabilities (such as geographic coverage) and uncertainties in the underlying scientific and economic studies used to configure the benefit and cost models. Despite these uncertainties, we believe this analysis provides a reasonable indication of the expected health co-benefits of the air pollution emission reductions for the illustrative compliance options for the proposed standards under a set of reasonable assumptions. This analysis does not include the type of detailed uncertainty assessment found in the 2012 $PM_{2.5}$ National Ambient Air Quality Standard (NAAQS) RIA (U.S. EPA, 2012) because we lack the necessary air quality input and monitoring data to conduct a complete benefits assessment. In addition, using a benefit-per-ton approach adds another important source of uncertainty to the benefits estimates.

ES 5.3 Combined Benefits Estimates

The EPA has evaluated the range of potential impacts by combining all four SCC values with health co-benefits values at the 3 percent and 7 percent discount rates. Different discount rates are applied to SCC than to the health co-benefit estimates; because CO_2 emissions are long-lived and subsequent damages occur over many years. Moreover, several discount rates are applied to SCC because the literature shows that the estimate of SCC is sensitive to assumptions about discount rate and because no consensus exists on the appropriate rate to use in an intergenerational context. The U.S. government centered its attention on the average SCC at a 3 percent discount rate but emphasized the importance of considering all four SCC estimates.

Tables ES-6 and ES-7 provide the combined climate benefits and health co-benefits for each option evaluated for 2020, 2025 and 2030 for Options 1 and 2, respectively for each discount rate combination.

Table ES-6. Combined Estimates of Climate Benefits and Health Co-Benefits for Proposed Existing EGU GHG Rule – Regional Compliance Approach (billions of 2011$)*

Option	SCC Discount Rate and Statistic**	Climate Benefits Only	Climate Benefits plus Health Co-Benefits (Discount Rate Applied to Health Co-Benefits) 3%			7%		
Option 1	In 2020	371	million metric tonnes CO_2					
	5%	$4.7	$21	to	$42	$19	to	$39
	3%	$17	$33	to	$54	$32	to	$51
	2.5%	$25	$41	to	$63	$40	to	$59
	3% (95th percentile)	$51	$67	to	$88	$65	to	$85
	In 2025	501	million metric tonnes CO_2					
	5%	$7.5	$30	to	$61	$28	to	$56
	3%	$25	$48	to	$78	$46	to	$74
	2.5%	$37	$60	to	$90	$57	to	$85
	3% (95th percentile)	$76	$99	to	$130	$97	to	$120
	In 2030	545	million metric tonnes CO_2					
	5%	$9.3	$35	to	$68	$32	to	$63
	3%	$30	$55	to	$89	$53	to	$84
	2.5%	$44	$69	to	$100	$66	to	$97
	3% (95th percentile)	$92	$120	to	$150	$120	to	$150
Option 2	In 2020	283	million metric tonnes CO_2					
	5%	$3.6	$17	to	$34	$16	to	$32
	3%	$13	$26	to	$44	$25	to	$41
	2.5%	$19	$33	to	$50	$31	to	$47
	3% (95th percentile)	$39	$52	to	$70	$51	to	$67
	In 2025	368	million metric tonnes CO_2					
	5%	$5.5	$23	to	$46	$21	to	$42
	3%	$18	$36	to	$59	$34	to	$55
	2.5%	$27	$44	to	$67	$43	to	$64
	3% (95th percentile)	$56	$73	to	$96	$72	to	$93

*All benefit estimates are rounded to two significant figures. Climate benefits are based on reductions in CO_2 emissions. Co-benefits are based on regional benefit-per-ton estimates. Ozone co-benefits occur in analysis year, so they are the same for all discount rates. The health co-benefits reflect the sum of the $PM_{2.5}$ and ozone co-benefits and reflect the range based on adult mortality functions (e.g., from Krewski et al. (2009) with Bell et al. (2004) to Lepeule et al. (2012) with Levy et al. (2005)). The monetized health co-benefits do not include reduced health effects from direct exposure to NO_2, SO_2, and HAP; ecosystem effects; or visibility impairment. See Chapter 4 for more information about these estimates and regarding the uncertainty in these estimates.

**Unless otherwise specified, it is the model average.

Table ES-7. Combined Estimates of Climate Benefits and Health Co-Benefits for Proposed Existing EGU GHG Rule – State Compliance Approach (billions of 2011$)*

Option	SCC Discount Rate and Statistic**	Climate Benefits Only	Climate Benefits plus Health Co-Benefits (Discount Rate Applied to Health Co-Benefits) 3%			7%		
Option 1	In 2020	383	million metric tonnes CO_2					
	5%	$4.9	$22	to	$45	$20	to	$41
	3%	$18	$35	to	$57	$33	to	$54
	2.5%	$26	$43	to	$66	$42	to	$62
	3% (95th percentile)	$52	$69	to	$92	$68	to	$88
	In 2025	506	million metric tonnes CO_2					
	5%	$7.6	$31	to	$62	$29	to	$57
	3%	$25	$49	to	$80	$46	to	$75
	2.5%	$37	$61	to	$92	$58	to	$87
	3% (95th percentile)	$77	$100	to	$130	$98	to	$130
	In 2030	555	million metric tonnes CO_2					
	5%	$9.5	$36	to	$72	$34	to	$66
	3%	$31	$57	to	$93	$55	to	$87
	2.5%	$44	$71	to	$110	$69	to	$100
	3% (95th percentile)	$94	$120	to	$160	$120	to	$150
Option 2	In 2020	295	million metric tonnes CO_2					
	5%	$3.8	$17	to	$35	$16	to	$32
	3%	$14	$27	to	$45	$26	to	$42
	2.5%	$20	$34	to	$52	$32	to	$49
	3% (95th percentile)	$40	$54	to	$72	$53	to	$69
	In 2025	376	million metric tonnes CO_2					
	5%	$5.6	$23	to	$47	$22	to	$43
	3%	$19	$36	to	$60	$35	to	$56
	2.5%	$28	$45	to	$69	$44	to	$65
	3% (95th percentile)	$57	$75	to	$98	$73	to	$95

*All benefit estimates are rounded to two significant figures. Climate benefits are based on reductions in CO_2 emissions. Co-benefits are based on regional benefit-per-ton estimates. Ozone co-benefits occur in analysis year, so they are the same for all discount rates. The health co-benefits reflect the sum of the $PM_{2.5}$ and ozone co-benefits and reflect the range based on adult mortality functions (e.g., from Krewski et al. (2009) with Bell et al. (2004) to Lepeule et al. (2012) with Levy et al. (2005)). The monetized health co-benefits do not include reduced health effects from direct exposure to NO_2, SO_2, and HAP; ecosystem effects; or visibility impairment. See Chapter 4 for more information about these estimates and regarding the uncertainty in these estimates.

**Unless otherwise specified, it is the model average.

ES.6 Monetized Benefits, Compliance Costs and Net Benefits of the Proposed Guidelines for Existing Sources

In this summary, the EPA provides the estimates of the climate benefits, health co-benefits, compliance costs and net benefits of the proposed Option 1 and alternative Option 2 assuming a regional compliance approach and an alternative state compliance approach. In Table

ES-8, the EPA estimates that in 2020 the proposed Option 1 regional compliance approach will yield monetized climate benefits of $17 billion using a 3 percent discount rate (model average, 2011$). The air pollution health co-benefits in 2020 are estimated to be $16 billion to $37 billion (2011$) for a 3 percent discount rate and $15 billion to $34 billion (2011$) for a 7 percent discount rate. The annual compliance costs, including monitoring and reporting costs, are approximately $5.5 billion (2011$) in 2020. The quantified net benefits (the difference between monetized benefits and costs) are $28 billion to $49 billion (2011$) for 2020 (Table ES-8 below) and $48 billion to $82 billion (2011$) for 2030 (Table ES-10 below), using a 3 percent discount rate (model average). For the Option 1 state compliance approach in 2020, the EPA estimates monetized climate benefits of approximately $18 billion using a 3 percent discount rate (model average). The air pollution health co-benefits in 2020 are estimated to be $17 billion to $40 billion for a 3 percent discount rate and $15 billion to $36 billion (2011$) for a 7 percent discount rate. The annual compliance costs including monitoring and reporting costs, are approximately $7.5 billion (2011$) in 2020. The quantified net benefits (the difference between monetized benefits and costs) are $27 billion to $50 billion for 2020 (Table ES-8 below) and $49 billion to $84 billion (2011$) for 2030 (Table ES-10 below). Benefit and cost estimates for Option 1 regional and state compliance approaches for 2020, 2025, and 2030 and are presented in Tables ES-8, ES-9, and ES-10, and similar estimates for Option 2 regional and state compliance approaches are presented in Tables ES-8 and ES-9 for 2020 and 2025.

The EPA could not monetize some important benefits of the guidelines. Unquantified benefits include climate benefits from reducing emissions of non-CO_2 greenhouse gases and co-benefits from reducing exposure to SO_2, NO_x, and hazardous air pollutants (e.g., mercury and hydrogen chloride), as well as ecosystem effects and visibility impairment. Upon considering these limitations and uncertainties, it remains clear that the benefits of this proposal are substantial and far outweigh the costs.

Table ES-8. Summary of Estimated Monetized Benefits, Compliance Costs, and Net Benefits for the Proposed Guidelines – 2020 (billions of 2011$) [a]

	Option 1 - state		Option 2 – state	
	3% Discount Rate	7% Discount Rate	3% Discount Rate	7% Discount Rate
Climate Benefits [b]				
5% discount rate	$4.9		$3.8	
3% discount rate	$18		$14	
2.5% discount rate	$26		$20	
95th percentile at 3% discount rate	$52		$40	
Air pollution health co-benefits [c]	$17 to $40	$15 to $36	$14 to $32	$12 to $29
Total Compliance Costs [d]	$7.5		$5.5	
Net Benefits [e]	$27 to $50	$26 to $46	$22 to $40	$20 to $37
Non-Monetized Benefits	Direct exposure to SO_2 and NO_2 1.5 tons of Hg Ecosystem Effects Visibility impairment		Direct exposure to SO_2 and NO_2 1.2 tons of Hg Ecosystem Effects Visibility impairment	
	Option 1 - regional		Option 2 – regional	
	3% Discount Rate	7% Discount Rate	3% Discount Rate	7% Discount Rate
Climate Benefits [b]				
5% discount rate	$4.7		$3.6	
3% discount rate	$17		$13	
2.5% discount rate	$25		$19	
95th percentile at 3% discount rate	$51		$39	
Air pollution health co-benefits [c]	$16 to $37	$15 to $34	$13 to $31	$12 to $28
Total Compliance Costs [d]	$5.5		$4.3	
Net Benefits [e]	$28 to $49	$26 to $45	$22 to $40	$21 to $37
Non-Monetized Benefits	Direct exposure to SO_2 and NO_2 1.3 tons of Hg Ecosystem effects Visibility impairment		Direct exposure to SO_2 and NO_2 0.9 tons of Hg Ecosystem effects Visibility impairment	

[a] All estimates are for 2020 and are rounded to two significant figures, so figures may not sum.

[b] The climate benefit estimates in this summary table reflect global impacts from CO_2 emission changes and do not account for changes in non-CO_2 GHG emissions. Also, different discount rates are applied to SCC than to the other estimates because CO_2 emissions are long-lived and subsequent damages occur over many years. The SCC estimates are year-specific and increase over time.

[c] The air pollution health co-benefits reflect reduced exposure to $PM_{2.5}$ and ozone associated with emission reductions of directly emitted $PM_{2.5}$, SO_2 and NO_X. The range reflects the use of concentration-response functions from different epidemiology studies. The reduction in premature fatalities each year accounts for over 90 percent of total monetized co-benefits from $PM_{2.5}$ and ozone. These models assume that all fine particles, regardless of their chemical composition, are equally potent in causing premature mortality because the scientific evidence is not yet sufficient to allow differentiation of effect estimates by particle type.

[d] Total social costs are approximated by the illustrative compliance costs which, in part, are estimated using the Integrated Planning Model for the proposed option and a discount rate of approximately 5%. This estimate also includes monitoring, recordkeeping, and reporting costs and demand side energy efficiency program and participant costs.

[e] The estimates of net benefits in this summary table are calculated using the global SCC at a 3 percent discount rate (model average). The RIA includes combined climate and health estimates based on these additional discount rates.

Table ES-9. Summary of Estimated Monetized Benefits, Compliance Costs, and Net Benefits for the Proposed Guidelines – 2025 (billions of 2011$) [a]

	Option 1 – state		Option 2 – state	
	3% Discount Rate	7% Discount Rate	3% Discount Rate	7% Discount Rate
Climate Benefits [b]				
5% discount rate	$7.6		$5.6	
3% discount rate	$25		$19	
2.5% discount rate	$37		$28	
95th percentile at 3% discount rate	$77		$57	
Air pollution health co-benefits [c]	$23 to $54	$21 to $49	$18 to $41	$16 to $37
Total Compliance Costs [d]	$5.5		$5.5	
Net Benefits [e]	$43to $74	$41 to $69	$31 to $55	$29 to $51
Non-Monetized Benefits	Direct exposure to SO_2 and NO_2 2.0 tons of Hg Ecosystem Effects Visibility impairment		Direct exposure to SO_2 and NO_2 1.7 tons of Hg Ecosystem Effects Visibility impairment	
	Option 1 – regional		Option 2 – regional	
	3% Discount Rate	7% Discount Rate	3% Discount Rate	7% Discount Rate
Climate Benefits [b]				
5% discount rate	$7.5		$5.5	
3% discount rate	$25		$18	
2.5% discount rate	$37		$27	
95th percentile at 3% discount rate	$76		$56	
Air pollution health co-benefits [c]	$23 to $53	$21 to $48	$17 to $40	$16 to $36
Total Compliance Costs [d]	$4.6		$4.5	
Net Benefits [e]	$43 to $74	$41 to $69	$31 to $54	$29 to $50
Non-Monetized Benefits	Direct exposure to SO_2 and NO_2 1.7 tons of Hg Ecosystem effects Visibility impairment		Direct exposure to SO_2 and NO_2 1.3 tons of Hg Ecosystem effects Visibility impairment	

[a] All estimates are for 2025 and are rounded to two significant figures, so figures may not sum.

[b] The climate benefit estimates in this summary table reflect global impacts from CO_2 emission changes and do not account for changes in non-CO_2 GHG emissions. Also, different discount rates are applied to SCC than to the other estimates because CO_2 emissions are long-lived and subsequent damages occur over many years. The SCC estimates are year-specific and increase over time.

[c] The air pollution health co-benefits reflect reduced exposure to $PM_{2.5}$ and ozone associated with emission reductions of directly emitted $PM_{2.5}$, SO_2 and NO_X. The range reflects the use of concentration-response functions from different epidemiology studies. The reduction in premature fatalities each year accounts for over 90 percent of total monetized co-benefits from $PM_{2.5}$ and ozone. These models assume that all fine particles, regardless of their chemical composition, are equally potent in causing premature mortality because the scientific evidence is not yet sufficient to allow differentiation of effect estimates by particle type.

[d] Total social costs are approximated by the illustrative compliance costs which, in part, are estimated using the Integrated Planning Model for the proposed option and a discount rate of approximately 5%. This estimate also includes monitoring, recordkeeping, and reporting costs and demand side energy efficiency program and participant costs.

[e] The estimates of net benefits in this summary table are calculated using the global SCC at a 3 percent discount rate (model average). The RIA includes combined climate and health estimates based on these additional discount rates.

Table ES-10. Summary of Estimated Monetized Benefits, Compliance Costs, and Net Benefits for the Proposed Guidelines –2030 (billions of 2011$) [a]

	Option 1– state	
	3% Discount Rate	7% Discount Rate
Climate Benefits [b]		
5% discount rate	$9.5	
3% discount rate	$31	
2.5% discount rate	$44	
95th percentile at 3% discount rate	$94	
Air pollution health co-benefits [c]	$27 to $62	$24 to $56
Total Compliance Costs [d]	$8.8	
Net Benefits [e]	$49 to $84	$46 to $79
Non-Monetized Benefits	Direct exposure to SO_2 and NO_2 2.1 tons of Hg and 590 tons of HCl Ecosystem effects Visibility impairment	
	Option 1– regional	
	3% Discount Rate	7% Discount Rate
Climate Benefits [b]		
5% discount rate	$9.3	
3% discount rate	$30	
2.5% discount rate	$44	
95th percentile at 3% discount rate	$92	
Air pollution health co-benefits [c]	$25 to $59	$23 to $54
Total Compliance Costs [d]	$7.3	
Net Benefits [e]	$48 to $82	$46 to $77
Non-Monetized Benefits	Direct exposure to SO_2 and NO_2 1.7 tons of Hg and 580 tons of HCl Ecosystem effects Visibility impairment	

[a] All estimates are for 2030, and are rounded to two significant figures, so figures may not sum.

[b] The climate benefit estimates in this summary table reflect global impacts from CO_2 emission changes and do not account for changes in non-CO_2 GHG emissions. Also, different discount rates are applied to SCC than to the other estimates because CO_2 emissions are long-lived and subsequent damages occur over many years. The SCC estimates are year-specific and increase over time.

[c] The air pollution health co-benefits reflect reduced exposure to $PM_{2.5}$ and ozone associated with emission reductions of directly emitted $PM_{2.5}$, SO_2 and NO_X. The range reflects the use of concentration-response functions from different epidemiology studies. The reduction in premature fatalities each year accounts for over 90 percent of total monetized co-benefits from $PM_{2.5}$ and ozone. These models assume that all fine particles, regardless of their chemical composition, are equally potent in causing premature mortality because the scientific evidence is not yet sufficient to allow differentiation of effect estimates by particle type.

[d] Total social costs are approximated by the illustrative compliance costs which, in part, are estimated using the Integrated Planning Model for the proposed option and a discount rate of approximately 5%. This estimate also includes monitoring, recordkeeping, and reporting costs and demand side energy efficiency program and participant costs.

[e] The estimates of net benefits in this summary table are calculated using the global SCC at a 3 percent discount rate (model average). The RIA includes combined climate and health estimates based on these additional discount rates.

ES.7 Economic Impacts of the Proposed Emission Guidelines for Existing EGUs

The proposed guidelines have important energy market implications. Under Option 1, average nationwide retail electricity prices are projected to increase roughly 6 to 7 percent in 2020, and roughly 3 percent in 2030 (contiguous U.S.), compared to base case price estimates modeled for these same years. Average monthly electricity bills are anticipated to increase by roughly 3 percent in 2020, but decline by roughly 9 percent by 2030 because increased energy efficiency will lead to reduced usage.

The average delivered coal price to the power sector is projected to decrease by 16 to 17 percent in 2020 and roughly 18 percent in 2030, relative to the base case (Option 1). The EPA projects coal production for use by the power sector, a large component of total coal production, will decline by roughly 25 to 27 percent in 2020 from base case levels. The use of coal by the power sector will decrease by roughly 30 to 32 percent in 2030.

The EPA also projects that the electric power sector-delivered natural gas prices will increase by 9 to 12 percent in 2020, with negligible changes by 2030 relative to the base case. Natural gas use for electricity generation will increase by as much as 1.2 trillion cubic feet (TCF) in 2020 relative to the base case, declining over time.

Renewable energy capacity is anticipated to increase by roughly 12 GW in 2020 and by 9 GW in 2030 under Option 1. Energy market impacts from the guidelines are discussed more extensively in Chapter 3 of this RIA.

ES.8 Economic Impacts of the Proposed Guidelines for Existing EGUs for Sectors Other Than the EGU Sector and for Employment

Changes in supply or demand for electricity, natural gas, and coal can impact markets for goods and services produced by sectors that use these energy inputs in the production process or that supply those sectors. Changes in cost of production may result in changes in price and/or quantity produced and these market changes may affect the profitability of firms and the economic welfare of their consumers. The EPA recognizes that these guidelines provide significant flexibilities and states implementing the guidelines may choose to mitigate impacts to some markets outside the EGU sector. Similarly, demand for new generation or energy efficiency can result in changes in production and profitability for firms that supply those goods and services. The guidelines provide flexibility for states that may want to enhance demand for goods and services from those sectors.

Executive Order 13563 directs federal agencies to consider the effect of regulations on job creation and employment. According to the Executive Order, "our regulatory system must protect public health, welfare, safety, and our environment while promoting economic growth, innovation, competitiveness, and job creation. It must be based on the best available science" (Executive Order 13563, 2011). Although standard benefit-cost analyses have not typically included a separate analysis of regulation-induced employment impacts, during periods of sustained high unemployment, employment impacts are of particular concern and questions may arise about their existence and magnitude.

States have the responsibility and flexibility to implement policies and practices for compliance with Proposed Electric Generating Unit Greenhouse Gas Existing Source Guidelines. Given the wide range of approaches that may be used, quantifying the associated employment impacts is difficult. The EPA's illustrative employment analysis includes an estimate of projected employment impacts associated with these guidelines for the electric power industry, coal and natural gas production, and demand side energy efficiency activities. These projections are derived, in part, from a detailed model of the electricity production sector used for this regulatory analysis, and U.S government data on employment and labor productivity. In the electricity, coal, and natural gas sectors, the EPA estimates that these guidelines could result in an increase of approximately 28,000 to 25,900 job-years in 2020 for Option 1, state and regional compliance approaches, respectively. For Option 2, the state and regional compliance approach estimates reflect an increase of approximately 29,800 to 26,700 job-years in 2020. The Agency is also offering an illustrative calculation of potential employment effects due to demand-side energy efficiency programs. Employment impacts in 2020 could be an increase of approximately 78,800 jobs for Option 1 (for both the state and regional compliance approaches). For Option 2 demand-side energy efficiency employment impacts in 2020 could be an increase of approximately 57,000 jobs (for both the state and regional compliance approaches). More detail about these analyses can be found in Chapter 6 of this RIA.

ES.9 Modified and Reconstructed Sources

The EPA is proposing emission limits for CO_2 emitted from reconstructed and modified EGUs under section 111(b) of the CAA. Based on historical information that has been reported to the EPA, the EPA anticipates few, if any, covered units will trigger the reconstruction or modification provisions in the period of analysis (through 2025). As a result, we do not anticipate any significant costs or benefits associated with this proposal. However, because there have been a few units that have notified the EPA of modifications in the past, in Chapter 9 of this RIA we present an illustrative analysis of the costs and benefits for a hypothetical unit if it were to trigger the modification provision.

ES.10 References

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CHAPTER 6: EMPLOYMENT IMPACT ANALYSIS

6.1 Introduction

Executive Order 13563 directs federal agencies to consider regulatory impacts on job creation and employment. According to the Executive Order, "our regulatory system must protect public health, welfare, safety, and our environment while promoting economic growth, innovation, competitiveness, and job creation. It must be based on the best available science" (Executive Order 13563, 2011). Although standard benefit-cost analyses have not typically included a separate analysis of regulation-induced employment impacts,[124] during periods of sustained high unemployment, employment impacts are of particular concern and questions may arise about their existence and magnitude. The chapter discusses and projects potential employment impacts of the Proposed Electric Generating Unit Greenhouse Gas (EGU GHG) Existing Source Guidelines for the electric power industry, coal and natural gas production, and demand-side energy efficiency.

Section 6.2 presents the overview of the guidelines and a general description of the associated building block framework. Section 6.3 describes the theoretical framework used to analyze regulation-induced employment impacts, discussing how economic theory alone cannot predict whether such impacts are positive or negative. Section 6.4 presents an overview of the peer-reviewed literature relevant to evaluating the effect of environmental regulation on employment. Section 6.5 provides background regarding recent employment trends in the electricity generation, coal and natural gas extraction, renewable energy, and demand-side energy efficiency-related sectors. Section 6.6 presents the EPA's quantitative projections of potential employment impacts in these sectors. These projections are based in part on a detailed model of the electricity production sectors used for this regulatory analysis. Additionally, this section discusses projected employment impacts due to demand-side energy efficiency activities. Section 6.7 offers several conclusions.

[124] Labor expenses do, however, contribute toward total costs in the EPA's standard benefit-cost analyses.

6.2 Overview of the Proposed EGU GHG Existing Source Guidelines

The EPA is proposing emission guidelines for states to use in developing plans to address greenhouse gas emissions from existing fossil fuel-fired EGUs. Specifically, EPA is proposing state-specific rate-based goals for carbon dioxide (CO_2) emissions from the power sector, as well as emission guidelines for states to use in developing plans to attain the state-specific goals. The guidelines, as proposed, will lower carbon intensity of power generation in the United States. Under the Clean Air Act (CAA) section 111(d), state plans must establish standards of performance that reflect the degree of emission limitation achievable through the application of the "best system of emission reduction" (BSER) that, taking into account the cost of achieving such reductions and non-air quality health and environmental impact and energy requirements, the Administrator determines has been adequately demonstrated. Consistent with CAA section 111(d), this proposed rule contains state-specific goals that reflect the EPA's calculation of emission reductions that a state can achieve through the cost-effective application of BSER. The EPA is using four building blocks as a basis to determine state-specific goals.

6.2.1 Determining State Goals Utilizing the Four Building Blocks

In proposing state goals, EPA is applying the following four building blocks. Each represents a demonstrated approach to improving the GHG performance of existing EGUs in the power sector:[125]

1. Reducing the carbon intensity of generation at individual affected EGUs through heat rate improvements.
2. Reducing emissions from the most carbon-intensive affected EGUs in the amount that results from substituting generation at those EGUs with generation from less carbon-intensive affected EGUs (including natural gas combined cycle [NGCC] units under construction).

[125] Refer to Chapter 3 for information regarding estimates of emissions reductions achievable by each building block and the determination of state-specific goals.

3. Reducing emissions from affected EGUs in the amount that results from substituting generation at those EGUs with expanded low- or zero-carbon generation.
4. Reducing emissions from affected EGUs in the amount that results from the use of demand-side energy efficiency that reduces the amount of generation required.

6.3 Economic Theory and Employment

Regulatory employment impacts are difficult to disentangle from other economic changes affecting employment decisions over time and across regions and industries. Labor market responses to regulation are complex. They depend on labor demand and supply elasticities and possible labor market imperfections (e.g., wage stickiness, long-term unemployment, etc). The unit of measurement (e.g., number of jobs, types of job hours worked, and earnings) may affect observability of that response. Net employment impacts are composed of a mix of potential declines and gains in different areas of the economy (e.g., the directly regulated sector, upstream and downstream sectors, etc.) over time. In light of these difficulties, economic theory provides a constructive framework for analysis.

Microeconomic theory describes how firms adjust their use of inputs in response to changes in economic conditions.[126] Labor is one of many inputs to production, along with capital, energy, and materials. In competitive markets, firms choose inputs and outputs to maximize profit as a function of market prices and technological constraints.[127,128]

Berman and Bui (2001) and Morgenstern, Pizer, and Shih (2002) adapt this model to analyze how environmental regulations affect labor demand.[129] They model environmental regulation as effectively requiring certain factors of production, such as pollution abatement capital, at levels that firms would not otherwise choose.

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[126] See Layard and Walters (1978), a standard microeconomic theory textbook, for a discussion, in Chapter 9.

[127] See Hamermesh (1993), Ch. 2, for a derivation of the firm's labor demand function from cost-minimization.

[128] In this framework, labor demand is a function of quantity of output and prices (of both outputs and inputs).

[129] Berman and Bui (2001) and Morgenstern, Pizer, and Shih (2002) use a cost-minimization framework, which is a special case of profit-maximization with fixed output quantities.

Berman and Bui (2001, pp. 274-75) model two components that drive changes in firm-level labor demand: output effects and substitution effects.[130] Regulation affects the profit-maximizing quantity of output by changing the marginal cost of production. If regulation causes marginal cost to increase, it will place upward pressure on output prices, leading to a decrease in demand, and resulting in a decrease in production. The output effect describes how, holding labor intensity constant, a decrease in production causes a decrease in labor demand. As noted by Berman and Bui, although many assume that regulation increases marginal cost, it need not be the case. A regulation could induce a firm to upgrade to less polluting and more efficient equipment that lowers marginal production costs. In such a case, output could increase. For example, in the context of the current rule, improving the heat rate of utility boiler increases fuel efficiency, lowering marginal production costs, and thereby potentially increasing the boiler's generation. An unregulated profit-maximizing firm may not have chosen to install such an efficiency-improving technology if the investment cost were too high.

The substitution effect describes how, holding output constant, regulation affects labor-intensity of production. Although increased environmental regulation may increase use of pollution control equipment and energy to operate that equipment, the impact on labor demand is ambiguous. For example, equipment inspection requirements, specialized waste handling, or pollution technologies that alter the production process may affect the number of workers necessary to produce a unit of output. Berman and Bui (2001) model the substitution effect as the effect of regulation on pollution control equipment and expenditures required by the regulation and the corresponding change in labor-intensity of production.

In summary, as output and substitution effects may be positive or negative, theory alone cannot predict the direction of the net effect of regulation on labor demand at the level of the regulated firm. Operating within the bounds of standard economic theory, however, empirical estimation of net employment effects on regulated firms is possible when data and methods of sufficient detail and quality are available. The literature, however, illustrates difficulties with

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[130] The authors also discuss a third component, the impact of regulation on factor prices, but conclude that this effect is unlikely to be important for large competitive factor markets, such as labor and capital. Morgenstern, Pizer and Shih (2002) use a very similar model, but they break the employment effect into three parts: 1) a demand effect; 2) a cost effect; and 3) a factor-shift effect.

empirical estimation. For example, studies sometimes rely on confidential plant-level employment data from the U.S. Census Bureau, possibly combined with pollution abatement expenditure data that are too dated to be reliably informative. In addition, the most commonly used empirical methods do not permit estimation of net effects.

The conceptual framework described thus far focused on regulatory effects on plant-level decisions within a regulated industry. Employment impacts at an individual plant do not necessarily represent impacts for the sector as a whole. The approach must be modified when applied at the industry level.

At the industry-level, labor demand is more responsive if: (1) the price elasticity of demand for the product is high, (2) other factors of production can be easily substituted for labor, (3) the supply of other factors is highly elastic, or (4) labor costs are a large share of total production costs.[131] For example, if all firms in an industry are faced with the same regulatory compliance costs and product demand is inelastic, then industry output may not change much, and output of individual firms may change slightly.[132] In this case, the output effect may be small, while the substitution effect depends on input substitutability. Suppose, for example, that new equipment for heat rate improvements requires labor to install and operate. In this case, the substitution effect may be positive, and with a small output effect, the total effect may be positive. As with potential effects for an individual firm, theory cannot determine the sign or magnitude of industry-level regulatory effects on labor demand. Determining these signs and magnitudes requires additional sector-specific empirical study. For environmental rules, much of the data needed for these empirical studies is not publicly available, would require significant time and resources in order to access confidential U.S. Census data for research, and also would not be necessary for other components of a typical Regulatory Impact Analysis (RIA).

In addition to changes to labor demand in the regulated industry, net employment impacts encompass changes in other related sectors. For example, the proposed guidelines may increase demand for heat rate improving equipment and services. This increased demand may increase

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[131] See Ehrenberg & Smith, p. 108.

[132] This discussion draws from Berman and Bui (2001), pp. 293.

revenue and employment in the firms supporting this technology. At the same time, the regulated industry is purchasing the equipment, and these costs may impact labor demand at regulated firms. Therefore, it is important to consider the net effect of compliance actions on employment across multiple sectors or industries.

If the U.S. economy is at full employment, even a large-scale environmental regulation is unlikely to have a noticeable impact on aggregate net employment.[133] Instead, labor would primarily be reallocated from one productive use to another (e.g., from producing electricity or steel to producing high efficiency equipment), and net national employment effects from environmental regulation would be small and transitory (e.g., as workers move from one job to another).[134]

Affected sectors may experience transitory effects as workers change jobs. Some workers may retrain or relocate in anticipation of new requirements or require time to search for new jobs, while shortages in some sectors or regions could bid up wages to attract workers. These adjustment costs can lead to local labor disruptions. Although the net change in the national workforce is expected to be small, localized reductions in employment may adversely impact individuals and communities just as localized increases may have positive impacts.

If the economy is operating at less than full employment, economic theory does not clearly indicate the direction or magnitude of the net impact of environmental regulation on employment; it could cause either a short-run net increase or short-run net decrease (Schmalansee and Stavins, 2011). An important research question is how to accommodate unemployment as a structural feature in economic models. This feature may be important in assessing large-scale regulatory impacts on employment (Smith, 2012).

Environmental regulation may also affect labor supply. In particular, pollution and other environmental risks may impact labor productivity or employees' ability to work.[135] While the

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[133] Full employment is a conceptual target for the economy where everyone who wants to work and is available to do so at prevailing wages is actively employed. The unemployment rate at full employment is not zero.

[134] Arrow et al. 1996; see discussion on bottom of p. 8. In practice, distributional impacts on individual workers can be important, as discussed in later paragraphs of this section.

[135] E.g. Graff Zivin and Neidell (2012).

theoretical framework for analyzing labor supply effects is analogous to that for labor demand, it is more difficult to study empirically. There is a small emerging literature described in the next section that uses detailed labor and environmental data to assess these impacts.

To summarize, economic theory provides a framework for analyzing the impacts of environmental regulation on employment. The net employment effect incorporates expected employment changes (both positive and negative) in the regulated sector and elsewhere. Labor demand impacts for regulated firms, and also for the regulated industry, can be decomposed into output and substitution effects which may be either negative or positive. Estimation of net employment effects for regulated sectors is possible when data of sufficient detail and quality are available. Finally, economic theory suggests that labor supply effects are also possible. In the next section, we discuss the empirical literature.

6.4 Current State of Knowledge Based on the Peer-Reviewed Literature

The labor economics literature contains an extensive body of peer-reviewed empirical work analyzing various aspects of labor demand, relying on the theoretical framework discussed in the preceding section.[136] This work focuses primarily on effects of employment policies such as labor taxes and minimum wages.[137] In contrast, the peer-reviewed empirical literature specifically estimating employment effects of environmental regulations is more limited.

Empirical studies, such as Berman and Bui (2001), suggest that net employment impacts were not statistically different from zero in the regulated sector. Other research suggests that more highly regulated counties may generate fewer jobs than less regulated ones (Greenstone, 2002). Environmental regulations may affect sectors that support pollution reduction earlier than the regulated industry. Rules are usually announced well in advance of their effective dates and then typically provide a period of time for firms to invest in technologies and process changes to meet the new requirements. When a regulation is promulgated, the initial response of firms is often to order pollution control equipment and services to enable compliance when the regulation

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[136] Again, see Hamermesh (1993) for a detailed treatment.

[137] See Ehrenberg & Smith (2000), Chapter 4: "Employment Effects: Empirical Estimates" for a concise overview.

becomes effective. Estimates of short-term increases in demand for specialized labor within the environmental protection sector have been prepared for several EPA regulations in the past, including the Mercury and Air Toxics Standards (MATS).[138] Overall, the peer-reviewed literature does not contain evidence that environmental regulation has a large impact on net employment (either negative or positive) in the long run across the whole economy.

6.4.1 Regulated Sector

Berman and Bui (2001) examine how an increase in local air quality regulation affects manufacturing employment in the South Coast Air Quality Management District (SCAQMD), which includes Los Angeles and its suburbs. From 1979 to 1992, the SCAQMD enacted some of the country's most stringent air quality regulations. Using SCAQMD's local air quality regulations, Berman and Bui identify the effect of environmental regulations on net employment in regulated manufacturing industries relative to other plants in the same 4-digit standard industrial classification (SIC) industries but in regions not subject to local regulations.[139] The authors find that "while regulations do impose large costs, they have a limited effect on employment" (Berman and Bui, 2001, p. 269). Their conclusion is that local air quality regulation "probably increased labor demand slightly" but that "the employment effects of both compliance and increased stringency are fairly precisely estimated zeros, even when exit and dissuaded entry effects are included" (Berman and Bui, 2001, p. 269).[140]

The few studies in peer-reviewed journals evaluating employment impacts of policies that reduce CO_2 emissions in the electric power generation sector are in the European context. In a sample of 419 German firms, 13 percent of which were in the electricity sector, Anger and Oberndorfer (2008) find that the initial allocation of emission permits did not significantly affect employment growth in the first year of the Eurpoean Union (EU) Emissions Trading Scheme (ETS). Examining European firms from 1996-2007, Commins et al. (2011) find that a 1 percent

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[138] U.S. EPA (2011b).

[139] Berman and Bui include over 40 4-digit SIC industries in their sample. They do not estimate the number of jobs created in the environmental protection sector.

[140] Including the employment effect of existing plants and plants dissuaded from opening will increase the estimated impact of regulation on employment.

increase in energy taxes is associated with a 0.01 percent decrease in employees in the electricity and gas sector. Chan et al. (2013) estimate the impact of the EU ETS on a panel of almost 6,000 firms in 10 European countries from 2005-2009. They find that firms in the power sector that participated in the ETS had 2-3 percent fewer employees relative to those that did not participate, but this effect is not statistically significant.

This literature suggests that the employment impacts of controlling CO_2 emissions in the European power sector were small. The degree to which these studies' results apply to the U.S. context is unclear. European policies analyzed in these studies effectively put a price on emissions either through taxes or tradable permits. A performance standard may not generate similar employment effects. Moreover, European firms face relative fuel prices and market regulatory structures different from their U.S. counterparts, further complicating attempts to transfer quantitative results from the EU experience to evaluate this rule.

A small literature examines impacts of environmental regulations on manufacturing employment. Kahn and Mansur (2013) study environmental regulatory impacts on geographic distribution of manufacturing employment, controlling for electricity prices and labor regulation (right to work laws). Their methodology identifies employment impacts by focusing on neighboring counties with different air quality regulations. They find limited evidence that environmental regulations may cause employment to be lower within "county-border-pairs." This result suggests that regulation may cause an effective relocation of labor across a county border, but since one county's loss is another's gain, such shifts cannot be transformed into an estimate of a national net effect on employment. Moreover this result is sensitive to model specification choices.

6.4.2 Labor Supply Impacts

The empirical literature on environmental regulatory employment impacts focuses primarily on labor demand. However, there is a nascent literature focusing on regulation-induced effects on labor supply.[141] Although this literature is limited by empirical challenges, researchers

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[141] For a recent review see Graff-Zivin and Neidell (2013).

have found that air quality improvements lead to reductions in lost work days (e.g., Ostro, 1987). Limited evidence suggests worker productivity may also improve when pollution is reduced. Graff Zivin and Neidell (2012) used detailed worker-level productivity data from 2009 and 2010, paired with local ozone air quality monitoring data for one large California farm growing multiple crops, with a piece-rate payment structure. Their quasi-experimental structure identifies an effect of daily variation in monitored ozone levels on productivity. They find "ozone levels well below federal air quality standards have a significant impact on productivity: a 10 parts per billion (ppb) decreases in ozone concentrations increases worker productivity by 5.5 percent." (Graff Zivin and Neidell, 2012, p. 3654).[142]

This section has outlined the challenges associated with estimating regulatory effects on both labor demand and supply for specific sectors. These challenges make it difficult to estimate net national employment estimates that would appropriately capture the way in which costs, compliance spending, and environmental benefits propagate through the macro-economy. Quantitative estimates are further complicated by the fact that macroeconomic models often have little sectoral detail and usually assume that the economy is at full employment. The EPA is currently seeking input from an independent expert panel on modeling economy-wide regulatory impacts, including employment effects.[143]

6.5 Recent Employment Trends

The U.S. electricity system includes employees that support electric power generation, transmission and distribution; the extraction of fossil fuels; renewable energy generation; and supply-side and demand-side energy efficiency. This section describes recent employment trends in the electricity system.

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[142] The EPA is not quantifying productivity impacts of reduced pollution in this rulemaking using this study. In light of this recent research, however, the EPA is considering how best to incorporate possible productivity effects in the future.

[143] For further information see: <https://www.federalregister.gov/articles/2014/02/05/2014-02471/draft-supporting-materials-for-the-science-advisory-board-panel-on-the-role-of-economy-wide-modeling>.

6.5.1 Electric Power Generation

In 2013, the electric power generation, transmission and distribution sector (NAICS 2211) employed 394,000 workers in the U.S.[144] Installation, maintenance, and repair occupations accounted for the largest share of workers (30 percent).[145] These categories include inspection, testing, repairing and maintaining of electrical equipment and/or installation and repair of cables used in electrical power and distribution systems. Other major occupation categories include office and administrative support (17 percent), production occupations (15 percent), architecture and engineering (11 percent), business and financial operations (7 percent) and management (6 percent).

As shown in Figure 6.1, employment in the Electric Power Industry averaged 435,000 workers in the early 2000s, declining to an average of 400,000 workers later in the decade, and to 394,000 workers in 2013.

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[144] U.S. Bureau of Labor Statistics. "Current Employment Survey Seasonally Adjusted Employment for Electric Power Generation, Transmission, and Distribution (national employment)." Series ID: CES4422110001. Data extracted on: February 19, 2014. Available at: <http://www.bls.gov/ces/data.htm>.

[145] U.S. Bureau of Labor Statistics, Occupational Employment Statistics, May 2012 National Industry-Specific Occupational Employment and Wage Estimates, Electric Power Generation, Transmission, and Distribution (NAICS 2211). Available at: <http://www.bls.gov/oes/current/naics4_221100.htm>.

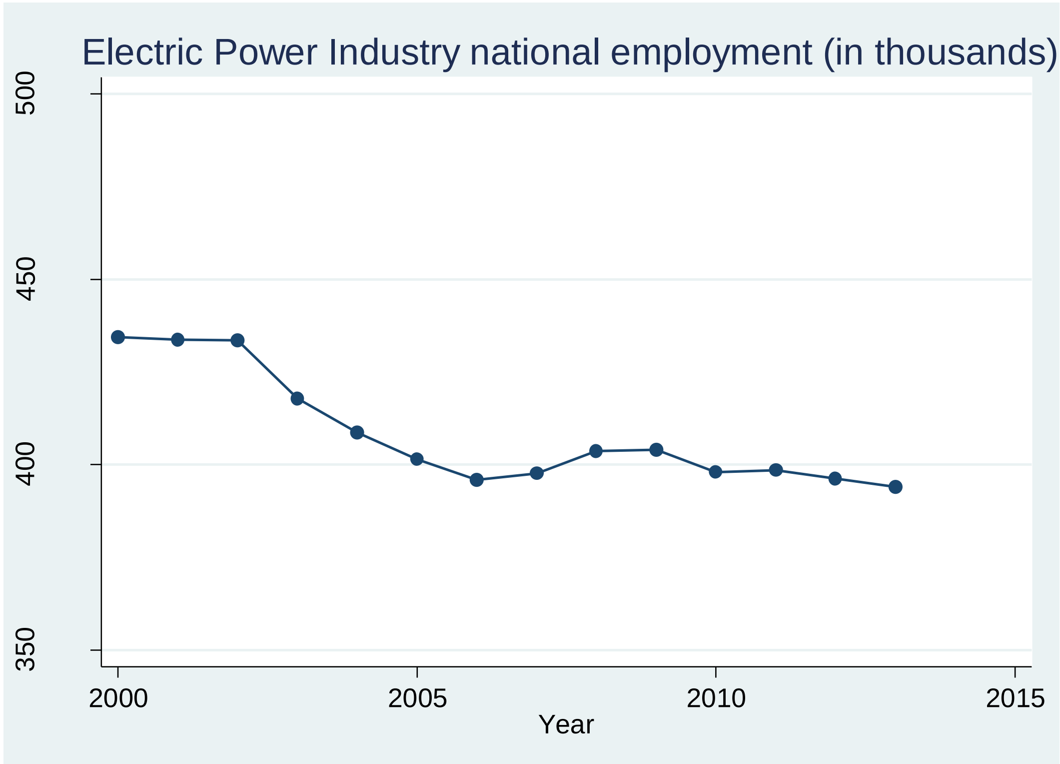

Figure 6.1. Electric Power Industry Employment

6.5.2 Fossil Fuel Extraction

6.5.2.1 Coal Extraction

The coal extraction sector is primarily engaged in coal mining and coal mine site development, excluding metal ore mining and nonmetallic mineral mining and quarrying. There are two sources of U.S. government data on coal mining employment, the Bureau of Labor Statistics (BLS) Current Employment Statistics (NAICS 2121), and the Department of Labor's Mine Safety and Health Administration (MSHA).[146] Both sources show similar national levels and trends, though one is survey-based (BLS) and the other is census-based (MSHA). MSHA tracks direct coal mine employment and independent contractor employment, whereas BLS does

[146] U.S. Bureau of Labor Statistics. "Current Employment Statistics Seasonally Adjusted Employment for Coal Mining (national employment)," NAICS 2121, Series ID: CES1021210001. Data extracted on: February 19, 2014. Available at: < http://www.bls.gov/ces/data.htm>.

not track contractors. Contractor employment reported by MSHA focuses primarily on mine development, construction, reconstruction or demolition of mine facilities, construction of dams, excavation or earth moving, equipment installation, service or repair, and material handling, drilling, or blasting.[147] In 2013, BLS reported 79,000 coal mining employees, and MSHA reported 80,000 coal mining employees and 32,000 contractors.[148] Both sets of data reveal a stable trend in employment over the past 10 years, with the exception of a small temporary increase in 2011. See Figure 6.2 below.

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[147] Mine Safety and Health Administration, CFR Part 50 Title 30 Employment Data – selected contract employment is included, p. 2. Available at: <http://www.msha.gov/Stats/Part50/WQ/MasterFiles/MIWQ%20Master_20133.pdf>. U.S. Bureau of Labor Statistics, Current Employment Statistics – contract employment not included. Available at: <http://www.bls.gov/ces/idcf/forme_sp.pdf>.

[148] Annual averages calculated for: (i) BLS monthly coal mining employment data for 2013, and (ii) MSHA Part 50 quarterly data for 2013. Available at: <http://www.msha.gov/STATS/PART50/P50Y2K/AETABLE.HTM>.

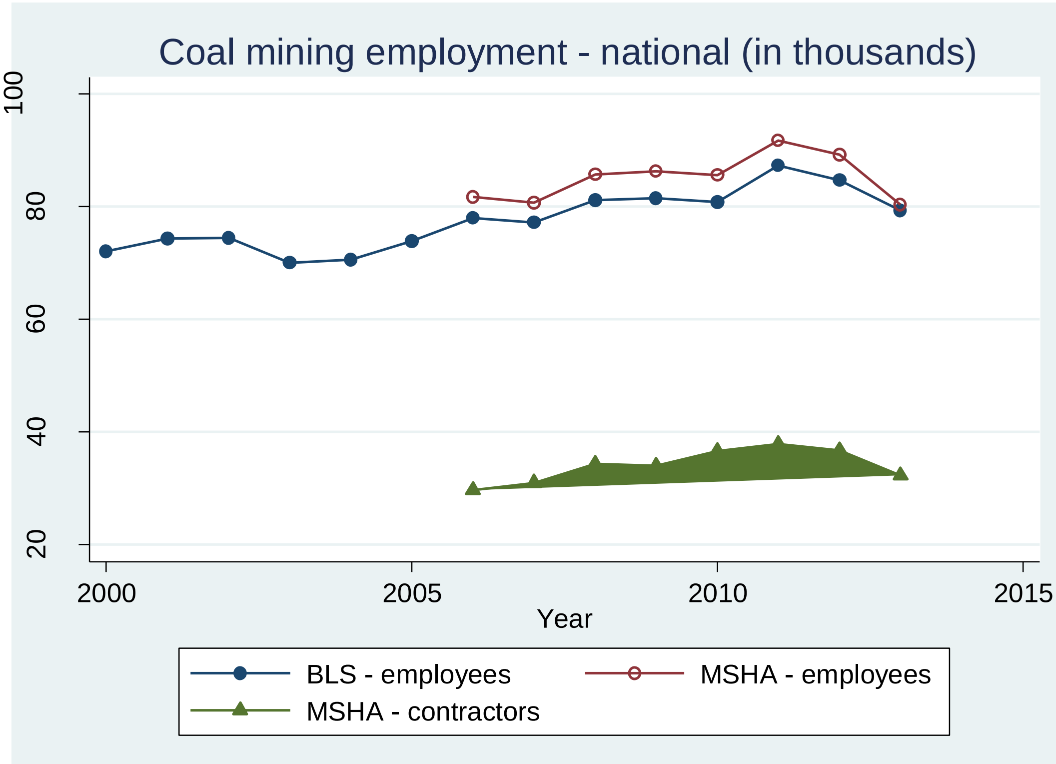

Figure 6.2. Coal Production Employment

6.5.2.2 Oil and Gas Extraction

In 2013, there were 198,000 employees in the oil and gas extraction sector (NAICS 211).[149] This sector includes production of crude petroleum, oil from oil shale and oil sands, production of natural gas, sulfur recovery from natural gas, and recovery of hydrocarbon liquids. Activities include the development of gas and oil fields, exploration activities for crude petroleum and natural gas, drilling, completing, and equipping wells, and other production activities.[150] In contrast with coal, and looking at Figure 6.3, there has been a sharp increase in employment in this sector over the past decade.

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[149] BLS, Current Employment Statistics. Seasonally adjusted employment for oil and gas extraction (national employment), NAICS 211. Series ID: CES1021100001. Data extracted on: February 19, 2014. Available at: <http://www.bls.gov/ces/data.htm

[150] U.S. Bureau of Labor Statistics. 20014. Available at: <http://www.bls.gov/iag/tgs/iag211.htm Accessed Feb. 19>.

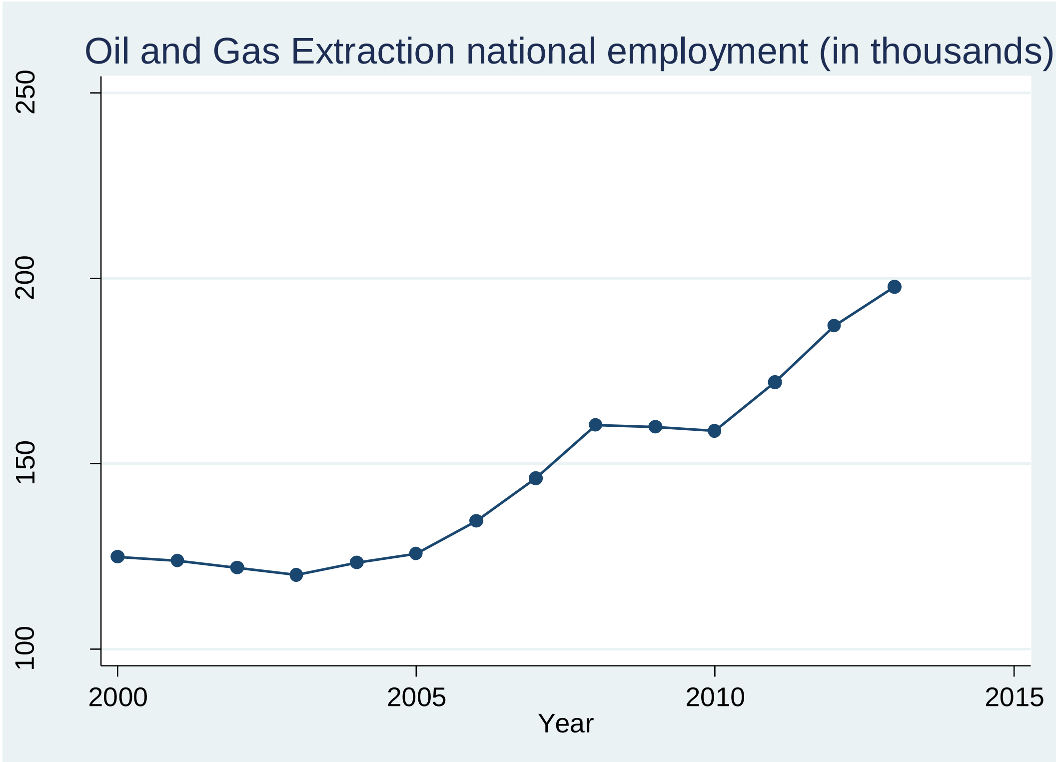

Figure 6.3. Oil and Gas Production Employment

6.5.3 Clean Energy Employment Trends

Clean energy resources, such as energy efficiency and renewable energy, are used to meet energy demand, reduce peak electricity system loads, and reduce reliance on the most carbon-intensive sources of electricity. However, there is not a single clean energy sector in standard national accounts classifications. Renewable generation is not reported to the BLS separately from other electric power generation. Similarly, manufacturers of energy efficient appliances are not reported separately from conventional appliance manufacturers and green building design is not separate from the construction sector. Instead, clean energy technology and services are supported by industries throughout the economy.

Without a specific industrial classification, it is difficult to quantify the exact number of clean energy-related jobs or document the trends. Employees engaged in clean energy can span many job classifications, such as experts required to design and produce a renewable or energy-efficient technology, workers that supply inputs and technicians who install service or operate equipment. As such, there are a variety of definitions of clean or green jobs used, some more expansive than others.

6.5.3.1 Defining Clean Energy Jobs

Two U.S. Government sources, the 2010 Department of Commerce (DOC) report, *Measuring the Green Economy* and the 2010 and 2011 BLS *Green Goods and Services* surveys have subdivided industrial classifications into “green” categories. In both cases the approach was to determine which product classifications, rather than industries, were green. They multiplied green production by product revenue and defined an industrial sector as green if it met a threshold of green revenue as a proportion of total revenue.

DOC broadly defined green jobs in 2010 as those “created and supported in businesses that produce green products and services.”[151] They further classified green jobs into a broad and a narrow category. The narrow category includes only products deemed to be green without disagreement, while the broad category is more inclusive definition of green goods and services to over 22,000 product codes in the 2007 Economic Census to estimate their contribution to the U.S. economy. The report found that the number of green jobs in 2007 ranged from 1.8 million to 2.4 million jobs, accounting for between 1.5 and 2 percent of total private sector employment.[152]

BLS used an expansive definition of clean or green jobs in 2010 and 2011. It goes beyond direct clean energy-related investments and includes “those in businesses that produce goods and provide services that benefit the environment or conserve natural resources. These goods and services, which are sold to customers, include research and development, installation, and maintenance services for renewable energy and energy efficiency and education and training related to green technologies and practices” but also include recycling and natural resource

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[151] U.S. Department of Commerce Economics and Statistics Administration. 2010. “Measuring the Green Economy,*”* April. Available at: <http://www.esa.doc.gov/sites/default/files/reports/documents/greeneconomyreport_0.pdf>.

[152] U.S. Department of Commerce Economics and Statistics Administration. 2010. “Measuring the Green Economy, April. Available at: <http://www.esa.doc.gov/sites/default/files/reports/documents/greeneconomyreport_0.pdf>.

conservation, such as forestry management.[153] Based on surveys across the 325 industries it identified as potential producers of green goods and services, BLS counts approximately 2.3 million jobs in the green economy in 2010, rising 7.4 percent to 2.5 million in 2011,[154] compared to increases of about one percent across all occupations in the entire economy over the same period.[155] The table below, Table 6-1, presents BLS green job estimates nationally and for the utility sector.

Table 6-1. U. S. Green Goods and Services (GGS) Employment (annual average)

	Total GGS Employment	Utility GGS Employment	Total GGS Growth 2010-11	Utility GGS Growth 2010-11
2010	2,342,562	69,031	NA	NA
2011	2,515,200	71,129	7.4%	3.0%

Source: Bureau of Labor Statistics

6.5.3.2 Renewable Electricity Generation Employment Trends

The DOC report does not separate renewable energy data and the BLS data include only privately owned electricity generating facilities. As such, neither source isolates renewable electricity generation employment. For historical trends in this sector, we therefore, rely on a Brookings Institution study, Muro et al. (2011). This study built a national database of "clean economy" jobs from the bottom up, verifying each company individually.[156] They include a list of categories similar but not identical to that of BLS, including agricultural and natural resources conservation, education and compliance, energy and resource efficiency, greenhouse gas reduction, environmental management and recycling, and renewable energy. This study found about 138,000 jobs in the renewable energy sector in 2010, with an overall average annual growth rate of 3.1 percent from 2003-2010. Table 6-2 details the national results by energy

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[153] BLS has identified 325 detailed industries (6-digit NAICS) as potential producers of green goods and services. Available at: <http://www.bls.gov/ggs/ggsoverview.htm>. (Accessed on 1-14-14, l**ast modified date:** March 19, 2013.

[154] U.S. Department of Labor, U.S. Bureau of Labor Statistics. (n.d.). 2011. "Green Goods and Services 2010-2011." (Retrieved on January 14, 2014). Available at :< http://www.bls.gov/ggs/ggsoverview.htm>.

[155]U.S. Department of Labor, U.S. Bureau of Labor Statistics. 2010. National Occupational Employment and Wage Estimates, United States. Available at: <http://www.bls.gov/oes/2010/may/oes_nat.htm>, May. National Occupational Employment and Wage Estimates, United States http://www.bls.gov/oes/2010/may/oes_nat.htm.

[156] <http://www.brookings.edu/~/media/Series/resources/0713_clean_economy.pdf> p. 15.

source.

Table 6-2. Renewable Electricity Generation-Related Employment

Sector	Jobs, 2010	2003-2010 Average Annual Growth Rate (%)
Biofuels/Biomass	20,680	8.9
Geothermal	2,720	6.7
Hydropower	55,467	-3.6
Renewable Energy Services	1,981	6.3
Solar Photovoltaic	24,152	10.7
Solar Thermal	5,379	18.4
Waste-to-Energy	3,320	3.7
Wave/Ocean Power	371	20.9
Wind	24,294	14.9
Total	138,364	3.1

Source: http://www.brookings.edu/~/media/Series/resources/0713_clean_economy.pdf, Appendix A.

6.5.3.3 Employment Trends in Demand-Side Energy Efficiency Activities

U.S. government data used for calculating the historical trends in the demand-side energy efficiency sector come from the BLS green goods and services surveys. BLS reports an energy efficiency category, finding 1.49 million private sector energy efficiency jobs in 2010 and 1.64 million in 2011.

For a longer term trend the Brookings Institution study (Muro et al., 2011) built a national database of "clean economy" jobs from the bottom up, verifying each company individually.[157] This study found about 428,000 jobs in the Energy and Resource Efficiency sector in 2010, with an overall average annual growth rate of 2.6 percent from 2003-2010. Table 6-3 details the results by energy sector.

[157] <http://www.brookings.edu/~/media/Series/resources/0713_clean_economy.pdf> p. 15

Table 6-3. Energy and Resources Efficiency-Related Employment

Sector	Jobs, 2010	2003-2010 Average Annual Growth Rate (%)
Appliances	36,608	-3.1
Energy-saving Building Materials	161,896	2.5
Energy-saving Consumer Products	19,210	-2.9
Green Architecture and Construction Services	56,190	6.4
HVAC and Building Control Systems	73,600	3.3
Lighting	14,298	-1.8
Professional Energy Services	49,863	6.9
Smart Grid	15,987	8.6
Total	427,652	2.6

Source: http://www.brookings.edu/~/media/Series/resources/0713_clean_economy.pdf, Appendix A

In addition, other research institutes and industry groups have clean economy or clean energy employment databases. While definitions and timeframes vary, all show positive employment trends of 1.9 percent or more growth in clean energy-related jobs annually.

6.6 Projected Sectoral Employment Changes due to Proposed Guidelines

EGUs may respond to these proposed guidelines by placing new orders for efficiency-related or renewable energy equipment and services to reduce GHG emissions. Installing and operating new equipment or improving heat rate efficiency could increase labor demand in the electricity generating sector itself, as well as associated equipment and services sectors. Specifically, the direct employment effects of supply-side initiatives include changes in labor demand for manufacturing, installing, and operating higher efficiency or renewable energy electricity generating assets supported by the initiative while reducing the demand for labor that would have been used by less efficient or higher emitting generating assets. Once implemented, increases in operating efficiency would impact the power sector's demand for fuel and plans for EGU retirement and new construction.

In addition, EPA expects state compliance plans to also include demand-side energy efficiency policies and programs that typically change energy consumption patterns of business and residential consumers by reducing the quantity of energy required for a given level of production or service. Demand-side initiatives generally aim to increase the use of cost-effective energy efficiency technologies (e.g., including more efficient appliances and air conditioning systems, more efficient lighting devices, more efficient design and construction of new homes and businesses), and advance efficiency improvements in motor systems and other industrial processes. Demand-side initiatives can also directly reduce energy consumption, such as through programs encouraging changing the thermostat during the hours a building is unoccupied or motion-detecting room light switches. Such demand-side energy efficiency initiatives directly affect employment by encouraging firms and consumers to shift to more efficient products and processes than would otherwise be the case. Employment in the sectors that provide these more efficient devices and services would be expected to increase, while employment in the sectors that produce less efficient devices would be expected to contract.

This analysis uses the cost projections from the engineering-based Integrated Planning Model (IPM) to project labor demand impacts of the proposed guidelines for the electricity generation sector (fossil, renewable, and nuclear), and the fuel production sector (coal and natural gas). These projections include effects attributable to heat rate improvements, construction of new EGUs, changes in fuel use, and reductions in electricity generation due to demand-side energy efficiency activities. To project labor requirements for demand-side energy efficiency activities, the analysis uses a different approach that combines data on historic changes in employment and expenditures in the energy efficiency sector with projected changes in expenditures in the sector arising from state implementation of the proposed guidelines.

We project labor impacts for two options for establishing the "best system of emission reduction" (BSER) for GHG emissions from existing EGUs. The EPA is proposing a BSER goal approach referred to as Option 1 and taking comment on a second approach referred to as Option 2. Each of these goal approaches use the four building blocks described above at different levels of stringency. Option 1 involves higher deployment of the four building blocks but allows a longer timeframe to comply (2030) whereas Option 2 has a lower deployment over a shorter timeframe (2025). This analysis estimates labor impacts of illustrative state and regional compliance approaches for the goals set for Options 1 and 2. With the state compliance approach, states are assumed to comply with the guidelines by implementing measures solely within the state and emissions rate averaging occurs between affected sources on an intrastate basis only. In contrast under the regional approach, groups of states are assumed to collaboratively comply with the guidelines.

6.6.1 Projected Changes in Employment in Electricity Generation and Fossil Fuel Extraction

The analytical approach used in this analysis is a bottom-up engineering method combining EPA's cost analysis of the proposed guidelines with data on labor productivity, engineering estimates of the amount and types of labor needed to manufacture, construct, and operate different types of generating units, and prevailing wage rates for skilled and general labor categories. This approach is different from the types of economic analyses discussed in section 6.3. Rather than projecting employment impacts throughout the U.S. economy, the engineering-based analysis focuses on the direct impact on labor demand in industries closely involved with electricity generation. The engineering approach projects labor changes measured as the change in each analysis year in job-years[158] employed in the power generation and directly related sectors (e.g., equipment manufacturing, fuel supply and generating efficiency services). For example, this approach projects the amounts and types of labor required to implement improvements in generating efficiency. It then uses the EPA's estimated effect of efficiency improvements on fuel demand to project reductions in the amount of labor required to produce coal and gas.

This analysis relies on projections and costing analysis from the IPM, which uses industry-specific data and assumptions to estimate costs and energy impacts of the proposed guidelines (see Chapter 3). The EPA uses the IPM to predict coal generating capacity that is likely to undertake improvements in heat rate efficiency (HRI).[159] IPM also predicts the guidelines' impacts on fuel use, retirement of existing units, and construction of new ones.

The methods we use to estimate the labor impacts are based on the analytical methods used in the Regulatory Impact Analysis for the Mercury and Air Toxics Standards (MATS). While the methods used in this analysis to estimate the recurring labor impacts (e.g., labor associated with operating and maintaining generating units, as well as labor needed to mine coal

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[158] Job-years are not individual jobs, but rather the amount of work performed by the equivalent of one full-time individual for one year. For example, 20 job-years in 2020 may represent 20 full-time jobs or 40 half-time jobs in that year.

[159] Heat rate improvements (HRI) could include a range of activities in the power plant to lower the heat rate required to generate a net electrical output. Assuming all other things being equal, a lower heat rate is more efficient because more electricity is generated from each ton of coal.

and natural gas) are the same as we used in MATS (with updated data where available), the methods used to estimate the labor associated with installing new capacity and implementing heat rate improvements were developed for the GHG guidelines analysis.

The bottom-up engineering-based labor analysis in the MATS RIA primarily was concerned with the labor needs of retrofitting pollution control equipment. A central feature of the GHG guidelines labor analysis, however, involves the quantity and timing of the labor needs of building new renewable (primarily wind) and NGCC generating capacity. The EPA IPM analysis finds that by 2020 a significantly larger amount of renewable and NGCC capacity will be built to implement the GHG guidelines under all of the option scenarios. For example, in the base case IPM estimates that 11 GW of non-hydro renewable capacity will be built between 2016 and 2020, while under Option 1 with regional compliance almost twice as much (21.3 GW) renewable capacity will be built. Similarly, in the base case 7.9 GW of NGCC capacity is built between 2016 and 2020, while almost 3 times as much (24.43 GW) is built under Option 1 with regional compliance.

An important aspect of building new units is that all of the construction-related labor occurs before the new units become operational. While the financial costs of building the new units are amortized and recouped over the book life of the new equipment, the labor involved with manufacturing equipment and constructing the new units occurs, and is actually paid for, in a concentrated amount of time before the new capacity begins to generate electricity. IPM assumes[160] that new NGCC units take 3 years to build, and both natural gas combustion turbines and wind-powered renewables take 2 years.

In addition to the amount of labor needed to build new generating capacity, IPM also estimates that there will be significant labor impacts in later years from avoiding having to build additional new capacity. Because of the demand-side energy efficiency programs, the total amount of electricity needed by 2030 is substantially lower with all of the Options than in the base case. For example, in Option 1 with regional compliance only half the total new NGCC capacity is built between 2016 and 2030 (40.6 GW), compared with 79.7 GW in the base case.

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[160] Table 4.7, IPM 5.13 Documentation.

The avoided new capacity results in both a significant net cost savings to consumers and the power sector, as well reduced emissions of both CO_2 and precursor pollutants from fossil fuel generation. The avoided new capacity, however, also has significant labor impacts. A portion of the employment that would have been used to build the new capacity in the base case will not occur with the implementation of the GHG guidelines. Similarly, less labor involved with operating and providing fuel for new units will be needed with the GHG guidelines than in the base case.

Overall, the impact of much more rapid construction of new renewable and fossil generation capacity in the early years of implementing the GHG guidelines, followed by the need to build substantially less capacity in later years as the demand-side energy efficiency programs reduce the overall electricity demand relative to the base case, creates an important but complex temporal dynamic to the supply-side labor analysis. In the early years of implementation there will be a sizable net increase in the amount of labor needed to construct and operate the new generating capacity. However, in later years, the reduced need for additional newly built capacity results in a sizable net decrease in the amount of labor needed relative to the base case.

The changes in the timing and overall need for new capacity have direct labor impacts not only on the construction-related one-time labor, but also on the subsequent needs for operating and fuel supply labor to operate the plants. In the case of avoided new capacity, the labor impacts include the loss of those ongoing labor needs. In addition, there are similar labor impacts from the loss of operating and fuel-related jobs arising from the retirement of existing coal generating capacity.

A critical component of the overall labor impacts of implementing the GHG guidelines is the impact of the labor associated with the demand-side energy efficiency activities. The demand-side labor impacts are presented in section 6.6.2. All of the labor impacts of the demand-side energy efficiency activities are increases in labor needs, which more than offset the loss of supply-side jobs associated with the decreasing demand for electricity arising from the demand-side programs. The IPM labor expenditure projections are distributed across different labor categories (e.g., general construction labor, boilermakers and engineering) using data from engineering analyses of labor's overall share of total expenditures, and apportionment of total labor cost to various labor categories. Hourly labor expenditures (including wages, fringe benefits, and employer-paid costs including taxes, insurance and administrative costs) for each category are used to estimate the labor quantity (measured in full-time job-years) consistent with the compliance scenario projections. Projected labor impacts arising from changes in fuel demand are primarily derived from labor productivity data for coal mining (tons mined per employee hour) and natural gas extraction (MMBtu produced/job-year). Tables 6.4 and 6.5 present projected changes relative to the baseline of four labor categories:

1. manufacturing, engineering and construction for building, designing and implementing heat rate improvements;
2. manufacturing and construction for new generating capacity;
3. operating and maintenance for existing generating capacity; and
4. extraction of coal and natural gas fuel.

All of the employment estimates presented in Tables 6-4 and 6-5 are estimates occurring in a single year. For the construction-related (one-time) labor impacts, including the installation of HRI, Tables 6-4 and 6-5 present the average annual impact occurring in each year of three different intervals of years. The multi-year intervals correspond with the analytical years reported by IPM. The three intervals are from 2017 through 2020 (a four year interval), from 2021 through 2025 (five years), and 2026 through 2030 (5 years). The construction-related labor analysis are based on the IPM estimates of the net change in capital investment that occurs during each multi-year interval to fund building new units completed during that interval. The new build labor analysis uses the net change in capital investment to estimate the amount and type of labor needed during the interval to build the new capacity. The analysis assumes that the new built labor within each interval is evenly distributed throughout the interval. Tables 6-4 and 6-5 reflect this assumption by presenting the average labor utilization per year during each of the three intervals.

The HRI-related labor impacts are estimated based on the assumed capital cost of $100/kw (see section 3.7.3). Note that all of the HRI-related labor impacts occur in the first interval (2017 to 2020), and are assumed to be occur evenly throughout that four year interval. Therefore, the HRI-related labor estimates in Tables 6-4 and 6-5 are the annual average labor impacts for of the four years. There are no HRI improvements made after 2020.

The labor estimates for operating and maintaining generating units annually are based on IPMs estimates of Fixed Operating and Maintenance (FOM) Costs. IPM estimates FOM for each year individually, so the net changes in O&M-related labor estimates in Tables 6-4 and 6-5 are single year estimates for 2020, 2025 and 2030. These O&M labor estimates are not the average annual averages labor needs throughout each multi-year interval. There are O&M labor changes occurring in the all years throughout the entire period 2017-2030, but labor impact changes each year. The fuel-related labor estimates are also single-year estimates, and not multi-year averages. The labor analysis uses IPM's estimates of the net changes in the amount of coal and natural gas in 2020, 2025 and 2030, which are inherently estimates of the fuel usage in a single year. As with the O&M labor impacts, the fuels-related labor impacts occur in every year throughout 2017-2030, and the labor impact changes every year.

It should be noted that the supply-side labor impact estimates in Tables 6-4 and 6-5 reflect all the supply-side changes that will occur with each alternative option and compliance alternative. These labor impacts include not only the impacts of Building Blocks 1 through 3, but also the changes in total generation needed that result from the demand-side energy efficiency activities in Building Block 4. The additional upstream labor impacts from the demand-side activities are presented below in section 6.2.2.

More details on methodology, assumptions, and data sources used to estimate the supply-side labor impacts discussed in this section can be found in Appendix 6A.

Table 6-4. Engineering-Based[a] Changes in Labor Utilization, Regional Compliance Approach - (Number of Job-Years[b] of Employment in a Single Year)

Category	Option 1			Option 2		
Construction-related (One-time) Changes*						
	2017-2020	**2021-2025**	**2026-2030**	**2017-2020**	**2021-2025**	**2026-2030**
Heat Rate Improvement: Total	**32,900**	**0**	**0**	**33,900**	**0**	**n/a**
Boilermakers and General Construction	22,800	0	0	23,600	0	n/a
Engineering and Management	6,000	0	0	6,200	0	n/a
Equipment-related	2,900	0	0	3,000	0	n/a
Material-related	1,100	0	0	1,100	0	n/a
New Capacity Construction: Total	**24,700**	**-33,300**	**-37,000**	**14,700**	**-23,100**	**n/a**
Renewables	17,000	-4,700	-2,100	11,600	-3,100	n/a
Natural Gas	7,700	-28,600	-34,900	3,100	-20,000	n/a
Recurring Changes**						
	2020	**2025**	**2030**	**2020**	**2025**	**2030**
Operation and Maintenance: Total	**-22,900**	**-23,800**	**-23,700**	**-15,300**	**-15,500**	**n/a**
Changes in Gas	2,300	-600	-3,400	1,000	-1,000	n/a
Retired Coal	-22,600	-20,800	-18,200	-14,600	-13,100	n/a
Retired Oil and Gas	-2,600	-2,400	-2,100	-1,700	-1,400	n/a
Fuel Extraction: Total	**-8,800**	**-14,900**	**-19,200**	**-6,600**	**-10,600**	**n/a**
Coal	-13,700	-17,000	-16,600	-10,900	-12,900	n/a
Natural Gas	4,900	2,100	-2,600	4,300	2,300	n/a
Supply-Side Employment Impacts - Quantified	**25,900**	**-72,000**	**-79,900**	**26,700**	**-49,200**	**n/a**

[a] Job-year estimates are derived from IPM investment and O&M cost estimates, as well as IPM fuel use estimates (tons coals or MMBtu gas).

[b] All job-year estimates on this are full-time equivalent (FTE) jobs. Job estimates in the Demand-Side energy efficiency section (below) include both full-time and part-time jobs.

*Construction-related job-year changes are one-time impacts, occurring during each year of the 2 to 4 year period during which construction and HRI installation activities occur. Figures in table are average job-years during each of the years in each range. Negative job-year estimates when additional generating capacity must be built in the base case, but is avoided in the Guideline implementation scenarios due to HRI or Demand-side energy efficiency programs.

**Recurring Changes are job-years associated with annual recurring jobs including operating and maintenance activities and fuel extraction jobs. Newly built generating capacity creates a recurring stream of positive job-years, while retiring generating capacity, as well as avoided new built capacity, create a stream of negative job-years. In addition, there are recurring jobs prior to 2020 to fuel and operate new generating capacity brought online before 2020; the recurring jobs prior to 2020 are not estimated.

Table 6-5. Engineering-Based[a] Changes in Labor Utilization, State Compliance Approach (Number of Job-Years of Employment in Year)

Category	Option 1			Option 2		
Construction-related (One-time) Changes*						
	2017-2020	**2021-2025**	**2026-2030**	**2017-2020**	**2021-2025**	**2026-2030**
Heat Rate Improvement: Total	**32,200**	**0**	**0**	**30,800**	**0**	**n/a**
Boilermakers and General Construction	22,400	0	0	21,400	0	n/a
Engineering and Management	5,900	0	0	5,700	0	n/a
Equipment-related	2,900	0	0	2,800	0	n/a
Material-related	1,000	0	0	1,000	0	n/a
New Capacity Construction: Total	**28,200**	**-38,000**	**-36,100**	**23,000**	**-29,500**	n/a
Renewables	19,100	-8,900	-2,200	15,800	-6,300	n/a
Natural Gas	9,100	-29,100	-33,900	7,200	-23,200	n/a
Recurring Changes**						
	2020	**2025**	**2030**	**2020**	**2025**	**2030**
Operation and Maintenance: Total	**-24,100**	**-25,300**	**-24,900**	**-16,800**	**-17,100**	n/a
Changes in Gas	2,500	-500	-3,200	1,500	-800	n/a
Retired Coal	-24,000	-22,500	-19,700	-16,400	-14,800	n/a
Retired Oil and Gas	**-2,600**	**-2,300**	**-2,000**	**-1,900**	**-1,500**	n/a
Fuel Extraction: Total	**-8,300**	**-14,600**	**-19,400**	**-6,500**	**-10,300**	n/a
Coal	-14,300	-17,800	-18,000	-11,500	-13,500	n/a
Natural Gas	6,000	3,200	-1,400	5,000	3,200	n/a
Supply-Side Employment Impacts – Quantified	**28,000**	**-77,900**	**-80,400**	**29,800**	**-56,900**	n/a

[a] Job-year estimates are derived from IPM investment and O&M cost estimates, as well as IPM fuel use estimates (tons coals or MMBtu gas)

[b] All job-year estimates on this are Full-Time Equivalent (FTE) jobs. Job estimates in the Demand-Side energy efficiency section (below) include both full-time and part-time jobs

*Construction-related job-year changes are one-time impacts, occurring during each year of the 2 to 4 year period during which construction and HRI installation activities occur. Figures in table are average job-years during each of the years in each range. Negative job-year estimates when additional generating capacity must be built in the base case, but is avoided in the Guideline implementation scenarios due to HRI or Demand-side energy efficiency programs.

**Recurring Changes are job-years associated with annual recurring jobs including operating and maintenance activities and fuel extraction jobs. Newly built generating capacity creates a recurring stream of positive job-years, while retiring generating capacity, as well as avoided new built capacity, create a stream of negative job-years. In addition, there are recurring jobs prior to 2020 to fuel and operate new generating capacity brought online before 2020; the recurring jobs prior to 2020 are not estimated.

6.6.2 Projected Changes in Employment in Demand-Side Energy Efficiency Activities

EPA anticipates that this rule may stimulate investment in clean energy technologies and services, resulting in considerable increases in energy efficiency in particular. We expect these increases in energy efficiency, specifically, to support a significant number of jobs existing in related industries.

In this section, we project employment impacts in demand-side energy efficiency activities arising from these guidelines using illustrative calculations. The approach uses information from power sector modeling and projected impacts on energy efficiency investments analyzed as part of Building Block 4 (see Chapter 3), and U.S. government data on employment and expenditures in energy efficiency. This approach is limited by the fact that we do not know which options states will choose for demand-side energy efficiency activities and by uncertainties associated with methods. These illustrative employment projections are gross; thus they do not include impacts of any shift in resources from other sectors. Nor does this analysis attempt to quantify employment impacts arising from changes in consumer expenditures away from energy towards other sectors. In other words, these projections are not attempts at estimating net national job creation. Also, this approach attempts to calculate the number of employees (full-time and part-time) rather than job-years as discussed in section 6.6.1. EPA requests public comment on all aspects of this proposed approach to partially quantifying demand-side management and energy efficiency employment impacts.

Investments in demand-side energy efficiency reduce energy required for a given activity by encouraging more efficient technologies (e.g., ENERGY STAR appliances), implementing energy improvements for existing systems (e.g., weatherization of older homes), or encouraging changes in behavior (e.g., reducing air conditioning during periods of high electricity demand).

Employment impacts of demand-side energy efficiency programs have not been extensively studied in the peer-reviewed, published economics literature. Instead, most research has focused on consumer response to and amount of energy savings achieved by these programs (e.g., Allcott (2011a, 2011b), Arimura et al. (2012)). Results suggest that demand-side energy efficiency programs reduce energy use and generate small increases in consumer welfare. These policy impacts are due to low investment in energy efficiency as described in "energy paradox" literature (Gillingham, Newell, and Palmer (2009), Gillingham and Palmer (2014)).[161]

Two recent articles discuss employment effects of demand-side energy efficiency

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[161] For more information on this efficiency paradox see Chapter 3.

programs. Aldy (2013) describes clean energy investments funded by the American Recovery and Reinvestment Act of 2009, which "included more than $90 billion for strategic clean energy investments intended to promote job creation and the deployment of low-carbon technologies" (p. 137), with nearly $20 billion for energy efficiency investments. The Council of Economic Advisors (CEA) (2011) estimated higher economic activity and employment than would have otherwise occurred without the American Recovery and Reinvestment Act. Using CEA's methods to quantify job creation for the Recovery Act, Aldy uses the share of stimulus funds for clean energy investments to estimate job-years supported by the Recovery Act. The largest sources of job creation in clean energy are those that received the largest shares of stimulus funds: renewable energy, energy efficiency, and transit. Aldy's estimates, while informative, are not directly applicable for employment analysis in this rulemaking as there are important differences in expected employment impacts from a historically large fiscal stimulus specifically targeting job creation during a period of exceptionally high unemployment versus environmental regulations taking effect several years from now.

Yi (2013) analyzes clean energy policies and employment for U.S. metropolitan areas in 2006, prior to the Recovery Act, to evaluate impacts on clean energy job growth. Implementing an additional state clean energy policy tool (renewable energy policies, GHG emissions policies, and energy efficiency polices such as energy efficiency resource standards, appliance or equipment energy efficiency standards, tax incentives, and public building energy efficiency standards) is associated with 1% more clean energy employment within that MSA. These estimates are not transferable to this rulemaking since states are likely to change intensity as well as number of clean energy programs.

Lacking a peer-reviewed methodology, we propose the following approach to illustrate possible effects on labor demand in the energy efficiency sector due to demand-side management strategies. We use U.S. government data to divide the historical change in employment in the energy efficiency sector by the historical change in expenditure in the sector and multiply this fraction by projected expenditure in the sector undertaken in response to these proposed guidelines.

Data used for calculating the numerator of the fraction comes from the "energy efficiency" category of the 2010 and 2011 BLS *Green Goods and Services* surveys.[162] BLS does not report the denominator of the job per additional dollar fraction, however. Instead, the data include the fraction of green revenues received relative to total revenues in each North American Industrial Classification System (NAICS) code.[163] We multiply data on total revenues by NAICS by the fraction of green revenues reported by BLS to obtain green revenues. The only U.S. Government data source containing this revenue information for all NAICS sectors is the U.S. Economic Census. This Census is conducted at 5-year intervals (the latest available year is 2007), however, making it unsuitable for identifying the change in revenues from 2010 to 2011. Instead, we use data from the Annual Survey of Manufacturers. The disadvantage of this data source is that the manufacturing sector makes up only 50 percent of the 132 NAICS codes belonging to the energy efficiency sector as defined by the BLS *Green Goods and Services* surveys, with the remainder in the construction or service sectors. Thus, this analysis implicitly assumes that the same number of jobs per dollar are supported in construction and service sectors as in manufacturing. Using this approach we obtain a factor of 2.56 additional demand-side energy efficiency jobs per additional million 2011 dollars of expenditure.

Having calculated the fraction of additional jobs per additional dollar of energy efficiency expenditure, we use energy sector model projections of the first-year costs required for states to attain the goal of demand-side efficiency improvements set by building block four.[164] Multiplying this dollar expenditure by the jobs per additional dollar figure results in projected employment impacts for demand-side energy efficiency activities of 78,800 in 2020, 112,000 in 2025, and 111,800 in 2030 for both the proposed Option 1 regional and state compliance approaches. The estimates for Option 2 are shown on Table 6-6 below.

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[162] For more details on these surveys, see section 7.5.3.

[163] See detailed listing available here: http://www.bls.gov/ggs/naics_2012.xlsx.

[164] See Greenhouse Gas Abatement Measures TSD, Appendix 5-4.

Table 6-6. Estimated Demand-Side Energy Efficiency Employment Impacts For Option 1 and Option 2 for Both Regional and State Compliance Approaches

Source	Factor	Employment impact (jobs)*					
		Option 1			Option 2		
		2020	2025	2030	2020	2025	2030
BLS GGS additional jobs per additional million dollars	2.56	78,800	112,000	111,800	57,000	76,200	n/a

*Since these figures represent number of employees (full- or part-time) they should not be added to the full-time equivalent job-years reported in Table 6-5.

Although this approach has the advantage of illuminating the change in jobs for an incremental change in expenditures, this approach is limited by its focus on manufacturing sectors and direction of bias (overestimation or underestimation) cannot be determined at this time. The EPA is requesting comment on this method, data, identification of related studies and peer reviewed articles and other methods.

There is more uncertainty involved in this approach than the standard bottom-up engineering analysis used to estimate electricity generation and fuel production employment impacts of this rulemaking. For those, the EPA was able to identify a limited set of activities (e.g., constructing a new NGCC power plant), and study associated labor requirements. Demand-side energy efficiency improvements, in contrast, encompass a wide array of activities (subsidies for efficient appliances, “smart meters,” etc.). In addition, there is considerable uncertainty regarding which activities a state will choose. Thus, the validity of the jobs per dollar approach used here relies on the assumption that states will use a mix of activities similar to the 2011 composition of energy efficiency sectors identified by BLS.

In addition, the EPA does not have access to bottom-up information regarding labor requirements for these activities. Use of a constant job per dollar fraction is at best a crude approximation of these labor requirements. The EPA has identified several other limitations of this approach, outlined below.

Job Reclassification. Job numbers in this chapter represent gross changes in the affected sector. As such they may over-estimate impacts to the extent that jobs created displace workers employed elsewhere in the economy. For demand-side efficiency activities this potential over-statement is may be higher than in other sectors. If states encourage consumers to purchase ENERGY STAR appliances, for example, currently employed workers in factories and retail outlets may simply be given a different task. This approach, however, would count these workers as jobs created

Imports. The job per additional dollar fraction used in the employment projection is calculated based on jobs per dollar of revenue for domestic firms only. To the extent that spending on demand-side energy efficiency activities goes toward the purchase of imported goods this projection will overstate the U.S. employment impact of those expenditures.

Fixed Coefficient. Implicit in this approach is the assumption that employment impacts can be projected decades into the future on the basis of a single calculation from 2010-2011 data. The labor intensity of demand-side energy efficiency will likely change with technological innovation in the sector. In addition, even absent technological change, labor intensity of expenditures will likely change over time as states alter their portfolio of efficiency activities (e.g., by moving to higher cost activities after exhausting opportunities for low cost efficiency gains).

Non-additional Activities. Here we assume that all activities financed by demand-side energy efficiency expenditures are additional to what would have been undertaken in the absence of these programs. If utilities finance some actions customers would have undertaken in the absence of these programs (e.g., if a customer receives a rebate for an energy efficient appliance that would have been purchased without the rebate), these numbers would overestimate employment impacts of the proposed guidelines.

6.7 Conclusion

This chapter presents qualitative and quantitative discussions of potential employment impacts of the proposed guidelines for electricity generation, fuel production, and demand-side energy efficiency sectors. The qualitative discussion identifies challenges associated with estimating net employment effects and discusses anticipated impacts related to the rule. It includes an in-depth discussion of economic theory underlying analysis of employment impacts. Labor demand impacts for regulated firms can be decomposed into output and substitution effects, both of which may be positive or negative. Consequently, theory alone cannot predict the direction or magnitude of a regulation's employment impact. It is possible to combine theory with empirical study specific to the regulated firms and other relevant sectors if data and methods of sufficient detail and quality are available. Finally, economic theory suggests that labor supply effects are also possible.

We examine the peer-reviewed economics literature analyzing various aspects of labor demand, relying on the above theoretical framework. Determining the direction of employment effects in regulated industries is challenging because of the complexity of the output and substitution effects. Complying with a new or more stringent regulation may require additional inputs, including labor, and may alter the relative proportions of labor and capital used by regulated firms (and firms in other relevant industries) in their production processes. The available literature illustrates some of the difficulties for empirical estimation: studies sometimes rely on confidential plant-level employment data from the U.S. Census Bureau, possibly combined with pollution abatement expenditure data that are too dated to be reliably informative. In addition, the methods do not permit estimation of net economy-wide effects. Empirical analysis at the industry level requires estimates of product demand elasticity; production factor substitutability; supply elasticity of production factors; and the share of total costs contributed by wages, by industry, and perhaps even by facility. For environmental rules, many of these data items are not publicly available, would require significant time and resources in order to access confidential U.S. Census data for research, and also would not be necessary for other components of a typical RIA. Econometric studies of environmental rules converge on the finding that employment effects, whether positive or negative, have been small in regulated sectors.

The illustrative quantitative analysis in this chapter projects a subset of potential employment impacts in the electricity generation, fuel production, and demand-side energy efficiency sectors. States have the responsibility and flexibility to implement policies and practices for compliance with Proposed EGU GHG Existing Source Guidelines. As such, given the wide range of approaches that may be used, quantifying the associated employment impacts is difficult. EPA's employment analysis includes projected employment impacts associated with these guidelines for the electric power industry, coal and natural gas production, and demand-side energy efficiency activities. These projections are derived, in part, from a detailed model of the electricity production sector used for this regulatory analysis, and U.S. government data on employment and labor productivity. In the electricity, coal, and natural gas sectors, the EPA estimates that these guidelines could have an employment impact of roughly 25,900 job-years in 2020 for Option 1 and 26,700 for Option 2 of that same year (see Tables 6-4 and 6-5). Employment impacts from demand-side energy efficiency activities are based on historic data on jobs supported per dollar of expenditure. Demand-side energy efficiency employment impacts would approximately be 78,800 jobs in 2020 for both Option 1 regional and state compliance approaches (see Table 6-6). The IPM-generated job-year numbers for the electricity, coal and natural gas sectors should not be added to the demand-side efficiency job impacts since the former are reported in full-time equivalent jobs, whereas the latter do not distinguish between full- and part-time employment. Finally, note again that this is an illustrative analysis, and CAA section 111(d) allows each state to determine the appropriate combination of, and the extent of its reliance on, measures for its state plan, by way of meeting its state-specific goal. Given the flexibilities afforded states in complying with the emission guidelines, the impacts reported in this chapter are illustrative of compliance actions states may take.

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APPENDIX 6A: ESTIMATING SUPPLY-SIDE EMPLOYMENT IMPACTS OF THE PROPOSED EGU GHG EXISTING SOURCE GUIDELINES

This appendix presents the methods used to estimate the supply-side employment impacts of the Proposed Electric Generating Unit Greenhouse Gas (EGU GHG) Existing Source Guidelines. The focus of the employment analysis is limited to the direct changes in the amount of labor needed in the power, fuels and generating equipment sectors directly influenced by compliance with the Guidelines. It does not include the ripple effects of these impacts on the broader economy (i.e., the "multiplier" effect), nor does it include the wider economy-wide effects of the changes to the energy markets, such as changes in electricity prices.

The methods used to estimate the supply-side employments are based on methods previously developed for the Mercury and Air Toxics Standards (MATS) Regulatory Impact Analysis (RIA). The methods used in this analysis to estimate the recurring labor impacts (e.g., labor associated with operating and maintaining generating units, as well as labor needed to mine coal and natural gas) are the same as was used in MATS (with updated data where available).

The labor analysis in the MATS RIA was primarily concerned with the labor needs of retrofitting pollution control equipment. The EGU GHG Existing Source Guidelines labor analysis, however, involves the quantity and timing of the labor needs of building new renewable and natural gas, as well as making heat rate improvements (HRI) at existing coal fired EGUs. These construction-related compliance activities in the EGU GHG Existing Source Guidelines required developing additional appropriate analytical methods that were not needed for the MATS analysis. The newly developed analytical methods for the construction-related activities are similar in structure and overall approach to the methods used in MATS, but required additional data and engineering information not needed in the MATS RIA.

6A.1 General Approach

The analytical approach used in this analysis is a bottom-up engineering method combining the EPA's cost analysis of the proposed guidelines with data on labor productivity, engineering estimates of the amount and types of labor needed to manufacture, construct, and operate different types of generating units, and prevailing wage rates for skilled and general labor categories. The approach involved using power sector projections and various energy market implications under the proposed EGU GHG Existing Source Guidelines from modeling conducted with the EPA Base Case version 5.13, using the Integrated Planning Model (IPM®)[165], along with data from secondary sources, to estimate the first order employment impacts for 2020, 2025, and 2030.

Throughout the supply-side labor analysis the engineering approach projects labor changes measured as the change in each analysis year in job-years[166] employed in the power generation and directly related sectors (e.g., equipment manufacturing, fuel supply and generating efficiency services). Job-years are not individual jobs, nor are they necessarily permanent nor full time jobs. Job-years the amount of work performed by one full time equivalent (FTE) employee in one year. For example, 20 job-years in 2020 may represent 20 full-time jobs or 40 half-time jobs in that year, or any combination of full- and part-time workers such that total 20 FTEs.

6A.1.1 Employment Effects Included In the Analysis

The estimates of the employment impacts (both positive and negative) are divided into five categories:

- additional employment to make HRI[167] at existing coal fired EGUs;
- additional construction-related employment to manufacture and install additional new generating capacity (renewables, and natural gas combined cycle or combustion turbine units) when needed as part of early compliance actions;

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[165] Results for this analysis were developed using various outputs from EPA's Base Case v.5.13 using ICF's Integrated Planning Model (IPM®). This case includes all of the underlying modeling that was developed by EPA with technical support from ICF International, Inc. See http://www.epa.gov/powersectormodeling/BaseCasev513.html for more information.

[166] Job-years are not individual jobs, but rather the amount of work performed by the equivalent of one full-time individual for one year. For example, 20 job-years in 2020 may represent 20 full-time jobs or 40 half-time jobs in that year.

[167] Heat rate improvements could include a range of activities in the power plant to lower the heat rate required to generate a net electrical output. Assuming all other things being equal, a lower heat rate is more efficient because less fuel is needed per unit of electric output.

- lost construction-related employment opportunities due to reductions in the total amount of new generating capacity needed to be built in the later years because of reduced overall demand for electricity because of demand-side energy efficiency activities;
- lost operating and maintenance employment opportunities due to increased retirements of coal and small oil/gas units;
- changes (both positive and negative) in coal mining and natural gas extraction employment due to the aggregate net changes in fuel demands arising from all the activities occurring due to compliance with the proposed guidelines.

Some of the changes are one-time labor effects which are associated with the building (or avoiding building) new generating capacity and installing HRI. This type of employment effects involves project-specific labor that is used for 2 to 4 years to complete a specific construction and installation type of project. There are other labor effects, however, which continue year after year. For example, bringing new generating capacity online creates an ongoing need for labor to operate and maintain the new generating capacity throughout the expected service life of the unit. New generating capacity also creates a need for additional employment to provide the fuel annually to run the new capacity. There are also continuing effects from the lost operations and maintenance (O&M) and fuel sector labor opportunities from decisions to retire existing capacity, as well as similar lost labor opportunities from decisions to reduce a portion of the amount of additional capacity needed in the base case.

6A.2 Employment Changes due to Heat Rate Improvements

The employment changes due to HRI were estimated based on the incremental MW capacity estimated to implement such improvements by 2020 as indicated by the analysis conducted by EPA. The heat rate improvement job impacts were assumed to have all occurred by 2020 and thus this study assumes there will be no HRI related jobs after 2020 (i.e., no permanent O&M related jobs due to HRI for 2025 or 2030). EPA modeled the heat rate improvements exogenously in IPM using the assumption that all "relevant" units can improve their heat rate by 6 percent at a capital cost of $100/kW. This study assumes that these investments will occur over a four-year period culminating in 2020. Hence, the per-year cost of heat rate was calculated to be $25/kW, and this cost was used in the next step.

This cost was then allocated to four categories based on the estimates provided by Andover Technology Partners (ATP), which were adapted from proxy projects involving installation of combustion control retrofits, such as those installed under the Best Available Retrofit Technology (BART) submissions from coal-fired power plants located in Wyoming and Arizona. For more details, refer to the Staudt (2014) report.[168] These proxies were chosen to ensure that the types of activities involved and their associated costs would be representative of those investments EPA expects power plants to undertake for efficiency upgrades.

Information on cost for these proxies were then extrapolated to approximate the labor requirements for four broad categories of labor – boilermakers and general construction, engineering and management support labor, labor required to produce the equipment in upstream sectors, and labor required to supply the materials (assumed to be primarily steel) in upstream sectors. More details about these estimates are provided in the Staudt (2014) report.

Based on the cost allocated in each categories and output per worker figures for respective industries in 2020, the employment gains for heat rate improvement were estimated[169] for 2020 using the assumptions summarized in Table 6A-1 below. Output per workers in future years were adjusted to account for growth in labor productivity, based on historical evidence of productivity growth rates for the relevant sectors.

Table 6A-1. Labor Productivity Growth Rate due to Heat Rate Improvement

	Share of the Total Capital Cost	Output/Worker (2020)	Labor Productivity Growth Rate
Boilermaker and Gen. Const.	40%	$78,500	0%
Management/Engineering	20%	$141,000	1.3%
Equipment	30%	$458,000	3.2%
Materials	10%	$424,000	-1.2%

[168] Staudt, James, Andover Technology Partners, Inc. Estimating Labor Effects of Heat Rate Improvements. Report prepared for the proposed EGU GHG Existing Source Guidelines, March 6, 2014.

[169] Total value of shipments or receipts in 2007 and total employees were taken from 2007 Economic Census, Statistics by Industry for Mining and Manufacturing sectors. The average annual growth rate of labor productivity was taken from the Bureau of Labor Statistics. Average growth rate calculated for years 1992-2007, applied to 2007 productivity to determine 2020 estimates of productivity. For the construction sector, BLS productivity growth rate data was unavailable. Because of this, and lack of reliable data on construction sector productivity growth, the output per worker for the construction sector was not forecasted to 2020, and the most recent available value from 2007 was used.

For these output per worker figures, a power sector construction industry (NAICS 237130) was used for general construction and boilermakers, Engineering Services (NAICS 54133) was used for the engineering and management component, Machinery Manufacturing (NAICS 333) was used for the equipment sector, and steel manufacturing (NAICS 33121) was used for materials. Use of machinery manufacturing for equipment and steel for materials was based on an analysis of the types of materials and equipment needed for these projects, and what EPA determined to be the most appropriate industry sectors for those. For more details, refer to the Staudt (2014) report.

6A.2.1 Employment Changes Due to Building (or Avoiding) New Generation Capacity

Employment changes due to new generation units were based on the incremental changes in capacity (MW), capital costs ($MM), and fixed operations and maintenance (FOM) costs ($MM) between the policy scenario and the base case in a given year.

New capacities were aggregated by generation type into the following categories:

- Combined Cycle,
- Combustion Turbine, and
- Renewables (which includes biomass, geothermal, landfill gas, onshore wind, and solar).

For each category, the analysis estimated the impacts due to both the construction and operating labor requirements for corresponding capacity changes. The construction labor was estimated using information on the capital costs, while the operating labor was estimated using the FOM costs.

Because IPM outputs provide annualized capital costs ($MM), EPA first converted the annualized capital costs to changes in the total capital investment using the corresponding capital charge rates.[170] These total capital investments were then converted to annual capital investments using assumptions about the estimated duration of the construction phase, in order to estimate the

[170] Capital charge rates obtained from EPA's resource, EPA #450R13002: Documentation for EPA Base Case v.5.13 using the Integrated Programming Model (IPM).

annual impacts on construction phase labor. Duration estimates were based on assumptions for construction lengths used in EPA's IPM modeling.[171] Specific assumptions used for different generating technologies are shown in Table 6A-2 below.

Table 6A-2. Capital Charge Rate and Duration Assumptions

New Investment Technology	Capital Charge Rate	Duration (Years)
Advanced Combined Cycle	10.3%	3
Advanced Combustion Turbine	10.6%	2
Renewables		
Biomass	9.5%	3
Wind (Onshore)	10.9%	3
Landfill Gas	10.9%	3
Solar	10.9%	3
Geothermal	10.9%	3

Annual capital costs for each generation type were then broken down into four categories: equipment, material (which is assumed to be primarily steel), installation labor, and support labor in engineering and management. The percentage breakdowns shown in Table 6A-3 were estimated using information provided by Staudt (2014), based primarily on published budgets for new unit assembled in a study for the National Energy Technology Laboratory (NETL). For more details, refer to the Staudt (2014) report. Annual capital costs for each generation type provided by the IPM output were allocated according to this breakdown.

Table 6A-3. Expenditure Breakdown due to New Generating Capacity

	Equipment	Material	Labor	Eng. and Const. Mgt
Renewables	54%	6%	31%	9%
Combined Cycle	65%	10%	18%	7%
Combustion Turbine	65%	10%	18%	7%

The short-term construction labor of the new generation units were based on output ($ per worker) figures for the respective sectors. The total direct workers per $1 million of output for the baseline year 2007 were forecasted to the years under analysis using the relevant labor productivity growth rate. Table 6A-4 shows the figures for each of the five productivities: general power plant construction; engineering and management; material use; equipment use;

[171] Ibid.

and plant operators. The resulting values were multiplied by the capital costs to get the job impact.

Table 6A-4. Labor Productivity due to New Generating Capacity

	Labor Productivity Growth Rate	Workers per Million $ (2007)
General Power Plant Construction	0.0%	5.7
Engineering and Management	1.3%	5.2
Material Use (Steel)	-1.2%	2.0
Equipment Use (Machinery)	3.2%	3.3
Plant Operators	2.8%	10.8

General installation labor, assumed to be mostly related to the general power plant construction phase, was matched with the power industry specific construction sector. Engineering/management was matched to the engineering services sector to determine their respective output per worker. For materials, EPA assumed steel to be the proxy and used the steel manufacturing sector for this productivity. Equipment was assumed to primarily come from machinery manufacturing sector (such as turbines, engines and fans).

The net labor impact for construction labor for a given year was adjusted to account for changes in capacity that has already taken place in the prior IPM run year. Because IPM reports cumulative changes for new generating capacity for any given run year, this adjustment ensured that the short-term construction phase job impacts in any given run year does not reflect the cumulative effects of prior construction changes for the given policy scenario. The estimated amount of the change in construction-related labor in a single IPM run year (e.g., 2025) represents the average labor impact that occurs in all years between that IPM run year and the previous run year (i.e., the labor estimates derived from the 2025 IPM run year are the average annual labor impacts in 2021 through 2025). The construction labor results for 2020 represent the average labor impacts in 2017 through 2020.

The plant operating employment estimates used a simpler methodology as the one described above. The operating employment estimates use the IPM estimated change in FOM costs for the IPM run year. Because the FOM costs are inherently estimates for a single year, the operating employment estimates are for a single year only. While there are obviously operating employment effects occurring in every year throughout the entire IPM estimation period (2017-2030), the labor analysis only estimates the single year labor impacts in the IPM run years: 2020, 2025 and 2030. The total direct workers for $1 million and labor productivity growth rate provided for plant operators in Table 6A-4 were used to estimate the employment impact.

6A.2.2 Employment Changes due to Coal and Oil/Gas Retirements

Employment changes due to plant retirements were calculated using the IPM projected changes in retirement capacities for coal and oil/gas units for the relevant year and the estimated changes in total FOM costs due to those retiring units. Thus, the basic assumption in this analysis was that increased retirements (over the base case) will lead to reduced FOM expenditures at those plants which were assumed to lead to direct job losses for plant workers.

In order to estimate the total FOM changes due to retirements, EPA first estimated the average FOM costs ($/kW) for existing coal-fired and oil/gas-fired units in the base case, as shown in Table 6A-5 below. It was assumed that the average FOM cost of existing units in the base case can be used as a proxy for the lost economic output due to fossil retirements. Thus, changes in the FOM costs for these retiring units were derived by taking the product of the incremental change in capacity and the average FOM costs. These values were converted to lost employment using data from the Economic Census and BLS on the output/worker estimates for the utility sector.[172]

Table 6A-5. Average FOM Cost Assumptions

	2020	2025	2030
Coal	65	68	69
Oil and Gas	21	22	22

Note that the retirement related employment losses are assumed to include losses directly affecting the utility sector, and do not include losses in upstream sectors that supply other inputs to the EGU sector (except fuel related job losses, which are estimated separately and discussed in the next section).

6A.2.3 Employment Changes due to Coal and Oil/Gas Retirements

Two types of employment impacts due to projected fuel use changes were estimated in

[172] The same specific sources as cited before, however, used workers and total payroll.

this section. First, employment losses due to either reductions or shifts in coal demand were estimated using an approach similar to EPA's coal employment analyses under Title IV of the Clean Air Act Amendments. Using this approach, changes in coal demand (in short tons) for various coal supplying regions were taken from EPA's base and policy case runs for the proposed EGU GHG NSPS. These changes were converted to job-years using U.S. Energy information Administration (EIA) data on regional coal mining productivity (in short tons per employee hour), using 2008 labor productivity estimates.[173,174]

Specifically, the incremental changes to coal demand were calculated based on the coal supply regions in IPM -- Appalachia, Interior, and West and Waste Coal (which was estimated using U.S. total productivity). Worker productivity values used for estimating coal related job impacts are shown in Table 6A-6 below.

Table 6A-6. Labor Productivity due to New Generating Capacity

	Labor Productivity
Coal (Short tons/ employee hour)	
Appalachia	2.91
Interior	4.81
West	19.91
Waste	5.96
Natural Gas (MMBtu/ employee hour)	126
Pipeline Construction (Workers per $Million)	5.1

For natural gas demand, labor productivity per unit of natural gas was unavailable, unlike coal labor productivities used above. Most secondary data sources (such as Census and EIA) provide estimates for the combined oil and gas extraction sector. This section thus used an adjusted labor productivity estimate for the combined oil and gas sector that accounts for the relative contributions of oil and natural gas in the total sector output (in terms of the value of energy output in MMBtu). This estimate of labor productivity was then used with the

[173] From EIA Annual Energy Review, Coal Mining Productivity Data. Used 2008.

[174] Unlike the labor productivity estimates for various equipment resources which were forecasted to 2020 using BLS average growth rates, this study uses the most recent historical productivity estimates for fuel sectors. In general, labor productivity for the fuel sectors (both coal and natural gas) showed a significantly higher degree of variability in recent years than the manufacturing sectors, which would have introduced a high degree of uncertainty in forecasting productivity growth rates for future years.

incremental natural gas demand for the respective IPM runs to estimate the job-years for the specific year (converting the TCF of gas used projected by IPM into MMBtu using the appropriate conversion factors). In addition, the pipeline construction costs were estimated using endogenously determined gas market model parameters in IPM used by EPA for the MATS rule (using assumptions for EPA's Base Case v4.10). This analysis assumed that the need for additional pipeline would be proportionate to those projected for the MATS rule and were hence extrapolated from those estimates.[175] The job-years associated with the pipeline construction were included in the natural gas employment estimates.

[175] See "Employment Estimates of Direct Labor in Response to the Proposed Toxics Rule in 2015". Technical Support Document, March 2011.

EXHIBIT 2

REGULATORY IMPACT ANALYSIS FOR THE CARBON POLLUTION EMISSION GUIDELINES SUPPLEMENTAL PROPOSAL

1 Introduction

On June 18, 2014, the Environmental Protection Agency (EPA) proposed emission guidelines for states to follow in developing plans to address greenhouse gas (GHG) emissions from existing fossil fuel-fired electric generating units (EGUs). In this supplemental action, the EPA is proposing emission guidelines for areas of Indian country and U.S. territories with existing fossil fuel-fired EGUs. Specifically, the EPA is proposing rate-based goals for carbon dioxide (CO_2) emissions from areas of Indian country and U.S. territories with existing fossil fuel-fired EGUs, as well as guidelines for plans to achieve the goals. This rule, as proposed, would continue progress already underway to reduce CO_2 emissions from existing fossil fuel-fired power plants in the United States. This regulatory impact analysis (RIA) examines the potential costs and benefits of the proposed goals.

2 Legal and Economic Basis for this Rulemaking

2.1 Statutory Requirement

On January 8, 2014, the EPA proposed standards for CO_2 emissions from newly constructed fossil fuel-fired EGUs under section 111(b) of the Clean Air Act (CAA) (79 FR 1430).[1] When the EPA establishes section 111(b) standards of performance for newly constructed, modified, or reconstructed sources in a particular source category for a pollutant that is not regulated as a criteria pollutant or hazardous air pollutant, the EPA must establish requirements for existing sources in that source category for that pollutant under section 111(d). Under section 111(d), the EPA develops "emission guidelines" that the states must develop plans to meet. On June 18, 2014, the EPA proposed state-specific rate-based goals for CO_2 emissions from the power sector, as well as guidelines for states to follow in developing plans to achieve

[1] 79 FR 1430.

Based upon the foregoing discussion, it is clear that this proposal's climate benefits alone are substantial and far outweigh the compliance costs for all of the regulatory options under the illustrative compliance approaches. The EPA could not monetize important categories of impacts. For example, in addition to reductions in CO_2 emissions, implementing these proposed guidelines is expected to reduce emissions of SO_2 and NO_X, which are precursors to formation of ambient $PM_{2.5}$, as well as directly emitted fine particles. Therefore, reducing these emissions would also reduce human exposure to ambient $PM_{2.5}$ and ozone precursors, thus the incidence of $PM_{2.5}$- and ozone related health effects.

4.3 Economic and Employment Impacts

Changes in supply or demand for electricity, natural gas, oil, and coal can impact markets for goods and services produced by sectors that use these energy inputs in the production process or that supply those sectors. Changes in cost of production may result in changes in price and/or quantity produced and these market changes may affect the profitability of firms and the economic welfare of their consumers. The EPA recognizes that these guidelines provide significant flexibilities and the areas implementing the guidelines may choose to mitigate impacts to some markets outside the EGU sector. Similarly, demand for new generation or energy efficiency can result in changes in production and profitability for firms that supply those goods and services. The guidelines provide flexibility for areas that may want to enhance demand for goods and services from those sectors.

Executive Order 13563 directs federal agencies to consider regulatory impacts on job creation and employment. According to the Executive Order, "our regulatory system must protect public health, welfare, safety, and our environment while promoting economic growth, innovation, competitiveness, and job creation. It must be based on the best available science" (Executive Order 13563, 2011). Although standard benefit-cost analyses can include macroeconomic analysis of net impacts on national employment they have not typically included a separate analysis of regulation-induced employment impacts in specific affected industries,[15] during periods of sustained high unemployment, sector-specific employment impacts are of particular concern and questions may arise about their existence and magnitude.

This section qualitatively discusses potential employment impacts of the Supplemental Proposal for areas of Indian country and territories. For a more detailed and quantitative discussion of employment impacts, please see Chapter 6 and Appendix 6A of the RIA for the June 2014 proposal. The June 2014 analysis uses cost projections from the engineering-based IPM to project sector-specific labor demand impacts of the proposed guidelines for the electricity generation sector (fossil and renewable), and the fuel production sector (coal and natural gas). The June 2014 RIA also projected labor requirements for demand-side energy efficiency activities.

In this supplemental proposal, the EPA is proposing emission guidelines for areas of Indian country and territories to use in developing plans to address greenhouse gas emissions from existing fossil fuel-fired EGUs. As mentioned in Section 4.1 of this RIA, EGUs in areas of Indian country are expected to meet the proposed goals based on existing generation decisions or compliance with other regulations for most of the evaluated options. As a result, we do not expect the proposed actions to have any impacts on employment in areas of Indian country.

In all of the approaches analyzed for the territories of Guam and Puerto Rico, the annualized costs of the illustrative compliance strategies are expected to be negative for each year in the analysis as a result of reductions in fuel expenditures that outweigh other costs of reducing emission. As each area has the responsibility and flexibility to implement policies and practices for compliance with Proposed EGU GHG Existing Source Guidelines, and, given the wide range of approaches that may be used, quantifying the associated employment impacts is difficult.

EGUs may respond to these proposed guidelines by placing new orders for efficiency-related or renewable energy equipment and services to reduce GHG emissions. Installing and operating new equipment or improving heat rate efficiency could increase labor demand in the electricity generating sector itself, as well as associated equipment and services sectors.

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[15] Labor expenses do, however, contribute toward total costs in the EPA's standard benefit-cost analyses.

Specifically, the direct employment effects of supply-side initiatives include changes in labor demand for manufacturing, installing, and operating higher efficiency or renewable energy electricity generating assets supported by the initiative while reducing the demand for labor that would have been used by less efficient or higher emitting generating assets. Once implemented, increases in operating efficiency would impact the power sector's demand for fuel and plans for EGU retirement and new construction.

In addition, EPA expects compliance plans to also include demand-side energy efficiency policies and programs that typically change energy consumption patterns of business and residential consumers by reducing the quantity of energy required for a given level of production or service. Demand-side initiatives generally aim to increase the use of cost-effective energy efficiency technologies (e.g., including more efficient appliances and air conditioning systems, more efficient lighting devices, more efficient design and construction of new homes and businesses), and advance efficiency improvements in motor systems and other industrial processes. Demand-side initiatives can also directly reduce energy consumption, such as through programs encouraging changing the thermostat during the hours a building is unoccupied or motion-detecting room light switches. Such demand-side energy efficiency initiatives directly affect employment by encouraging firms and consumers to shift to more efficient products and processes than would otherwise be the case. Employment in the sectors that provide these more efficient devices and services would be expected to increase, while employment in the sectors that produce less efficient devices would be expected to contract.

A critical component of the overall labor impacts of implementing the GHG guidelines is the impact of the labor associated with the demand-side energy efficiency activities. As the 2014 RIA indicated, the EPA anticipates that this rule may stimulate investment in clean energy technologies and services, resulting in considerable increases in demand-side energy efficiency in particular. We expect these increases in demand-side energy efficiency projects, specifically, to support a significant amount of employment in energy efficiency-related industries.

4.4 Limitations of Analysis

As discussed previously, in the absence of an optimization model for electric systems in Guam and Puerto Rico, this analysis does not attempt to find a least-cost solution to the illustrative compliance strategy. As a result, the approach taken to estimate the costs of

EXHIBIT 3

March 2011

Regulatory Impact Analysis of the Proposed Toxics Rule:

Final Report

Chapter 1
EXECUTIVE SUMMARY

This Regulatory Impact Analysis (RIA) presents the health and welfare benefits, costs, and other impacts of the proposed Toxics Rule (the Utility MACT and NSPS proposals) in 2016.

1.1 Key Findings

This proposed rule will reduce emissions of Hazardous Air Pollutants (HAP) including mercury from the electric power industry. As a co-benefit, the emissions of certain $PM_{2.5}$ precursors such as SO_2 will also decline. EPA estimates that this proposed rule will yield annual monetized benefits (in 2007$) of between $59 to $140 billion using a 3% discount rate and $53 and $130 billion using a 7% discount rate. The great majority of the estimates are attributable to co-benefits from reductions in $PM_{2.5}$-related mortality. The annual social costs are $10.9 billion (2007$) and the annual quantified net benefits are $48 to $130 billion using 3% discount rate or $42 to $120 billion using a 7% discount rate. The benefits outweigh costs by between 5 to 1 or 13 to 1 depending on the benefit estimate and discount rate used. The co-benefits are substantially attributable to the 6,800 to 17,000 fewer $PM_{2.5}$-related premature mortalities. There are some costs and important benefits that EPA could not monetize, such as those for the HAP being reduced by this proposed rule other than mercury. Upon considering these limitations and uncertainties, it remains clear that the benefits of the proposed Toxics Rule are substantial and far outweigh the costs. The annualized private compliance costs to the power industry in 2015 are $10.9 billion (2007$). Employment impacts associated with the proposed rule are estimated to be small. Effective policies to support end-use energy efficiency investments can reduce compliance costs and lessen impacts on electric rates and bills. In 2015, annualized private compliance costs to the industry are reduced by $0.3 billion (2007$) under an illustrative energy efficiency scenario.[1]

The benefits and costs in 2016 of the proposed rule are in Table 1-1.

[1] This is based on the illustrative energy efficiency sensitivity analysis discussed in Section 8.13 and Appendix D.

Table 1-1. Summary of EPA's Estimates of Benefits, Costs, and Net Benefits of the Proposed Toxics Rule in 2016[a] (billions of 2007$)

Description	Estimate (3% Discount Rate)	Estimate (7% Discount Rate)
Social costs[b]	$10.9	$10.9
Social benefits[c,d]	$59 to $140 + B	$53 to $130 + B
Net benefits (benefits-costs)	$48 to $130	$42 to $120

[a] All estimates are rounded to two significant digits and represent annualized benefits and costs anticipated for the year 2016. For notational purposes, unquantified benefits are indicated with a ―B" to represent the sum of additional monetary benefits and disbenefits. Data limitations prevented us from quantifying these endpoints, and as such, these benefits are inherently more uncertain than those benefits that we were able to quantify. A listing of health and welfare effects is provided in Table 1-5. Estimates here are subject to uncertainties discussed further in the body of the document.

[b] The reduction in premature mortalities account for over 90% of total monetized benefits. Valuation assumes discounting over the SAB-recommended 20-year segmented lag structure described in Chapter 6. Results reflect 3 percent and 7 percent discount rates consistent with EPA and OMB guidelines for preparing economic analyses (U.S. EPA, 2000; OMB, 2003).

[c] Social costs are estimated using the MultiMarket model, the model employed by EPA in this RIA to estimate economic impacts of the proposal to industries outside the electric power sector. This model does not estimate indirect impacts associated with a regulation such as this one. Details on the social cost estimates can be found in Chapter 9 and Appendix E of this RIA.

[d] Potential benefit categories that have not been quantified and monetized are listed in Table 1-5.

1.1.1 Health Benefits

The proposed Toxics Rule is expected to yield significant health benefits by reducing emissions not only of HAP such as mercury, but also significant co-benefits due to reductions in direct fine particles and in two key contributors to fine particle formation. Sulfur dioxide contributes to the formation of fine particle pollution ($PM_{2.5}$), and nitrogen oxide contributes to the formation of $PM_{2.5}$.

Our analyses suggest this rule would yield benefits in 2016 of $59 to $140 billion (based on a 3 percent discount rate) and $53 to $130 billion (based on a 7 percent discount rate). This estimate reflects the economic value of a range of avoided health outcomes, including 510 fewer mercury-related IQ points lost as well as a variety of avoided $PM_{2.5}$-related impacts, including 6,800 to 17,000 premature deaths, 11,000 nonfatal heart attacks, 5,300 hospitalizations for respiratory and cardiovascular diseases, 850,000 lost work days and 5.1 million days when adults restrict normal activities because of respiratory symptoms exacerbated by $PM_{2.5}$. This rule is also likely to produce significant ozone-related benefits, which we were unable to quantify in the RIA due to the limitations of the scaling approach used to estimate benefits; further details may be found in the benefits chapter.

We also estimate substantial additional health improvements for children from reductions in upper and lower respiratory illnesses, acute bronchitis, and asthma attacks. See Table 1-2 for a list of the annual reduction in health effects expected in 2016 and Table 1-3 for the estimated value of those reductions.

We also include in our monetized benefits estimates the effect from the reduction in CO_2 emissions that is an outcome of this proposal. We calculate the benefits associated with these emission reductions using the social cost of carbon (SCC) approach, an approach that has been used to estimate such benefits in several recent rulemakings (e.g., proposed Transport Rule, final industrial boilers major and source area sources rules).

1.1.2 Welfare Benefits

The term *welfare benefits* covers both environmental and societal benefits of reducing pollution, such as reductions in damage to ecosystems, improved visibility and improvements in recreational and commercial fishing, agricultural yields, and forest productivity.

Table 1-2. Estimated Reduction in Incidence of Adverse Health Effects in 2016 for the Proposed Toxics Rule[a,b]

Health Effect	*Eastern U.S.*	*Western U.S.*	*Total*
Mercury-Related endpoints			
IQ Points Lost			510.8
PM-Related endpoints			
Premature death			
Pope et al. (2002) (age >30)	6,700 (1,900—12,000)	120 (33—200)	6,800 (1,900—12,000)
Laden et al. (2006) (age >25)	17,000 (7,900—26,000)	300 (140—470)	17,000 (8,100—27,000)
Infant (< 1 year)	29 (-32—90)	1 (-1—2)	30 (-33—92)
Chronic bronchitis	4,400 (150—8,600)	97 (3—190)	4,500 (150—8,800)
Non-fatal heart attacks (age > 18)	11,000 (2,700—18,000)	190 (48—330)	11,000 (2,700—19,000)
Hospital admissions—respiratory (all ages)	1,600 (650—2,600)	24 (10—39)	1,700 (660—2,600)
Hospital admissions—cardiovascular (age > 18)	3,500 (2,500—4,200)	50 (35—61)	3,600 (2,500—4,200)
Emergency room visits for asthma (age < 18)	6,900 (3,500—10,000)	52 (27—78)	6,900 (3,600—10,000)
Acute bronchitis (age 8-12)	10,000 (-2,300—23,000)	250 (-57—560)	11,000 (-2,400—23,000)
Lower respiratory symptoms (age 7-14)	120,000 (47,000—200,000)	3,000 (1,100—4,800)	130,000 (48,000—200,000)
Upper respiratory symptoms (asthmatics age 9-18)	93,000 (17,000—170,000)	2,300 (420—4,100)	95,000 (18,000—170,000)
Asthma exacerbation (asthmatics 6-18)	110,000 (4,000—380,000)	2,700 (96—9,300)	120,000 (4,100—390,000)
Lost work days (ages 18-65)	830,000 (710,000—960,000)	20,000 (17,000—22,000)	850,000 (720,000—980,000)
Minor restricted-activity days (ages 18-65)	5,000,000 (4,000,000—5,900,000)	110,000 (94,000—140,000)	5,100,000 (4,100,000—6,000,000)

[a] Estimates rounded to two significant figures; column values will not sum to total value.

[b] The negative estimates for certain endpoints are the result of the weak statistical power of the study used to calculate these health impacts and do not suggest that increases in air pollution exposure result in decreased health impacts.

Table 1-3. Estimated Monetary Value of Reductions in Incidence of Health and Welfare for the Proposed Toxics Rule (in billions of 2007$)[a,b,c]

Health Effect		*Eastern U.S.*	*Western U.S.*	*Total*
Avoided IQ Loss Associated with Methylmercury Exposure from Self-Caught Fish Consumption among Recreational Anglers				
3% discount rate				$0.004 - $0.006
7% discount rate				$0.000005 - $0.000009
Adult premature death (Pope et al. 2002 PM mortality estimate)				
3% discount rate	$PM_{2.5}$	$53 ($4.2—$160)	$0.9 ($0.1—$2.8)	$54 ($4.3—$160)
7% discount rate	$PM_{2.5}$	$48 ($3.8—$140)	$0.8 ($0. 1—$2.5)	$48 ($3.8—$150)
Adult premature death (Laden et al. 2006 PM mortality estimate)				
3% discount rate	$PM_{2.5}$	$140 ($12—$390)	$2.4 ($0.2—$6.9)	$140 ($12—$400)
7% discount rate	$PM_{2.5}$	$120 ($11—$350)	$2.2 ($0.2—$6.3)	$120 ($11—$360)
Infant premature death	$PM_{2.5}$	$0.3 ($-0.3—$1.2)	<$0.01	$0.3 ($-0.3—$1.2)
Chronic Bronchitis	$PM_{2.5}$	$2.1 ($0.1—$9.6)	$0.05 (<$0.01—$0.2)	$2.1 ($0.1—$9.8)
Non-fatal heart attacks				
3% discount rate	$PM_{2.5}$	$1.2 ($0.2—$2.9)	$0.02 (<$0.01—$0.05)	$1.2 ($0.2—$2.9)
7% discount rate	$PM_{2.5}$	$1.1 ($0.2—$2.8)	$0.02 (<$0.01—$0.03)	$1.2 ($0.2—$2.9)
Hospital admissions—respiratory	$PM_{2.5}$	<$0.01	<$0.01	$0.02 ($0. 01—$0.03)
Hospital admissions—cardiovascular	$PM_{2.5}$	<$0.01	<$0.01	$0.1 ($0.05—$0.14)
Emergency room visits for asthma	$PM_{2.5}$	<$0.01	<$0.01	<$0.01
Acute bronchitis	$PM_{2.5}$	<$0.01	<$0.01	<$0.01
Lower respiratory symptoms	$PM_{2.5}$	<$0.01	<$0.01	<$0.01
Upper respiratory symptoms	$PM_{2.5}$	<$0.01	<$0.01	<$0.01
Asthma exacerbation	$PM_{2.5}$	<$0.01	<$0.01	<$0.01
Lost work days	$PM_{2.5}$	$0.1 ($0.1—$0.1)	<$0.01	$0.1 ($0.1—$0.1)
Minor restricted-activity days	$PM_{2.5}$	$0.3 ($0.2—$0.5)	<$0.01	$0.3 ($0.2—$0.5)
Social cost of carbon (3% discount rate, 2016 value)	CO_2			$0.57

(continued)

Table 1-3. Estimated Monetary Value of Reductions in Incidence of Health and Welfare for the Proposed Toxics Rule (in billions of 2007$)[a,b,c] (continued)

Health Effect	*Eastern U.S.*	*Western U.S.*	*Total*
Monetized total Benefits			
(Pope et al. 2002 $PM_{2.5}$ mortality estimate)			
3% discount rate	$57 ($4.6—$170)	$1 ($0.1—$3.1)	$59 ($4.6—$180)
7% discount rate	$52 ($4.1—$160)	$0.9 ($0.1—$2.8)	$53 ($4.2—$160)
(Laden et al. 2006 $PM_{2.5}$ mortality estimate)			
3% discount rate	$140 ($12—$410)	$2.5 ($0.2—$7.2)	$140 ($12—$410)
7% discount rate	$130 ($11—$370)	$2.2 ($0.2—$6.6)	$130 ($11—$370)

[a] Estimates rounded to two significant figures. The negative estimates for certain endpoints are the result of the weak statistical power of the study used to calculate these health impacts and do not suggest that increases in air pollution exposure result in decreased health impacts. Confidence intervals reflect random sampling error and not the additional uncertainty associated with benefits scaling described above.

[1] The national scale assessment conducted for the RIA focuses on the exposures to methylmercury in populations who consume self-caught freshwater fish (recreational fishers and their families, especially women of child-bearing age). Benefits reflect estimated avoided IQ loss for children, as projected based on fertility rates applied to the women of child-bearing age, among all recreational freshwater anglers in the 48 contiguous U.S. states.

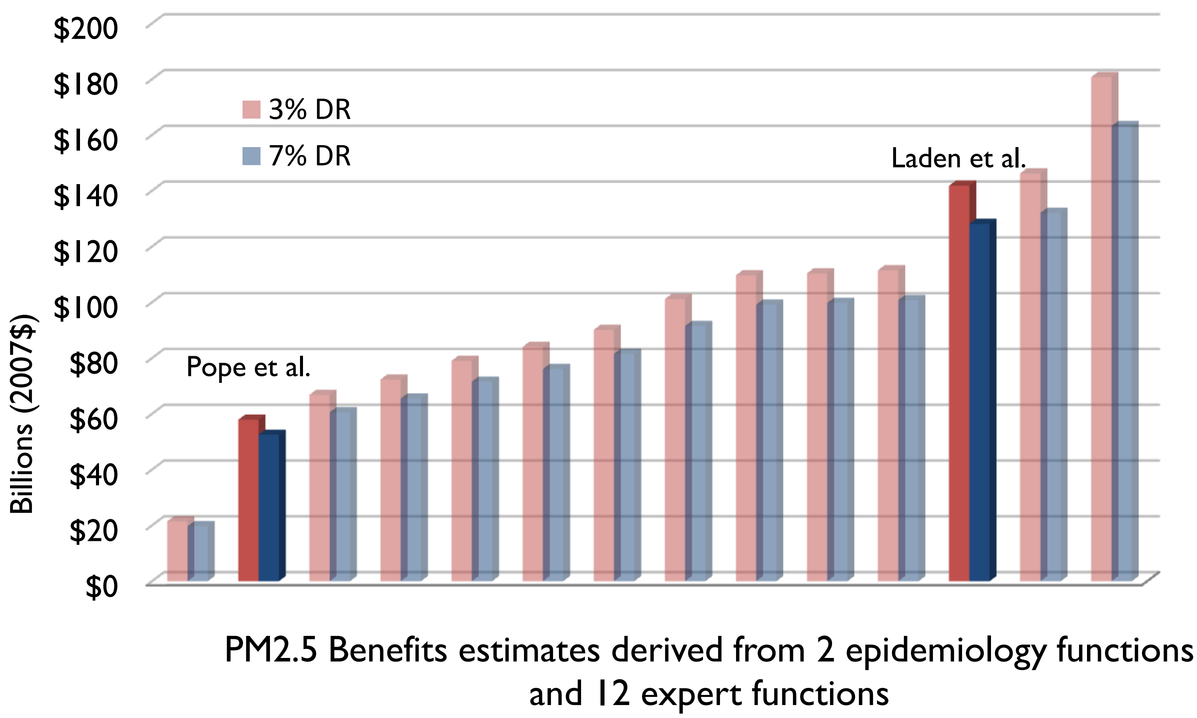
[2] As noted in chapter 5, monetized benefits estimates are for an immediate change in MeHg levels in fish (i.e., the potential lag period associated with fully realizing fish tissue MeHg levels was not reflected in benefits modeling). If a lag in the response of MeHg levels in fish were assumed, the monetized benefits could be significantly lower, depending on the length of the lag and the discount rate used. As noted in the discussion of the Mercury Maps modeling, the relationship between deposition and fish tissue MeHg is proportional in equilibrium, but the MMaps approach does not provide any information on the time lag of response.

[3] Monetized benefits estimates reported here are for the implementation year: 2016. As such, certain health endpoints that take years to manifest, such as avoided IQ loss from MeHg prenatal exposure, may not be fully quantified in the analysis year.

Figure 1-1 summarizes an array of $PM_{2.5}$-related monetized benefits estimates based on alternative epidemiology and expert-derived PM-mortality estimate.

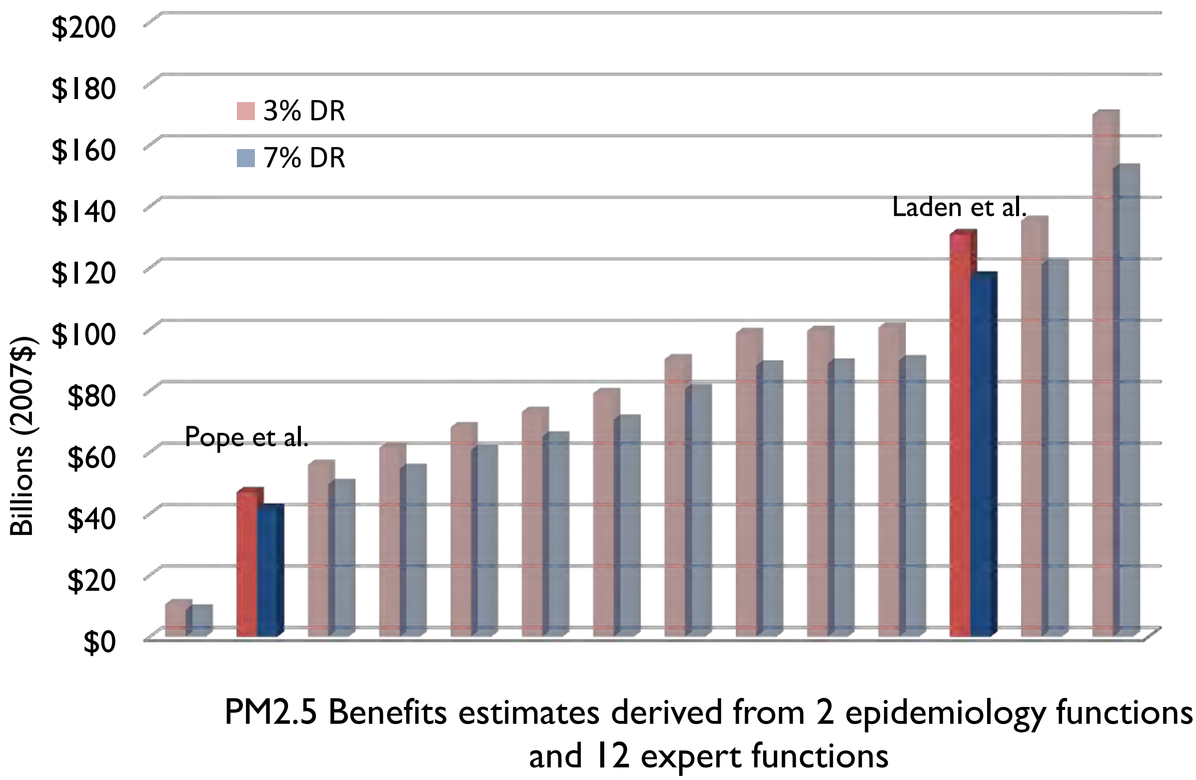
Figure 1-2 summarizes the estimated net benefits for the proposed rule by displaying all possible combinations of PM and ozone-related monetized benefits and costs. Each of the 14 bars in each graph represents a separate point estimate of net benefits under a certain combination of cost and benefit estimation methods. Because it is not a distribution, it is not possible to infer the likelihood of any single net benefit estimate.

Figure 1-1. Estimated Monetized Value of Estimated $PM_{2.5}$- Related Premature Mortalities Avoided According to Epidemiology or Expert-derived Derived PM Mortality Risk Estimate[a]



[A] Column total equals sum of $PM_{2.5}$-related mortality and morbidity benefits.

Figure 1-2. Net Benefits of the Toxics Rule According to $PM_{2.5}$ Epidemiology or Expert-derived Mortality Risk Estimate[a]



[A] Column total equals sum of $PM_{2.5}$-related mortality and morbidity.

1.2 Not All Benefits Quantified

EPA was unable to quantify or monetize all of the health and environmental benefits associated with the proposed Toxics Rule. EPA believes these unquantified benefits are substantial, including the overall value associated with HAP reductions, value of increased agricultural crop and commercial forest yields, visibility improvements, and reductions in nitrogen and acid deposition and the resulting changes in ecosystem functions. Table 1-4 provides a list of these benefits.

Table 1-4. Human Health and Welfare Effects of Pollutants Affected by the Toxics Rule

Pollutant/ Effect	*Quantified and monetized in base estimate*	*Unquantified*
PM: health[a]	Premature mortality based on cohort study estimates[b] and expert elicitation estimates Hospital admissions: respiratory and cardiovascular Emergency room visits for asthma Nonfatal heart attacks (myocardial infarctions) Lower and upper respiratory illness Minor restricted activity days Work loss days Asthma exacerbations (among asthmatic populations Respiratory symptoms (among asthmatic populations) Infant mortality	Low birth weight, pre-term birth and other reproductive outcomes Pulmonary function Chronic respiratory diseases other than chronic bronchitis Non-asthma respiratory emergency room visits UVb exposure (+/-)[c]
PM: welfare		Visibility in Class I areas in SE, SW, and CA regions[d] Household soiling Visibility in residential areas Visibility in non-class I areas and class 1 areas in NW, NE, and Central regions UVb exposure (+/-)[c] Global climate impacts[c]
Ozone: health		Premature mortality based on short-term study estimates Hospital admissions: respiratory Emergency room visits for asthma Minor restricted activity days School loss days Chronic respiratory damage Premature aging of the lungs Non-asthma respiratory emergency room visits UVb exposure (+/-)[c]
Ozone: welfare		Decreased outdoor worker productivity Yields for: --Commercial forests --Fruits and vegetables, and --Other commercial and noncommercial crops Damage to urban ornamental plants Recreational demand from damaged forest aesthetics Ecosystem functions UVb exposure (+/-)[c] Climate impacts

Pollutant/ Effect	*Quantified and monetized in base estimate*	*Unquantified*
NO_2: health		Respiratory hospital admissions Respiratory emergency department visits Asthma exacerbation Acute respiratory symptoms Premature mortality Pulmonary function
NO_X: welfare		Commercial fishing and forestry from acidic deposition effects Commercial fishing, agriculture and forestry from nutrient deposition effects Recreation in terrestrial and estuarine ecosystems from nutrient deposition effects Other ecosystem services and existence values for currently healthy ecosystems Coastal eutrophication from nitrogen deposition effects
SO_2: health		Respiratory hospital admissions Asthma emergency room visits Asthma exacerbation Acute respiratory symptoms Premature mortality Pulmonary function
SO_X: welfare		Commercial fishing and forestry from acidic deposition effects Recreation in terrestrial and aquatic ecosystems from acid deposition effects Increased mercury methylation
Mercury: health		Impaired cognitive development Problems with language Abnormal social development Potential for fatal and non-fatal AMI (heart attacks) Association with genetic effects Possible autoimmunity effects in antibodies
Mercury: welfare		Neurological, behavioral, reproductive and survival effects in wildlife (birds, fish, and mammals)

[A] In addition to primary economic endpoints, there are a number of biological responses that have been associated with PM health effects including morphological changes and altered host defense mechanisms. The public health impact of these biological responses may be partly represented by our quantified endpoints.

[B] Cohort estimates are designed to examine the effects of long term exposures to ambient pollution, but relative risk estimates may also incorporate some effects due to shorter term exposures (see Kunzli et al., 2001 for a discussion of this issue). While some of the effects of short term exposure are likely to be captured by the cohort estimates, there may be additional premature mortality from short term PM exposure not captured in the cohort estimates included in the primary analysis.

[C] May result in benefits or disbenefits.

[D] Visibility-related benefits quantified in air quality modeled scenario, but not the revised scenario. The total benefits reported in Table 1-1 do not reflect visibility benefits.

1.3 Costs, Economic, and Employment Impacts

The projected annual incremental private costs of the proposed Toxics Rule to the electric power industry are $10.9 billion in 2015. These costs represent the total cost to the electricity-generating industry of reducing HAP emissions to meet the emissions limits set out in the rule. Estimates are in 2007 dollars. These costs of the rule are estimated using the Integrated Planning Model (IPM).

There are several national changes in energy prices that result from the proposed Toxics Rule. Retail electricity prices are projected to increase nationally by an average of 3.7% in 2015 with the proposed Toxics Rule. On a weighted average basis, consumer natural gas price impacts are anticipated to range from 0.6% to 1.3% based on consumer class in response to the proposed Toxics Rule between 2015 and 2030.

There are several other types of energy impacts associated with the proposed Toxics Rule. A small amount of coal-fired capacity, about 9.9 GW (3 percent of all coal-fired capacity and 1 percent of all generating capacity in 2015), is projected to be uneconomic to maintain. These units are predominantly smaller and less frequently-used generating units dispersed throughout the area affected by the rule. If current forecasts of either natural gas prices or electricity demand were revised in the future to be higher, that would create a greater incentive to keep these units operational. Coal production for use in the power sector is projected to decrease by less than 2 percent by 2015, and we expect slightly reduced coal demand in Appalachia and the West with the proposed Toxics Rule.

Effective policies to support end-use energy efficiency investments can reduce compliance costs, lessen impacts on electric rates and bills, and reduce the need for new capacity. In 2015 and 2020, annualized private compliance costs to the industry are reduced by $0.3 billion (2007$) and $1.1 billion, respectively, under an energy efficiency scenario. Furthermore, the impacts of the Toxics Rule on retail electricity prices are reduced by 0.04 cents/kWh and 0.38 cents/kWh in 2015 and 2020, respectively, and the need for new capacity is reduced by 0.3 GW and 8.5 GW, respectively, in 2015 and 2020 under an energy efficiency scenario.

In addition to addressing the costs and benefits of the proposed Utility Air Toxics Rule (Toxics Rule), EPA has estimated a portion of the employment impacts of this rulemaking. We have estimated two types of impacts. One provides an estimate of the employment impacts on the regulated industry over time. The second covers the short-term employment impacts associated with the construction of needed pollution control equipment until the compliance date of the regulation. We expect that the rule's impact on employment will be small, but will (on net) result in an increase in employment.

The approaches to estimate employment impacts use different analytical techniques and are applied to different industries during different time periods, and they use different units of analysis. No overlapping estimates are summed. Estimates from Morgenstern et al. (2002) are used to calculate the ongoing annual employment impacts for the regulated entities (the electric power sector). The short term estimates for employment needed to design, construct, and install the control equipment in the three or four year period before the compliance date are also provided using an approach that estimates employment impacts for the environmental protection sector. Finally some of the other types of employment impacts that will be ongoing are estimated but not summed because they omit some potentially important categories.

In Table 1-5, we show the employment impacts of the Toxics Rule as estimated by the environmental protection sector approach and by the Morgenstern approach.

Table 1-5. Estimated Employment Impact Table

	Annual (reoccurring)	**One time (construction during compliance period)**
Environmental Protection Sector approach*	Not Applicable	30,900
Net Effect on Electric Utility Sector Employment from Morgenstern et al. approach***	9,000** -17, 000 to +35,000****	Not Applicable

*These one-time impacts on employment are estimated in terms of job-years.

**This estimate is not statistically different from zero.

**These annual or reoccurring employment impacts are estimated in terms of production workers as defined by the US Census Bureau's Annual Survey of Manufacturers (ASM).

**** 95% confidence interval

1.4 Small Entity and Unfunded Mandates Impacts

After preparing an analysis of small entity impacts, EPA cannot certify that this proposal will not have a no SISNOSE (significant economic impacts on a substantial number of small entities). Of the 83 small entities affected, 59 are projected to have costs greater than 1 percent of their revenues. EPA's decision to exclude units smaller than 25 Megawatt capacity (MW) as per the requirements of the Clean Air Act has already significantly reduced the burden on small entities, and EPA participated in a Small Business Regulatory Enforcement Fairness Act

(SBREFA) to examine ways to mitigate the impact of the proposed Toxics Rule on affected small entities

EPA examined the potential economic impacts on state and municipality-owned entities associated with this rulemaking based on assumptions of how the affected states will implement control measures to meet their emissions. These impacts have been calculated to provide additional understanding of the nature of potential impacts and additional information.

According to EPA's analysis, of the 96 government entities considered in this, 55 may experience compliance costs in excess of 1 percent of revenues in 2015, based on our assumptions of how the affected states implement control measures to meet their emissions budgets as set forth in this rulemaking.

Government entities projected to experience compliance costs in excess of 1 percent of revenues may have some potential for significant impact resulting from implementation of the Toxics Rule.

1.5 Limitations and Uncertainties

Every analysis examining the potential benefits and costs of a change in environmental protection requirements is limited to some extent by data gaps, limitations in model capabilities (such as geographic coverage), and variability or uncertainties in the underlying scientific and economic studies used to configure the benefit and cost models. Despite the uncertainties, we believe this benefit-cost analysis provides a reasonable indication of the expected economic benefits and costs of the proposed Toxics Rule.

For this analysis, such uncertainties include possible errors in measurement and projection for variables such as population growth and baseline incidence rates; uncertainties associated with estimates of future-year emissions inventories and air quality; variability in the estimated relationships between changes in pollutant concentrations and the resulting changes in health and welfare effects; and uncertainties in exposure estimation.

Below is a summary of the key uncertainties of the analysis:

Costs

- Analysis does not capture employment shifts as workers are retrained at the same company or re-employed elsewhere in the economy.

- We do not include the costs of certain relatively small permitting costs associated with Title V that new program entrants face.
- Technological innovation is not incorporated into these cost estimates. Thus, these cost estimates may be potentially higher than what may occur in the future, all other things being the same.

Benefits

- The mercury concentration estimates for the analysis come from several different sources
- The mercury concentration estimates used in the model were based on simple temporal and spatial averages of reported fish tissue samples. This approach assumes that the mercury samples are representative of ―local" conditions (i.e., within the same HUC 12) in similar waterbodies (i.e., rivers or lakes).
- State-level averages for fishing behavior of recreational anglers are applied to each modeled census tract in the state; which does not reflect within-state variation in these factors.
- Application of state-level fertility rates to specific census tracts (and specifically to women in angler households.
- Applying the state-level individual level fishing participation rates to approximate the household fishing rates conditions at a block level.
- Populations are only included in the model if they are within a reasonable distance of a waterbody with fish tissue MeHg samples. This approach undercounts the exposed population (by roughly 40 to 45%) and leads to underestimates of national aggregate baseline exposures and risks and underestimates of the risk reductions and benefits resulting from mercury emission reductions.
- Assumption of 8 g/day fish consumption rate for the general population in freshwater angler households.
- The dose-response model used to estimate neurological effects on children because of maternal mercury body burden has several important uncertainties, including selection of IQ as a primary endpoint when there may be other more sensitive

endpoints, selection of the blood-to-hair ratio for mercury, and the dose-response estimates from the epidemiological literature. Control for confounding from the potentially positive cognitive effects of fish consumption and, more specifically, omega-3 fatty acids.

- Valuation of IQ losses using a lost earning approach has several uncertainties, including (1) there is a linear relationship between IQ changes and net earnings losses, (2) the unit value applies to even very small changes in IQ, and (3) the unit value will remain constant (in real present value terms) for several years into the future. Each unit value for IQ losses has two main sources of uncertainty (1). The statistical error in the average percentage change in earnings as a result of IQ changes and (2) estimates of average lifetime earnings and costs of schooling. Most of the estimated PM-related benefits in this rule accrue to populations exposed to higher levels of $PM_{2.5}$. Of these estimated PM-related mortalities avoided, about 30% occur among populations initially exposed to annual mean $PM_{2.5}$ level of 10 $\mu g/m^3$ and about 80% occur among those initially exposed to annual mean $PM_{2.5}$ level of 7.5 $\mu g/m^3$; these are the lowest air quality levels considered in the Laden et al. (2006) and Pope et al. (2002) studies, respectively. This fact is important, because as we estimate PM-related mortality among populations exposed to levels of $PM_{2.5}$ that are successively lower, our confidence in the results diminishes. However, our analysis shows that a substantial portion of the impacts occur at higher exposures.

- There are uncertainties related to the health impact functions used in the analysis. These include: within study variability; across study variation; the application of concentration-response (C-R) functions nationwide; extrapolation of impact functions across population; and various uncertainties in the C-R function, including causality and thresholds. Therefore, benefits may be under- or over-estimates.

- Analysis is for 2016, and projecting key variables introduces uncertainty. Inherent in any analysis of future regulatory programs are uncertainties in projecting atmospheric conditions and source level emissions, as well as population, health baselines, incomes, technology, and other factors.

- This analysis omits certain unquantified effects due to lack of data, time and resources. These unquantified endpoints include other health and ecosystem effects. EPA will continue to evaluate new methods and models and select those most appropriate for estimating the benefits of reductions in air pollution. Enhanced collaboration between air quality modelers, epidemiologists, toxicologists, ecologists, and economists should result in a more tightly integrated analytical framework for measuring benefits of air pollution policies.

- $PM_{2.5}$ mortality benefits represent a substantial proportion of total monetized benefits (over 90%), and these estimates have following key assumptions and uncertainties.

1. The $PM_{2.5}$ -related benefits of the alternative scenarios were derived through a benefit per-ton approach, which does not fully reflect local variability in population density, meteorology, exposure, baseline health incidence rates, or other local factors that might lead to an over-estimate or under-estimate of the actual benefits of controlling SO_2.
2. We assume that all fine particles, regardless of their chemical composition, are equally potent in causing premature mortality. This is an important assumption, because $PM_{2.5}$ produced via transported precursors emitted from EGUs may differ significantly from direct $PM_{2.5}$ released from diesel engines and other industrial sources, but no clear scientific grounds exist for supporting differential effects estimates by particle type.
3. We assume that the health impact function for fine particles is linear within the range of ambient concentrations under consideration. Thus, the estimates include health benefits from reducing fine particles in areas with varied concentrations of $PM_{2.5,}$ including both regions that are in attainment with fine particle standard and those that do not meet the standard down to the lowest modeled concentrations.
4. To characterize the uncertainty in the relationship between $PM_{2.5}$ and premature mortality, we include a set of twelve estimates based on results of the expert elicitation study in addition to our core estimates. Even these multiple characterizations omit the uncertainty in air quality estimates, baseline incidence rates, populations exposed and transferability of the effect estimate to diverse locations. As a result, the reported confidence intervals and range of estimates give an incomplete picture about the overall uncertainty in the $PM_{2.5}$ estimates. This information should be interpreted within the context of the larger uncertainty surrounding the entire analysis.

1.6 References

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Chapter 9
ECONOMIC AND EMPLOYMENT IMPACTS

9.1 Partial Equilibrium Analysis (Multiple Markets)

Our partial equilibrium analysis uses a market model that simulates how stakeholders (consumers and industries) might respond to the additional regulatory program costs. In this section, we provide an overview of the economic model and the results for a short-run economic impact analysis (in this case, for 2016, the analysis year for this RIA). More details on the economic model, the results, and data used by the model can be found in Appendix E.

9.1.1 Overview

Although several tools are available to estimate social costs, current EPA guidelines suggest that multimarket models ―. . .are best used when potential impacts on related markets might be considerable" and modeling using a computable general equilibrium model is not available or practical (EPA, 2010, p. 9-21). Other guides for environmental economists offer similar advice (Berck and Hoffmann, 2002; Just, Hueth, and Schmitz, 2004). Multimarket models focus on ―short-run" time horizons and measure a policy's near-term or transition costs (EPA, 1999). Our multimarket model contains the following features:

- Industry sectors and benchmark data set
  - 100 industry sectors
  - multiple benchmark years
- Economic behavior
  - industries respond to regulatory costs by changing production rates
  - market prices rise and fall to reflect higher energy and other non-energy material costs and changes in demand
  - customers respond to price increases and consumption falls
- Model scope
  - 100 sectors are linked with each other based on their use of energy and other non-energy materials. For example, the construction industry is linked with the petroleum, cement, and steel industries and is influenced by price changes that occur in each sector. The links allow EPA to account for indirect effects the regulation has on related markets.
  - production adjustments influence employment levels
  - international trade (imports/exports) responds to domestic price changes

- Model time horizon (―short run") for a single period (2015)[1]
  - fixed production resources (e.g., capital) lead to an upward-sloping industry supply function
  - firms cannot alter certain input mixes; there is no substitution among intermediate production inputs
  - there is no explicit labor market (a real wage and labor supply is not determined within the model)
  - investment and government expenditures are fixed.

  Although the model is intended to examine transition or short-term effects of this rulemaking, the results may be muted due to the use of annualized capital cost as an input to the model rather than the total capital cost.

9.1.2 Economic Impact Analysis Results

Market-Level Results

Market-level impacts include price and quantity adjustments including the changes in international trade (Table 9-1). Under the Toxics rule, the Agency's economic model suggests the average national price increase for energy is 0.8%. Higher energy costs result in subsequent manufacturing sector price increases nationwide of 0.1% or less. Imports also slightly rise because of higher U.S. prices. The one exception is transportation services; since sectors using transportation services are producing less, the demand for transportation services declines. The size of the transportation services demand shift outweighs any supply side cost increases that place upward pressure on service prices (e.g. higher electricity and refined petroleum prices). As a result, the average transportation services price falls.

Social Cost Estimates Toxics Rule

In the short run, the Agency's partial equilibrium multi-market model suggests that industries are able to pass on $8.4 billion (2007$) of the Toxic Rule's costs to U.S. households in the form of higher prices (Table 9-2). Existing U.S. industries' surplus falls by $2.6 billion and the net U.S. loss in aggregate, is $11.0 billion (2007$). This is slightly higher than the annualized nationwide compliance cost estimate of the proposal as shown in Chapter 8 of the RIA because it excludes gains to other countries discussed below.

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[1] For this analysis, we use 2015 as our analysis year and as a proxy for 2016. This allows us to maintain consistency with the results of the analysis using IPM (found in Chapter 8) that serve as inputs to this economic impact analysis.

Table 9-1. Short-Term Market-Level Changes within the U.S. Economy in 2015

Industry Sector	U.S. Prices	U.S. Production	Imports	U.S. Consumption	Exports
Energy	0.769%	−0.120%	0.035%	−0.072%	−0.120%
Coal	−0.078%	−0.215%	−0.167%	−0.214%	0.008%
Crude Oil Extraction	0.018%	−0.234%	0.068%	−0.011%	0.000%
Electric generation	3.770%	−0.261%	0.000%	−0.261%	−0.592%
Natural Gas	0.018%	−0.142%	0.217%	−0.075%	−0.005%
Refined Petroleum	0.011%	−0.011%	0.010%	−0.007%	−0.001%
Nonmanufacturing	0.003%	−0.012%	0.005%	−0.010%	−0.003%
Manufacturing					
Food, beverages, and textiles	0.018%	−0.023%	0.025%	−0.013%	−0.014%
Lumber, paper, and printing	0.035%	−0.023%	0.035%	−0.017%	−0.024%
Chemicals	0.009%	−0.024%	0.010%	−0.017%	−0.009%
Plastics and Rubber	0.026%	−0.026%	0.029%	−0.017%	−0.026%
Nonmetallic Minerals	0.048%	−0.029%	0.043%	−0.018%	−0.040%
Primary Metals	0.031%	−0.041%	0.028%	−0.024%	−0.030%
Fabricated Metals	0.026%	−0.016%	0.028%	−0.011%	−0.013%
Machinery and Equipment	0.003%	−0.015%	0.002%	−0.010%	−0.004%
Electronic Equipment	0.003%	−0.017%	0.004%	−0.008%	−0.007%
Transportation Equipment	0.004%	−0.011%	0.005%	−0.007%	−0.009%
Other	0.011%	−0.027%	0.017%	−0.011%	−0.014%
Wholesale and Retail Trade	0.007%	−0.008%	0.005%	−0.008%	−0.005%
Transportation Services	−0.012%	−0.015%	−0.011%	−0.014%	0.010%
Other Services	0.007%	−0.008%	0.003%	−0.007%	−0.005%

Note: Approximated using the IPM cost analysis. For example, with the $11 billion increase in compliance costs for the electric power sector, IPM projects a 3.77 percent increase in the retail price of electricity. All other energy market-level changes are determined within the multimarket model. Appendix F provides additional details.

As U.S. prices rise, other countries are affected through international trade relationships. The price of goods produced in the United States increase, domestic exports decline, and domestic production is replaced to a certain degree by imports; the model estimates a net gain of about $0.1 billion for other countries. The net change in total surplus is *lower* than the annualized nationwide compliance cost estimate of the proposal as shown in Chapter 8 of the RIA. Our estimate of social costs for the proposal incorporates the net change in total surplus, and this estimate is $10.9 billion (2007 dollars) as shown in Table 9-2, or nearly identical to the compliance costs.[2] Compliance costs based on the pre-policy output levels would be overstated if we do not consider the new lower levels of consumption as a result of higher market prices.[3]

[2] The same is true for many recent rulemakings, including the Boiler MACT.

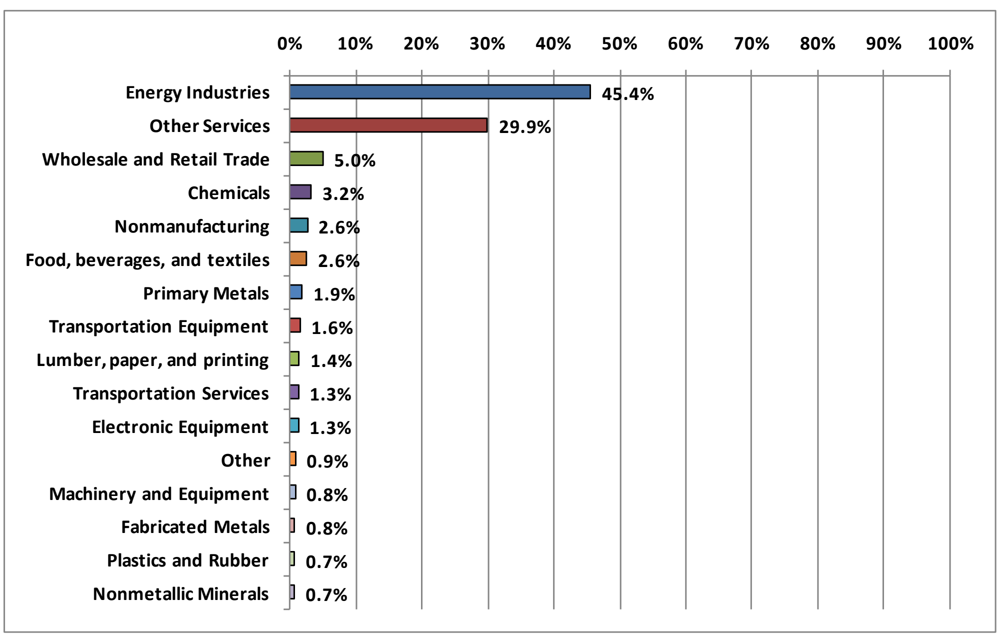
[3] There are small additional losses associated with the foregone benefits associated with reduced consumption (e.g. deadweight loss). However, in a perfectly competitive market without pre-existing distortions, the costs represent only a small fraction of total social costs. A more detail discussion of the economic costs of regulation are discussed in Chapter 8 of EPA (2010).

Table 9-2. Distribution of Social Costs (billions, 2007$): 2015

Change in U.S. consumer surplus	−$8.4
Change in U.S. producer surplus	−$2.6
Net Change in U.S. Surplus	**−$11.0**
Net change in rest of world surplus	$0.1
Net change in Total Surplus	**−$10.9**

As shown in Figure 9-1, the surplus losses are concentrated in the electric generation sector (45.4 percent) and other services (29.9 percent). Other services include information, finance and insurance, real estate, professional services, management, administrative services, education, health care, arts, accommodations, and public services. Although electricity costs represent a small share of total service industry production costs, the service sectors represent a significant economic sector within the U.S. economy and use a large amount of electricity. The transition or short-term evaluation using a partial equilibrium model does not allow for resources to be allocated according to price changes. So the results of the model does not capture any distortions in the economy that may results as the price of electricity changes. If the distortions are significant, the ―true" social cost would be higher than the compliance cost and the results of this partial equilibrium model.

Figure 9-1. Distribution of Total Surplus Change ($10.9 billion) by Sector



9.1.3 Alternative Approach to Estimating Social Cost

In the Transport Rule proposed last summer, EPA used a different model to estimate the social cost of the regulatory approach than applied in this RIA. That model, EPA‗s Economic Model for Policy Analysis (EMPAX), is a computable general equilibrium model (CGE) which dynamically cascades the cost of a regulation through the entire economy. However, since that rule was proposed, an updated version of EMPAX was used to estimate the social cost of the Clean Air Act in a new EPA report entitled ―The Benefits and Costs of the Clean Air Act from 1990 to 2020. This report is available at http://www.epa.gov/air/sect812/feb11/fullreport.pdf.

This updated version of EMPAX added in the benefit-side effects (incorporating labor-force and health care expenditures) which significantly changed the social cost estimate from the previous edition. In December 2010, EPA‗s Science Advisory Board (SAB) found that ―The inclusion of benefit-side effects (reductions in mortality, morbidity, and health-care expenditures) in a computable general equilibrium (CGE) model represents a significant step forward in benefit-cost analysis." http://yosemite.epa.gov/sab/sabproduct.nsf/1E6218DE3BFF682E852577FB005D46F1/$File/EPA-COUNCIL-11-001-unsigned.pdf. A description of the changes to the model and implications are covered in detail in chapter 8 of the section 812 report. EPA has determined that it needs to update the EMPAX model version used for RIAs to add this benefit-side effect prior to use in any additional regulatory analysis. EPA plans to use the updated version of EMPAX for the final RIA.

9.2 Employment Impacts for the Proposed Toxics Rule

In addition to addressing the costs and benefits of the proposed Utility Air Toxics Rule (Toxics Rule), EPA has estimated preliminary impacts of this rulemaking on labor demand, which are presented in this section.[4] While a standalone analysis of employment impacts is not included in a standard cost-benefit analysis, such an analysis is of particular concern in the current economic climate of sustained unemployment. Executive Order 13563, states, ―Our regulatory system must protect public health, welfare, safety, and our environment while promoting economic growth, innovation, competitiveness, and job creation" (emphasis added). Therefore, we have provided this analysis to inform the discussion of labor demand and job impacts. We provide an estimate of the employment impacts on the regulated industry over time. We also provide the short-term employment impacts (increase in labor demand) associated

[4] See TSD as part of the Toxics Rule Docket: ―Employment Estimates of Direct Labor in Response to the Proposed Toxics Rule in 2015."

with the construction of needed pollution control equipment until the compliance date of the regulation.

We have not quantified the rule‘s effects on all labor in other sectors not regulated by this proposal, or the effects induced by changes in workers‘ incomes. What follows is an overview of the various ways that environmental regulation can affect employment, followed by a discussion of the estimated impacts of this rule. EPA continues to explore the relevant theoretical and empirical literature and to seek public comments in order to ensure that such estimates are as accurate, useful and informative as possible.

From an economic perspective labor is an input into producing goods and services; if regulation requires that more labor be used to produce a given amount of output, that additional labor is reflected in an increase in the cost of production. Moreover, when the economy is at full employment, we would not expect an environmental regulation to have an impact on overall employment because labor is being shifted from one sector to another. On the other hand, in periods of high unemployment, an increase in labor demand due to regulation may result in a net increase in overall employment. With significant numbers of workers unemployed, the opportunity costs associated with displacing jobs in other sectors are likely to be much smaller.

To provide a partial picture of the employment consequences of this rule, EPA takes two approaches. First, the analysis uses the results of Morgenstern, Pizer, and Shih (2002) to estimate the effects of the regulation on the regulated industry, the electric power industry in this case. This approach has been taken by EPA previously in Regulatory Impact Analyses. (See, for example, the Regulatory Impact Analysis for the recently finalized Industrial Boilers and CISWI rulemakings, promulgated on February 21, 2011). Second, EPA uses information derived from its cost estimation documentation for the IPM model. Historically, EPA has only reported employment impacts on a few regulations. EPA is interested in public comments on the merits of including information derived in this fashion for assessing the employment consequences of regulations.

Section 9.3 discusses the estimates of the employment consequences in the electricity sectors, using the Morgenstern, et al. approach. Section 9.4 estimates the employment consequences in the environmental protection sector, using the new approach.

9.3 Employment Impacts primarily on the regulated industry: Morgenstern, Pizer, and Shih (2002)

EPA examined possible employment effects within the electric utility sector using a peer-reviewed, published study that explores historical relationships between industrial employment and environmental regulations (Morgenstern, Pizer, and Shih, 2002). The fundamental insight of Morgenstern, et al. is that environmental regulations can be understood as requiring regulated firms to add a new output (environmental quality) to their product mixes. Although legally compelled to satisfy this new demand, regulated firms have to finance this additional production with the proceeds of sales of their other (market) products. Satisfying this new demand requires additional inputs, including labor, and may alter the relative proportions of labor and capital used by regulated firms in their production processes.

Thus, Morgenstern et al. decompose the overall effect of a regulation on employment into the following three subcomponents:

- The ―Demand Effect": higher production costs raise market prices, reducing consumption (and production), thereby reducing demand for labor within the regulated industry [5];
- The ―Cost Effect": As production costs increase, plants use more of all inputs, including labor, to maintain a given level of output. For example, in order to reduce pollutant emissions while holding output levels constant, regulated firms may require additional labor;
- The ―Factor-Shift Effect": Regulated firms' production technologies may be more or less labor intensive after complying with a regulation (i.e., more/less labor is required per dollar of output).
- Decomposing the overall employment impact of environmental regulation into three subcomponents clarifies the conceptual relationship between environmental regulation and employment in regulated sectors, and permitted Morgenstern, et al. to provide an empirical estimate of the net impact. For present purposes, the net effect is of particular interest, and is the focus of our analysis.

Using plant-level Census information between the years 1979 and 1991, Morgenstern et al. estimate the size of each effect for four polluting and regulated industries (petroleum, plastic

[5] The Morgenstern et al. results rely on industry demand and supply elasticities to determine cost pass-through and reductions in output.

material, pulp and paper, and steel). On average across the four industries, each additional $1 million ($1987) spending on pollution abatement results in a (statistically insignificant) net increase of 1.55 (+/- 2.24) jobs. As a result, the authors conclude that increases in pollution abatement expenditures do not necessarily cause economically significant employment changes. The conclusion is similar to Berman and Bui (2001) who found that increased air quality regulation in Los Angeles did not cause in large employment changes[6].

Since the Morgenstern, et al. parameter estimates are expressed in jobs per million ($1987)[7] of environmental compliance expenditures, their study offers a transparent and simple way to transfer estimates for other employment analysis. For each of the three job effects outlined above, EPA used the Morgenstern et al. four industry average parameters and standard errors along with the estimated private compliance costs to provide a range of electricity sector employment effects associated with the proposed Toxics Rule.

By applying these estimates to pollution abatement costs for the proposed rule for the electric power sector, we estimated each effect. The results are

- Demand effect: −45,000 to +2,500 jobs in the directly affected sector with a central estimate of −21,000;
- Cost effect: +4,700 to +24,000 jobs in the directly affected sector with a central estimate of +14,000; and
- Factor-shift effect: +200 to +32,000 jobs in the directly affected sector with a central estimate of +16,000.
- EPA estimates the net employment effect to range from 17,000 to +35,000 jobs in the directly affected sector with a central estimate of +9,000. [8, 9]

These estimates are shown in Table 9-3.

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[6] For alternative views, see Henderson (1996) and Greenstone (2002).

[7] The Morgenstern et al. analysis uses ―production worker" as defined in the US Census Bureau‘s Annual Survey of Manufactures (ASM) in order to define a job. This definition can be found on the Internet at http://www.census.gov/manufacturing/asm/definitions/index.html.

[8] Since Morgenstern‘s analysis reports environmental expenditures in $1987, we make an inflation adjustment the IPM costs using the ratio of the consumer price index, U.S. city, all items reported by the U.S. Bureau of Labor Statistics: $CPI_{1987}/ CPI_{2007} = (113.6/207.3) = 0.55$

[9] Net employment effect = 1.55× $10,900 million × 0.55. This estimated net result is not statistically different from zero.

Table 9-3. Employment Impacts Using Peer-Reviewed Study

	Estimates using Morgenstern et al. (2002)			
	Demand Effect	**Cost Effect**	**Factor Shift Effect**	**Net Effect**
Change in Full-Time Jobs per Million Dollars of Environmental Expenditure[a]	−3.56	2.42	2.68	1.55
Standard Error	2.03	1.35	0.83	2.24
EPA estimate for Toxics Rule[b]	−21,000 −45,000 to +2,500	+14,000 +4,700 to +24,000	+16,000 +200 to +32,000	+9,000 −17,000 to +35,000

[a] Expressed in 1987 dollars. See footnote 8 for inflation adjustment factor used in the analysis.

[b] According to the 2007 Economic Census, the electric power generation, transmission and distribution sector (NAICS 2211) had approximately 510,000 paid employees. Both the midpoint and range for each effect are reported in the last row of the table.

All ranges for these job changes are based on the 95th percentile of results. EPA recognizes there may be other employment effects which are not considered in the Morgenstern et al. study. For example, employment in environmental protection industries may increase as firms purchase more pollution control equipment and services to meet the proposed rule‘s requirements. EPA does provide such an estimate of employment change later in this section in a separate analysis. On the other hand, industries that use electricity will face higher electricity prices as the result of the toxics rule, reduce output, and demand less labor. We do not currently have sufficient information to quantify these as potential employment gains or losses.

9.3.1 Limitations

Although the Morgenstern et al. paper provides information about the potential job effects of environmental protection programs, there are several caveats associated with using those estimates to analyze the final rule. First, the Morgenstern et al. estimates presented in Table 9-3 and used in EPA‘s analysis represent the weighted average parameter estimates for a set of manufacturing industries (pulp and paper, plastics, petroleum, and steel). Morgenstern, et al. present those industries‘ estimates separately, and they range from -1.13 jobs per $1 million (in 1987 dollars) of environmental expenditures for pulp and paper, to +6.90 jobs for plastics. Only two of the total jobs estimates are statistically significantly different from zero, and the overall weighted average used here, 1.55 jobs per $1 million, is not statistically significant. Moreover, here we are applying the estimate to the electricity generating industry.

Second, relying on Morgenstern et al. implicitly assumes that estimates derived from 1979–1991 data are still applicable. Third, the methodology used in Morgenstern et al. assumes that regulations affect plants in proportion to their total costs. In other words, each additional dollar of regulatory burden affects a plant by an amount equal to that plant's total costs relative to the aggregate industry costs. By transferring the estimates, EPA assumes a similar distribution of regulatory costs by plant size and that the regulatory burden does not disproportionately fall on smaller or larger plants.

9.4 Employment Impacts of the Proposed Toxics Rule-Environmental Protection Sector Approach by 2015 [10]

Regulations set in motion new orders for pollution control equipment and services. New categories of employment have been created in the process of implementing regulations to make our air safer to breathe. When a regulation is promulgated, the first response of industry is to order pollution control equipment and services in order to comply with the regulation when it becomes effective. Revenue and employment in the environmental technology industry have grown steadily between 2000 and 2008, reaching an industry total of approximately $300 billion in revenues and 1.7 million employees in 2008.[11] While these revenues and employment figures represent gains for the environmental technologies industry, they are costs to the regulated industries required to install the equipment. Moreover, it is not clear the 1.7 million employees in 2008 represent anything other than workers diverted from other productive employment as opposed to new additional employment.

Regulated firms hire workers to operate and maintain pollution controls. Once the equipment is installed, regulated firms hire workers to operate and maintain the pollution control equipment – much like they hire workers to produce more output. A study by Resources for the

[10] EPA expects that the installation of retrofit control equipment in response to the requirements of this proposal will primarily take place within 3 years of the effective date of the final rule, but there may be a possibility that some installations may occur within 4 years of the effective date.

[11] In 2008, the industry totaled approximately $315 billion in revenues and 1.9 million employees including indirect employment effects, pollution abatement equipment production employed approximately 4.2 million workers in 2008. These indirect employment effects are based on a multiplier for indirect employment = 2.24 (1982 value from Nestor and Pasurka - approximate middle of range of multipliers 1977-1991). Environmental Business International (EBI), Inc., San Diego, CA. Environmental Business Journal, monthly (copyright). http://www.ebiusa.com/ EBI data taken from the Department of Commerce International Trade Administration Environmental Industries Fact Sheet from April 2010: http://web.ita.doc.gov/ete/eteinfo.nsf/068f3801d047f26e85256883006ffa54/4878b7e2fc08ac6d85256883006c452c?OpenDocument

Future examined how regulated industries respond to regulation. They found that on average, employment goes up in regulated firms.[12,13] Of course, these firms may also reassign existing employees to do these activities.

Environmental regulations support employment in many basic industries. In addition to the increase in employment in the environmental protection industry (increased orders for pollution control equipment), environmental regulations also support employment in industries that provide intermediate goods to the environmental protection industry. For example, $1 billion in capital expenditures to reduce air pollution involves the purchase of abatement equipment. The equipment manufacturers, in turn, order steel, tanks, vessels, blowers, pumps, and chemicals to manufacture and install the equipment.

A study (2008) by Bezdek, Wendling, and DiPernab found that investments in environmental protection industries create jobs and displace jobs, but the net effect on employment is positive."[14]

The focus of this part of the employment analysis is on short-term jobs related to the compliance actions of the affected entities. This analysis estimates of the employment impacts due to the increased demand for pollution control retrofits.[15] Results indicate that the Toxics Rule has the potential to result in a net increase of labor in these industries, driven by the high demand for new pollution controls. Overall, the preliminary results of the environmental protection sector approach indicate that the Toxics Rule could support an increase of about 31,000 job-years[16] by 2015.

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[12] A recent study Bezdek, Wendling, and DiPernab shows that ―investments in EP create jobs and displace jobs, but the net effect on employment is positive." *Environmental protection, the economy, and jobs: National and regional analyses,* Roger H. Bezdek, Robert M. Wendling and Paula DiPerna**,** Journal of Environmental Management Volume 86, Issue 1, January 2008, Pages 63-79.

[13] Environmental Business International (EBI), Inc., San Diego, CA. Environmental Business Journal, monthly (copyright). http://www.ebiusa.com/ EBI data taken from the Department of Commerce International Trade Administration Environmental Industries Fact Sheet from April 2010: http://web.ita.doc.gov/ete/eteinfo.nsf/068f3801d047f26e85256883006ffa54/4878b7e2fc08ac6d85256883006c452c?OpenDocument.

[14] Environmental protection, the economy, and jobs: National and regional analyses, Roger H. Bezdek, Robert M. Wendling and Paula DiPerna, Journal of Environmental Management Volume 86, Issue 1**,** January 2008, Pages 63-79.

[15] For more detail on methodology, approach, and assumptions, see TSD as part of the Toxics Rule Docket: ―Employment Estimates of Direct Labor in Response to the Proposed Toxics Rule in 2015."

[16] Numbers of job years are not the same as numbers of individual jobs, but represents the amount of work that can be performed by the equivalent of one full-time individual for a year (or FTE). For example, 25 job years may be equivalent to five full-time workers for five years, twenty-five full-time workers for one year, or one full-time worker for twenty-five years.

9.4.1 Overall Approach and Methodology for Environmental Protection Sector Approach

EPA commissioned ICF International to provide estimates for the Environmental Protection Sector, and the analysis utilizes a bottom-up engineering based methodology combined with macroeconomic data on industrial output and productivity, to estimate employment impacts. It relies heavily on the cost analysis from the IPM model which uses labor and capital estimates to derive control costs. The approach also relies upon prior EPA studies on similar issues, and in particular uses data and information from an extensive resource study conducted in 2002, which was updated for purposes of the proposed rule to reflect more recent information.[17] The approach involves using IPM projected results from the proposed Toxics Rule analysis for the set of pollution control technologies expected to be installed to comply with the rule, along with data from secondary sources, to estimate the job impacts using this approach.[18] This will cover the labor needed to design, manufacture and install the needed pollution control equipment over the 3 to 4 years leading up to compliance in 2015.

For construction labor, the labor needs are derived from the 2002 EPA resource analysis for installing various retrofits (FGD – Flue Gas Desulfurization scrubbers, SCR- selective catalytic reduction, ACI – activated carbon injection, DSI - dry sorbent injection, and FF 0-Fabric Filters) and are further classified into different labor categories, such as boilermakers, engineers and a catch-all ―other installation labor.” For the inputs needed (e.g., steel), the 2002 resource study was used to determine the steel demand for each MW of additional pollution control and combined with labor productivity data from the Economic Census and BLS for relevant industries.

More detail on methodology, assumptions, and data sources can be found in the TSD ―Employment Estimates of Direct Labor in Response to the Proposed Toxics Rule in 2015.”

Projections from IPM were used to estimate the incremental retrofit capacities projected in response to the proposed rule. These additional pollution controls are shown in Table 9-4 below, and reflect the added pollution controls needed to meet the requirements of the rule. Additional information on the power sector impacts can be found in Chapter 8 of the RIA.

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[17] Engineering and Economic Factors Affecting the Installation of Control Technologies for Multipollutant Strategies EPA-600/R-02/073 (2002).

[18] Detailed results from IPM for the proposed Toxics Rule can be found in Chapter 8 of the RIA.

Table 9-4. Increased Retrofit Demand due to the Toxics Rule, by 2015 (GW)

Retrofit Type	IPM Projected Additional Pollution Control
FGD	21
SCR	3
ACI	93
DSI	56
FF[19]	107

9.4.2 Summary of Employment Estimates from Environmental Protection Sector Approach

Table 9-5 presents additional detail on the estimated employment impacts using the environmental protection sector approach resulting from the proposed Toxics Rule. Results for the Environmental Protection Sector Approach indicate the proposed Toxics Rule could support or create roughly 31,000 one-time job-years of increased cost of direct labor, driven by the need to build the pollution control retrofits.

Table 9-5. Employment Effects Using the Environmental Protection Sector Approach for the Proposed Toxics Rule (in Job-Years)

Employment	Incremental Employment
One-Time Employment Changes for Construction	
1. Boilermakers	13,400
2. Engineers	3,270
3. General Construction	13,770
4. Steel Manufacturing	430
	30,870

9.4.3 Other Employment Impacts of the Proposed Toxics Rule

We expect ongoing employment impacts on regulated and non-regulated entities for a variety of reasons. These include labor changes in the regulated entities resulting from shifts in demand for fuel changes, increased demand for materials to operate pollution control equipment, changes in employment resulting from coal retirements, and changes in other industries due to changes in the price of electricity and natural gas. We provide preliminary estimates of some of

[19] In the policy case modeling, EPA assumes that a fabric filter (also known as a baghouse) is necessary for coal- and solid-oil derived fuel-fired EGUs to meet the total PM standard. The estimate for FFs include here is for stand-alone FFs, and does not include some additional FFs that may be installed in conjunction with other pollution controls (e.g., in combination with a dry scrubber).

these effects below. The most notable of the ones we are unable to estimate are the impacts on employment as a result of the increase in electricity and other energy prices in the economy. Because of this inability to estimate all the important employment impacts, EPA neither sums the impacts that the Agency is able to estimate for the ongoing non-regulated group or make any inferences of whether there is a net gain or loss of employment for the non-regulated group. These other ongoing employment impacts are found in Table 9-6.

Table 9-6. Employment Impacts for Entities Not Regulated by the Proposed Toxics Rule

Employment Changes for Ongoing Annual Operation	
Employment Changes from Changes to Demand in Materials	
1. Limestone (FGD)	2,020
2. Ammonia (SCR)	20
3. Catalyst (SCR)	100
4. Activated Carbon (ACI)	90
5. Sodium Bicarbonate (DSI)	2,940
6. Baghouse material (FF)	60
Sub-Total:	**5,230**
Employment Changes for Ongoing Annual Retrofit Operation	**5,500**
Employment Annual Changes due to Coal Capacity Retirements	**(5,630)**
Annual Employment Changes due to Changes in Fuel Use	
Coal	(2,200)
Natural Gas	1,090
New Natural Gas Pipeline	300

9.5 Summary

The three approaches use different analytical techniques and are applied to different industries during different time periods, and they use different units of analysis. These estimates should not be summed because of the different metrics, length and methods of analysis. The Morgenstern estimates are used for the ongoing employment impacts for the regulated entities (the electric power sector). The short term estimates for employment needed to design, construct, and install the control equipment in the three or four year period leading up to the compliance date are also provided. Finally some of the other types of employment impacts that will be ongoing are estimated.

In Table 9-7, we show the employment impacts of the Toxics Rule as estimated by the environmental protection sector approach and by the Morgenstern approach.

Table 9-7. Estimated Employment Impact Table

	Annual (reoccurring)	**One time (construction during compliance period)**
Environmental Protection Sector approach*	Not Applicable	30,870
Net Effect on Electric Utility Sector Employment from Morgenstern et al. approach***	****9,000** **-17, 000 to +35,000******	Not Applicable

*These one-time impacts on employment are estimated in terms of job-years.

**This estimate is not statistically different from zero.

***These annual or recurring employment impacts are estimated in terms of production workers as defined by the US Census Bureau‘s Annual Survey of Manufacturers (ASM).

**** 95% confidence interval

9.6 References

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EXHIBIT 4

EPA United States Environmental Protection Agency

Regulatory Impact Analysis for the Final Mercury and Air Toxics Standards

EPA-452/R-11-011
December 2011

Regulatory Impact Analysis for the Final Mercury and Air Toxics Standards

U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Health and Environmental Impacts Division
Research Triangle Park, NC

EXECUTIVE SUMMARY

This Regulatory Impact Analysis (RIA) presents the health and welfare benefits, costs, and other impacts of the final Mercury and Air Toxics Standards (MATS) in 2016.

ES.1 Key Findings

This rule will reduce emissions of Hazardous Air Pollutants (HAP), including mercury, from the electric power industry. As a co-benefit, the emissions of certain $PM_{2.5}$ precursors such as SO_2 will also decline. EPA estimates that this final rule will yield annual monetized benefits (in 2007$) of between $37 to $90 billion using a 3% discount rate and $33 to $81 billion using a 7% discount rate. The great majority of the estimates are attributable to co-benefits from 4,200 to 11,000 fewer $PM_{2.5}$-related premature mortalities. The monetized benefits from reductions in mercury emissions, calculated only for children exposed to recreationally caught freshwater fish, are expected to be $0.004 to $0.006 billion in 2016 using a 3% discount rate and $0.0005 to $0.001 billion using a 7% discount rate. The annual social costs, approximated by the compliance costs, are $9.6 billion (2007$) and the annual monetized net benefits are $27 to $80 billion using 3% discount rate or $24 to $71 billion using a 7% discount rate.[1] The benefits outweigh costs by between 3 to 1 or 9 to 1 depending on the benefit estimate and discount rate used. There are some costs and important benefits that EPA could not monetize, such as other mercury reduction benefits and those for the HAP other than mercury being reduced by this final rule. Upon considering these limitations and uncertainties, it remains clear that the benefits of the MATS are substantial and far outweigh the costs. Employment impacts associated with the final rule are estimated to be small.

The benefits and costs in 2016 of the final rule are in Table ES-1. The emission reductions from the electricity sector that are expected to result from the rule are reported in Table ES-2.

[1] As discussed in Chapter 3, costs were annualized using a 6.15% discount rate.

Table ES-1. Summary of EPA's Estimates of Annualized[a] Benefits, Costs, and Net Benefits of the Final MATS in 2016[b] (billions of 2007$)

Description	Estimate (3% Discount Rate)	Estimate (7% Discount Rate)
Costs[c]	\$9.6	\$9.6
Benefits[d,e,f]	\$37 to \$90 + B	\$33 to \$81 + B
Net benefits (benefits-costs)[g]	\$27 to \$80 + B	\$24 to \$71 + B

[a] All estimates presented in this report represent annualized estimates of the benefits and costs of the final MATS in 2016 rather than the net present value of a stream of benefits and costs in these particular years of analysis.

[b] Estimates rounded to two significant figures and represent annualized benefits and costs anticipated for the year 2016.

[c] Total social costs are approximated by the compliance costs. Compliance costs consist of IPM projections, monitoring/reporting/recordkeeping costs, and oil-fired fleet analysis costs. For a complete discussion of these costs refer to Chapter 3. Costs were annualized using a 6.15% discount rate.

[d] Total benefits are composed primarily of monetized PM-related health benefits. The reduction in premature fatalities each year accounts for over 90% of total monetized benefits. Benefits in this table are nationwide and are associated with directly emitted $PM_{2.5}$ and SO_2 reductions. The estimate of social benefits also includes CO_2-related benefits calculated using the social cost of carbon, discussed further in Chapter 5.

[e] Not all possible benefits or disbenefits are quantified and monetized in this analysis. B is the sum of all unquantified benefits and disbenefits. Data limitations prevented us from quantifying these endpoints, and as such, these benefits are inherently more uncertain than those benefits that we were able to quantify. Estimates here are subject to uncertainties discussed further in the body of the document. Potential benefit categories that have not been quantified and monetized are listed in Table ES-5.

[f] Mortality risk valuation assumes discounting over the SAB-recommended 20-year segmented lag structure. Results reflect the use of 3% and 7% discount rates consistent with EPA and OMB guidelines for preparing economic analyses (EPA, 2000; OMB, 2003).

[g] Net benefits are rounded to two significant figures. Columnar totals may not sum due to rounding.

Table ES-2: Projected Electricity Generating Unit (EGU) Emissions of SO_2, NO_X, Mercury, Hydrogen Chloride, PM, and CO_2 with the Base Case and with MATS, 2015[a,b]

		Million Tons			Thousand Tons		CO_2
		SO_2	NO_X	Mercury (Tons)	HCl	$PM_{2.5}$	(Million Metric Tonnes)
Base	All EGUs	3.4	1.9	28.7	48.7	277	2,230
	Covered EGUs	3.3	1.7	26.6	45.3	270	1,906
MATS	All EGUs	2.1	1.9	8.8	9.0	227	2,215
	Covered EGUs	1.9	1.7	6.6	5.5	218	1,883

[a] Source: Integrated Planning Model run by EPA, 2011

[b] The year 2016 is the compliance year for MATS, though as we explain in later chapters, we use 2015 as a proxy for compliance in 2016 for IPM emissions and costs due to availability of modeling impacts in that year.

ES.1.1 Health Co-Benefits

The final MATS Rule is expected to yield significant health co-benefits by reducing emissions not only of HAP such as mercury, but also significant co-benefits by reducing to direct fine particles ($PM_{2.5}$) and sulfur dioxide, which contributes to the formation of $PM_{2.5}$.

Our analyses suggest this rule would yield co-benefits in 2016 of $37 to $90 billion (based on a 3% discount rate) and $33 to $81 billion (based on a 7% discount rate). This estimate reflects the economic value of a range of avoided health outcomes including 510 fewer mercury-related IQ points lost as well as avoided $PM_{2.5}$-related impacts, including 4,200 to 11,000 premature deaths, 4,700 nonfatal heart attacks, 2,600 hospitalizations for respiratory and cardiovascular diseases, 540,000 lost work days, and 3.2 million days when adults restrict normal activities because of respiratory symptoms exacerbated by $PM_{2.5}$. We also estimate substantial additional health improvements for children from reductions in upper and lower respiratory illnesses, acute bronchitis, and asthma attacks. See Table ES-3 for a list of the annual reduction in health effects expected in 2016 and Table ES -4 for the estimated value of those reductions. In addition, we include in our monetized co-benefits estimates the effect from the reduction in CO_2 emissions resulting from this rule. We calculate the co-benefits associated with these emission reductions using the interagency estimates of the social cost of carbon (SCC)[1].

It is important to note that the health co-benefits from reduced $PM_{2.5}$ exposure reported here contain uncertainty, including from the following key assumptions:

1. The $PM_{2.5}$-related co-benefits of the regulatory alternatives were derived through a benefit per-ton approach, which does not fully reflect local variability in population density, meteorology, exposure, baseline health incidence rates, or other local factors that might lead to an over-estimate or under-estimate of the actual co-benefits of controlling PM precursors. In addition, differences in the distribution of emissions reductions across states between the modeled scenario and the final rule scenario add uncertainty to the final benefits estimates.

[1] Docket ID EPA-HQ-OAR-2009-0472-114577, *Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866,* Interagency Working Group on Social Cost of Carbon, with participation by Council of Economic Advisers, Council on Environmental Quality, Department of Agriculture, Department of Commerce, Department of Energy, Department of Transportation, Environmental Protection Agency, National Economic Council, Office of Energy and Climate Change, Office of Management and Budget, Office of Science and Technology Policy, and Department of Treasury (February 2010). Also available at http://www.epa.gov/otaq/climate/regulations.htm

2. We assume that all fine particles, regardless of their chemical composition, are equally potent in causing premature mortality. This is an important assumption, because $PM_{2.5}$ produced via transported precursors emitted from EGUs may differ significantly from direct $PM_{2.5}$ released from diesel engines and other industrial sources, but the scientific evidence is not yet sufficient to allow differential effects estimates by particle type.

3. We assume that the health impact function for fine particles is linear within the range of ambient concentrations under consideration. Thus, the estimates include health co-benefits from reducing fine particles in areas with varied concentrations of $PM_{2.5}$, including both regions that are in attainment with fine particle standard and those that do not meet the standard down to the lowest modeled concentrations.

A large fraction of the $PM_{2.5}$-related benefits associated with this rule occur below the level of the National Ambient Air Quality Standard (NAAQS) for annual $PM_{2.5}$ at 15 $\mu g/m^3$, which was set in 2006. It is important to emphasize that NAAQS are not set at a level of zero risk. Instead, the NAAQS reflect the level determined by the Administrator to be protective of public health within an adequate margin of safety, taking into consideration effects on susceptible populations. While benefits occurring below the standard may be less certain than those occurring above the standard, EPA considers them to be legitimate components of the total benefits estimate.

Based on the modeled interim baseline which is approximately equivalent to the final baseline (see Appendix 5A), 11% and 73% of the estimated avoided premature deaths occur at or above an annual mean $PM_{2.5}$ level of 10 $\mu g/m^3$ (the LML of the Laden et al. 2006 study) and 7.5 $\mu g/m^3$ (the LML of the Pope et al. 2002 study), respectively. These are the source studies for the concentration-response functions used to estimate mortality benefits. As we model avoided premature deaths among populations exposed to levels of $PM_{2.5,}$ we have lower confidence in levels below the LML for each study. However, studies using data from more recent years, during which time PM concentrations have fallen, continue to report strong associations with mortality. EPA briefly describes these uncertainties below and in more detail in the benefits chapter of this RIA.

ES.1.2 Welfare Co-Benefits

The term *welfare co-benefits* covers both environmental and societal benefits of reducing pollution, such as reductions in damage to ecosystems, improved visibility and improvements in recreational and commercial fishing, agricultural yields, and forest productivity. EPA did not quantify any of the important welfare co-benefits expected from the final MATS, but these are discussed in detail in Chapter 5.

Table ES-3. Estimated Reduction in Incidence of Adverse Health Effects of the Mercury and Air Toxics Standards (95% confidence intervals)[a,b]

Impact	Eastern U.S.[c]	Western U.S.	Total
Mercury-Related Endpoints			
IQ Points Lost			510.8
PM-Related Endpoints			
Premature death			
Pope et al. (2002) (age >30)	4,100 (1,100 – 7,000)	130 (30 – 220)	4,200 (1,200 – 7,200)
Laden et al. (2006) (age >25)	10,000 (4,800 – 16,000)	320 (140 – 510)	11,000 (5,000 – 17,000)
Infant (< 1 year)	19 (-21 – 59)	1 (-1 – 2)	20 (-22 – 61)
Chronic bronchitis	2,700 (89 – 5,400)	100 (-1 – 210)	2,800 (88 – 5,600)
Non-fatal heart attacks (age > 18)	4,600 (1,200 – 8,100)	120 (25 – 210)	4,700 (1,200 – 8,300)
Hospital admissions—respiratory (all ages)	820 (320 – 1,300)	17 (6 – 27)	830 (330 – 1,300)
Hospital admissions—cardiovascular (age > 18)	1,800 (1,200 – 2,100)	42 (27 – 50)	1,800 (1,200 – 2,200)
Emergency room visits for asthma (age < 18)	3,000 (1,500 – 4,500)	110 (52 – 160)	3,100 (1,600 – 4,700)
Acute bronchitis (age 8-12)	6,000 (-1,400 – 13,000)	250 (-69 – 560)	6,300 (-1,400 – 14,000)
Lower respiratory symptoms (age 7-14)	77,000 (30,000 – 120,000)	3,100 (1,100 – 5,200)	80,000 (31,000 – 130,000)
Upper respiratory symptoms (asthmatics age 9-18)	58,000 (11,000 – 110,000)	2,400 (360 – 4,400)	60,000 (11,000 – 110,000)
Asthma exacerbation (asthmatics age 6-18)	130,000 (4,500 – 430,000)	5,200 (-6 – 18,000)	130,000 (4,500 – 450,000)
Lost work days (ages 18-65)	520,000 (440,000 – 600,000)	21,000 (18,000 – 24,000)	540,000 (460,000 – 620,000)
Minor restricted-activity days (ages 18-65)	3,100,000 (2,500,000 – 3,700,000)	120,000 (99,000 – 150,000)	3,200,000 (2,600,000 – 3,800,000)

[a] Estimates rounded to two significant figures; column values will not sum to total value.

[b] The negative estimates for certain endpoints are the result of the weak statistical power of the study used to calculate these health impacts and do not suggest that increases in air pollution exposure result in decreased health impacts.

[c] Includes Texas and those states to the north and east.

Table ES-4. Estimated Economic Value of Health and Welfare Co-Benefits of the Mercury and Air Toxics Standards (95% confidence intervals, billions of 2007$)[a]

Impact	Pollutant	Eastern U.S.[b]	Western U.S.	Total
Avoided IQ loss associated with methylmercury exposure from self-caught fish consumption among recreational anglers				
3% discount rate	Hg			$0.004 – $0.006
7% discount rate	Hg			$0.0005 – $0.001
Adult premature death (Pope et al., 2002 PM mortality estimate)				
3% discount rate	$PM_{2.5}$	$33 ($2.6 - $99)	$1.0 (<$0.01 - $3.1)	$34 ($2.6 - $100)
7% discount rate	$PM_{2.5}$	$30 ($2.3 - $90)	$0.9 (<$0.01 - $2.8)	$30 ($2.4 - $92)
Adult premature death (Laden et al., 2006 PM mortality estimate)				
3% discount rate	$PM_{2.5}$	$84 ($7.4 - $240)	$2.6 ($0.1 - $7.6)	$87 ($7.5 - $250)
7% discount rate	$PM_{2.5}$	$76 ($6.7 - $220)	$2.3 ($0.1 - $6.9)	$78 ($6.8 - $230)
Infant premature death	$PM_{2.5}$	$0.2 ($-0.2 – $0.8)	<$0.01	$0.2 ($-0.2 - $0.8)
Chronic bronchitis	$PM_{2.5}$	$1.3 ($0.1 - $6.1)	$0.1 (<$0.01 - $0.2)	$1.4 ($0.1 - $6.4)
Non-fatal heart attacks				
3% discount rate	$PM_{2.5}$	$0.5 ($0.1 - $1.3)	<$0.01	$0.5 ($0.1 - $1.3)
7% discount rate	$PM_{2.5}$	$0.4 ($0.1 - $1.0)	<$0.01	$0.4 ($0.1 - $1.0)
Hospital admissions—respiratory	$PM_{2.5}$	$0.01 (<$0.01 - $0.02)	<$0.01	$0.01 ($0.01 - $0.02)
Hospital admissions—cardiovascular	$PM_{2.5}$	$0.03 (<$0.01 - $0.05)	<$0.01	$0.03 (<$0.01 - $0.05)
Emergency room visits for asthma	$PM_{2.5}$	<$0.01	<$0.01	<$0.01
Acute bronchitis	$PM_{2.5}$	<$0.01	<$0.01	<$0.01
Lower respiratory symptoms	$PM_{2.5}$	<$0.01	<$0.01	<$0.01
Upper respiratory symptoms	$PM_{2.5}$	<$0.01	<$0.01	<$0.01
Asthma exacerbation	$PM_{2.5}$	<$0.01	<$0.01	<$0.01
Lost work days	$PM_{2.5}$	$0.1 ($0.1 - $0.1)	<$0.01	$0.1 ($0.1 - $0.1)

(continued)

Table ES-4. Estimated Economic Value of Health and Welfare Co-Benefits of the Mercury and Air Toxics Standards (95% confidence intervals, billions of 2007$)[a] (continued)

Impact	Pollutant	Eastern U.S.[b]	Western U.S.	Total
Minor restricted-activity days	$PM_{2.5}$	$0.2 ($0.1 - $0.3)	<$0.01	$0.2 ($0.1 - $0.3)
CO_2-related benefits				
(3% discount rate)	CO_2			$0.36
Monetized total Benefits (Pope et al., 2002 $PM_{2.5}$ mortality estimate)				
3% discount rate		$35+B ($2.8 - $110)	$1.1+B ($0.03 - $3.4)	$37+B ($3.2 - $110)
7% discount rate		$32+B ($2.5 - $98)	$1.0+B ($0.03 - $3.1)	$33+B ($2.9 - $100)
Monetized total Benefits (Laden et al., 2006 $PM_{2.5}$ mortality estimate)				
3% discount rate		$87+B ($7.5 - $250)	$2.7+B ($0.1 - $7.9)	$90+B ($8.0 - $260)
7% discount rate		$78+B ($6.8 - $230)	$2.4+B ($0.1 - $7.2)	$81+B ($7.3 - $240)

[a] Economic value adjusted to 2007$ using GDP deflator. Estimates rounded to two significant figures. The negative estimates for certain endpoints are the result of the weak statistical power of the study used to calculate these health impacts and do not suggest that increases in air pollution exposure result in decreased health impacts. Confidence intervals reflect random sampling error and not the additional uncertainty associated with accounting for differences in air quality baseline forecasts described in Chapter 5. The net present value of reduced CO_2 emissions are calculated differently than other benefits. The same discount rate used to discount the value of damages from future emissions (SCC at 5, 3, 2.5 percent) is used to calculate net present value of SCC for internal consistency. This table shows monetized CO_2 co-benefits at discount rates at 3 and 7 percent that were calculated using the global average SCC estimate at a 3% discount rate because the interagency workgroup on this topic deemed this marginal value to be the central value. In section 5.6 we also report CO_2 co-benefits using discount rates of 5 percent (average), 2.5 percent (average), and 3 percent (95th percentile).

[b] Includes Texas and those states to the north and east.

Figure ES-1 summarizes an array of $PM_{2.5}$-related monetized benefits estimates based on alternative epidemiology and expert-derived PM-mortality estimate.

Figure ES-2 summarizes the estimated net benefits for the final rule by displaying all possible combinations of health and climate co-benefits and costs. Each of the 14 bars in each graph represents a separate point estimate of net benefits under a certain combination of cost and benefit estimation methods. Because it is not a distribution, it is not possible to infer the likelihood of any single net benefit estimate.

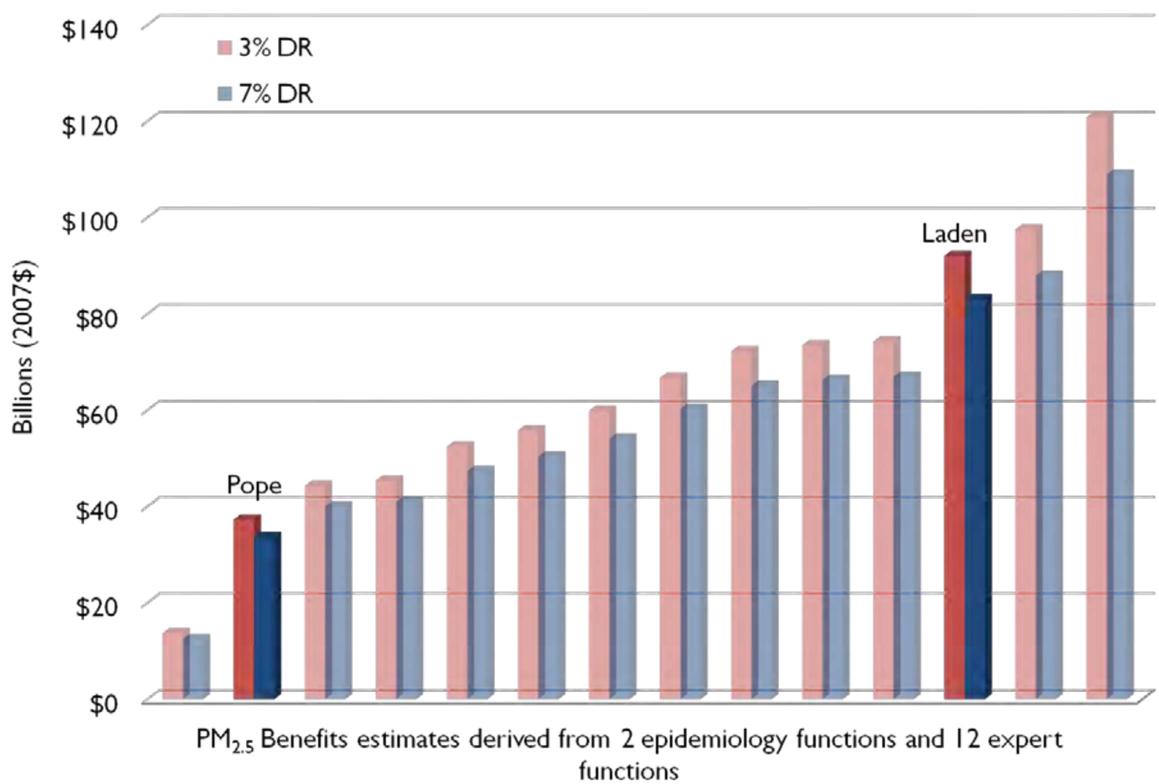

Figure ES-1. Economic Value of Estimated $PM_{2.5}$-Related Health Co-Benefits According to Epidemiology or Expert-Derived PM Mortality Risk Estimate[a,b]

[a] Based on the modeled interim baseline, which is approximately equivalent to the final baseline (see Appendix 5A)

[b] Column total equals sum of $PM_{2.5}$-related mortality and morbidity benefits.

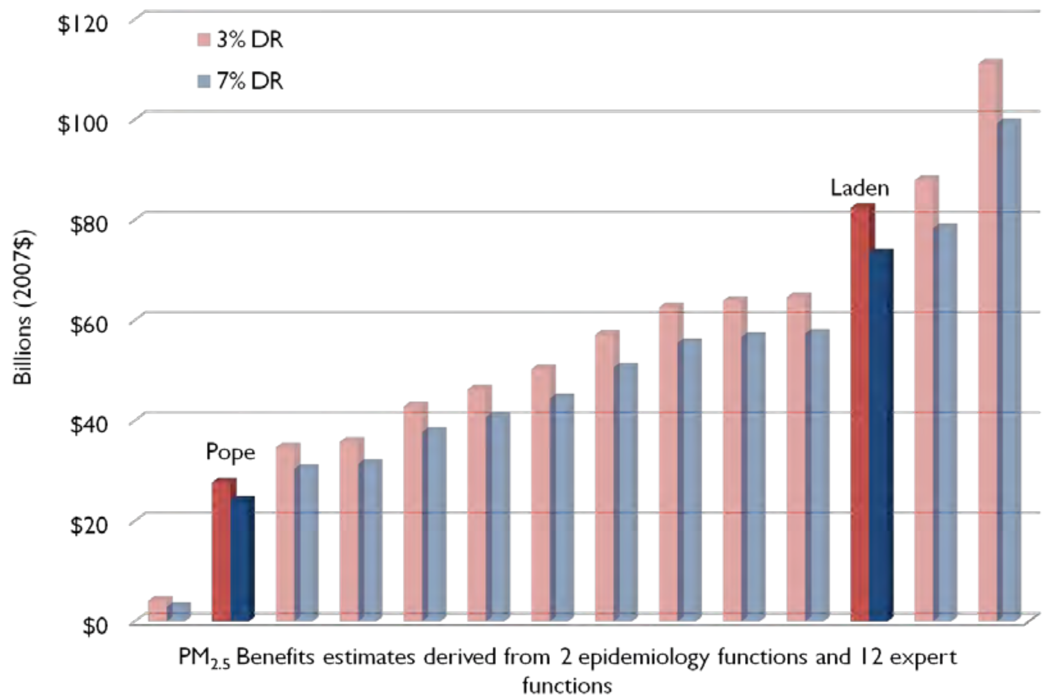

Figure ES-2. Net Benefits of the MATS Rule According to $PM_{2.5}$ Epidemiology or Expert-Derived Mortality Risk Estimate[a,b]

[a] Based on the modeled interim baseline, which is approximately equivalent to the final baseline (see Appendix 5A)

[b] Column total equals sum of $PM_{2.5}$-related mortality and morbidity benefits.

ES.2 Not All Benefits Quantified

EPA was unable to quantify or monetize all of the health and environmental benefits associated with the final MATS Rule. EPA believes these unquantified benefits could be substantial, including the overall value associated with HAP reductions, value of increased agricultural crop and commercial forest yields, visibility improvements, and reductions in nitrogen and acid deposition and the resulting changes in ecosystem functions. Tables ES-5 and ES-6 provide a list of these benefits.

Table ES-5. Human Health Effects of Pollutants Affected by the Mercury and Air Toxics Standards

Benefits Category	Specific Effect	Effect Has Been Quantified	Effect Has Been Monetized	More Information[a]
Improved Human Health				
Reduced incidence of premature mortality from exposure to $PM_{2.5}$	Adult premature mortality based on cohort study estimates and expert elicitation estimates (age >25 or age >30)	✓	✓	Section 5.4
	Infant mortality (age <1)	✓	✓	Section 5.4
Reduced incidence of morbidity from exposure to $PM_{2.5}$	Non-fatal heart attacks (age > 18)	✓	✓	Section 5.4
	Hospital admissions—respiratory (all ages)	✓	✓	Section 5.4
	Hospital admissions—cardiovascular (age >18)	✓	✓	Section 5.4
	Emergency room visits for asthma (age <18)	✓	✓	Section 5.4
	Acute bronchitis (age 8–12)	✓	✓	Section 5.4
	Lower respiratory symptoms (age 7–14)	✓	✓	Section 5.4
	Upper respiratory symptoms (asthmatics age 9-11)	✓	✓	Section 5.4
	Asthma exacerbation (asthmatics age 6–18)	✓	✓	Section 5.4
	Lost work days (age 18-65)	✓	✓	Section 5.4
	Minor restricted-activity days (age 18–65)	✓	✓	Section 5.4
	Chronic bronchitis (age >26)	✓	✓	Section 5.4
	Other cardiovascular effects (e.g., other ages)	—	—	PM ISA[c]
	Other respiratory effects (e.g., pulmonary function, non-asthma ER visits, non-bronchitis chronic diseases, other ages and populations)	—	—	PM ISA[c]
	Reproductive and developmental effects (e.g., low birth weight, pre-term births, etc)	—	—	PM ISA[c, d]
	Cancer, mutagenicity, and genotoxicity effects	—	—	PM ISA[c, d]
Reduced incidence of mortality from exposure to ozone	Premature mortality based on short-term study estimates (all ages)	—	—	Ozone CD, Draft Ozone ISA[b]
	Premature mortality based on long-term study estimates (age 30–99)	—	—	Ozone CD, Draft Ozone ISA[b]
Reduced incidence of morbidity from exposure to ozone	Hospital admissions—respiratory causes (age > 65)	—	—	Ozone CD, Draft Ozone ISA[b]
	Hospital admissions—respiratory causes (age <2)	—	—	Ozone CD, Draft Ozone ISA[b]
	Emergency room visits for asthma (all ages)	—	—	Ozone CD, Draft Ozone ISA[b]
	Minor restricted-activity days (age 18–65)	—	—	Ozone CD, Draft Ozone ISA[b]

(continued)

Table ES-5. Human Health Effects of Pollutants Affected by the Mercury and Air Toxics Standards (continued)

Benefits Category	Specific Effect	Effect Has Been Quantified	Effect Has Been Monetized	More Information
	School absence days (age 5–17)	—	—	Ozone CD, Draft Ozone ISA[b]
	Decreased outdoor worker productivity (age 18-65)	—	—	Ozone CD, Draft Ozone ISA[b]
	Other respiratory effects (e.g., premature aging of lungs)	—	—	Ozone CD, Draft Ozone ISA[c]
	Cardiovascular and nervous system effects	—	—	Ozone CD, Draft Ozone ISA[d]
	Reproductive and developmental effects	—	—	Ozone CD, Draft Ozone ISA[d]
Reduced incidence of morbidity from exposure to NO_2	Asthma hospital admissions (all ages)	—	—	NO_2 ISA[b]
	Chronic lung disease hospital admissions (age > 65)	—	—	NO_2 ISA[b]
	Respiratory emergency department visits (all ages)	—	—	NO_2 ISA[b]
	Asthma exacerbation (asthmatics age 4–18)	—	—	NO_2 ISA[b]
	Acute respiratory symptoms (age 7–14)	—	—	NO_2 ISA[b]
	Premature mortality	—	—	NO_2 ISA[c,d]
	Other respiratory effects (e.g., airway hyperresponsiveness and inflammation, lung function, other ages and populations)	—	—	NO_2 ISA[c,d]
Reduced incidence of morbidity from exposure to SO_2	Respiratory hospital admissions (age > 65)	—	—	SO_2 ISA[b]
	Asthma emergency room visits (all ages)	—	—	SO_2 ISA[b]
	Asthma exacerbation (asthmatics age 4–12)	—	—	SO_2 ISA[b]
	Acute respiratory symptoms (age 7–14)	—	—	SO_2 ISA[b]
	Premature mortality	—	—	SO_2 ISA[c,d]
	Other respiratory effects (e.g., airway hyperresponsiveness and inflammation, lung function, other ages and populations)	—	—	SO_2 ISA[c,d]
Reduced incidence of morbidity from exposure to methyl mercury (through reduced mercury deposition as well as the role of sulfate in methylation)	Neurologic effects—IQ loss	✓	✓	IRIS; NRC, 2000[b]
	Other neurologic effects (e.g., developmental delays, memory, behavior)	—	—	IRIS; NRC, 2000c
	Cardiovascular effects	—	—	IRIS; NRC, 2000[c,d]
	Genotoxic, immunologic, and other toxic effects	—	—	IRIS; NRC, 2000[c,d]

[a] For a complete list of references see Chapter 5.
[b] We assess these benefits qualitatively due to time and resource limitations for this analysis.
[c] We assess these benefits qualitatively because we do not have sufficient confidence in available data or methods.
[d] We assess these benefits qualitatively because current evidence is only suggestive of causality or there are other significant concerns over the strength of the association.

Table ES-6. Environmental Effects of Pollutants Affected by the Mercury and Air Toxics Standards

Benefits Category	Specific Effect	Effect Has Been Quantified	Effect Has Been Monetized	More Information[a]
Improved Environment				
Reduced visibility impairment	Visibility in Class I areas in SE, SW, and CA regions	—	—	PM ISA[b]
	Visibility in Class I areas in other regions	—	—	PM ISA[b]
	Visibility in residential areas	—	—	PM ISA[b]
Reduced climate effects	Global climate impacts from CO_2	—	✓	Section 5.6
	Climate impacts from ozone and PM	—	—	Section 5.6
	Other climate impacts (e.g., other GHGs, other impacts)	—	—	IPCC[c]
Reduced effects on materials	Household soiling	—	—	PM ISA[c]
	Materials damage (e.g., corrosion, increased wear)	—	—	PM ISA[c]
Reduced effects from PM deposition (metals and organics)	Effects on Individual organisms and ecosystems	—	—	PM ISA[c]
Reduced vegetation and ecosystem effects from exposure to ozone	Visible foliar injury on vegetation	—	—	Ozone CD, Draft Ozone ISA[c]
	Reduced vegetation growth and reproduction	—	—	Ozone CD, Draft Ozone ISA[b]
	Yield and quality of commercial forest products and crops	—	—	Ozone CD, Draft Ozone ISA[b,d]
	Damage to urban ornamental plants	—	—	Ozone CD, Draft Ozone ISA[c]
	Carbon sequestration in terrestrial ecosystems	—	—	Ozone CD, Draft Ozone ISA[c]
	Recreational demand associated with forest aesthetics	—	—	Ozone CD, Draft Ozone ISA[c]
	Other non-use effects			Ozone CD, Draft Ozone ISA[c]
	Ecosystem functions (e.g., water cycling, biogeochemical cycles, net primary productivity, leaf-gas exchange, community composition)	—	—	Ozone CD, Draft Ozone ISA[c]

(continued)

Table ES-6. Environmental Effects of Pollutants Affected by the Mercury and Air Toxics Standards (continued)

Benefits Category	Specific Effect	Effect Has Been Quantified	Effect Has Been Monetized	More Information
Reduced effects from acid deposition	Recreational fishing	—	—	NO_x SO_x ISA[b]
	Tree mortality and decline	—	—	NO_x SO_x ISA[c]
	Commercial fishing and forestry effects	—	—	NO_x SO_x ISA[c]
	Recreational demand in terrestrial and aquatic ecosystems	—	—	NO_x SO_x ISA[c]
	Other nonuse effects			NO_x SO_x ISA[c]
	Ecosystem functions (e.g., biogeochemical cycles)	—	—	NO_x SO_x ISA[c]
Reduced effects from nutrient enrichment	Species composition and biodiversity in terrestrial and estuarine ecosystems	—	—	NO_x SO_x ISA[c]
	Coastal eutrophication	—	—	NO_x SO_x ISA[c]
	Recreational demand in terrestrial and estuarine ecosystems	—	—	NO_x SO_x ISA[c]
	Other non-use effects			NO_x SO_x ISA[c]
	Ecosystem functions (e.g., biogeochemical cycles, fire regulation)	—	—	NO_x SO_x ISA[c]
Reduced vegetation effects from ambient exposure to SO_2 and NO_x	Injury to vegetation from SO_2 exposure	—	—	NO_x SO_x ISA[c]
	Injury to vegetation from NO_x exposure	—	—	NO_x SO_x ISA[c]
Reduced incidence of morbidity from exposure to methyl mercury (through reduced mercury deposition as well as the role of sulfate in methylation)	Effects on fish, birds, and mammals (e.g., reproductive effects)	—	—	Mercury Study RTC[c,d]
	Commercial, subsistence and recreational fishing	—	—	Mercury Study RTC[c]

[a] For a complete list of references see Chapter 5.
[b] We assess these benefits qualitatively due to time and resource limitations for this analysis.
[c] We assess these benefits qualitatively because we do not have sufficient confidence in available data or methods.
[d] We assess these benefits qualitatively because current evidence is only suggestive of causality or there are other significant concerns over the strength of the association.

ES.3 Costs and Employment Impacts

The projected annual incremental private costs of the final MATS Rule to the electric power industry are $9.6 billion in 2015.[1] These costs represent the total cost to the electricity-generating industry of reducing HAP emissions to meet the emissions limits set out in the rule. Estimates are in 2007 dollars. These total costs of the rule are estimated using the Integrated Planning Model (IPM), as well as additional analyses for oil-fired units and monitoring/record-keeping costs.

There are several national changes in energy prices that result from the final MATS Rule. Retail electricity prices are projected to increase in the contiguous US by an average of 3.1% in 2015 with the final MATS Rule. On a weighted average basis between 2015 and 2030, consumer natural gas price anticipated to increase from 0.3% to 0.6% depending on consumer class in response to the final MATS Rule.

There are several other types of energy impacts associated with the final MATS Rule. A small amount of coal-fired capacity, about 4.7 GW (less than 2 percent of all coal-fired capacity in 2015), is projected to become uneconomic to maintain by 2015. These units are predominantly smaller and less frequently-used generating units dispersed throughout the contiguous US. If current forecasts of either natural gas prices or electricity demand were revised in the future to be higher, that would create a greater incentive to keep these units operational. Coal production for use in the power sector is projected to decrease by 1 percent by 2015, and we expect slightly reduced coal demand in Appalachia and the West with the final MATS Rule.

In addition to addressing the costs and benefits of the final MATS Rule, EPA has estimated a portion of the employment impacts of this rulemaking. We have estimated two types of impacts. One provides an estimate of the employment impacts on the regulated industry over time. The second covers the short-term employment impacts associated with the construction of needed pollution control equipment until the compliance date of the regulation. We expect that the rule's impact on employment will be small, but will (on net) result in an expected increase in employment.

[1] The year 2016 is the compliance year for MATS, though as we explain in later chapters, we use 2015 as a proxy for compliance in 2016 for IPM emissions, costs and economic impact analysis due to availability of modeling impacts in that year.

The approaches to estimate employment impacts use different analytical techniques, are applied to different industries during different time periods, and use different units of analysis. No overlapping estimates are summed. Estimates of employment changes per dollar of expenditure on pollution control from Morgenstern et al. (2002) are used to estimate the ongoing annual employment impacts for the regulated entities (the electric power sector) as a result of this rule. The short term estimates for employment needed to design, construct, and install the control equipment in the three year period before the compliance date are also provided using an approach that estimates employment impacts for the environmental protection sector based on forecast changes from IPM on the number and scale of pollution controls and labor intensities in relevant sectors. Finally, some of the other types of employment impacts that will be ongoing are estimated using IPM outputs and labor intensities, as reported in Chapter 6, but not included in this table because they omit some potentially important categories.

In Table ES-7, we show the employment impacts of the MATS Rule as estimated by the environmental protection sector approach and by the Morgenstern approach.

Table ES-7. Estimated Employment Impact Table

	Annual (Reoccurring)	One Time (Construction During Compliance Period)
Environmental protection sector approach[a]	Not applicable	46,000
Net effect on electric utility sector employment from Morgenstern et al., approach[c]	8,000[b] −15,000 to 30,000[d]	Not Applicable

[a] These one-time impacts on employment are estimated in terms of job-years.

[b] This estimate is not statistically different from zero.

[c] These annual or reoccurring employment impacts are estimated in terms of production workers as defined by the US Census Bureau's Annual Survey of Manufacturers (ASM).

[d] 95% confidence interval

ES.4 Small Entity and Unfunded Mandates Impacts

After preparing an analysis of small entity impacts, EPA cannot certify that there will be no SISNOSE (significant economic impacts on a substantial number of small entities) for this rule. Of the 82 small entities affected, 40 are projected to have costs greater than 1 percent of their revenues. The exclusion of units smaller than 25 Megawatt capacity (MW) as per the requirements of the Clean Air Act has already significantly reduced the burden on small entities, and EPA participated in a Small Business Regulatory Enforcement Fairness Act (SBREFA) Panel to examine ways to mitigate the impact of the proposed Toxics Rule on affected small entities

EPA examined the potential economic impacts on state and municipality-owned entities associated with this rulemaking based on assumptions of how the affected states will implement control measures to meet their emissions. These impacts have been calculated to provide additional understanding of the nature of potential impacts and additional information.

According to EPA's analysis, of the 96 government entities considered in this, EPA projects that 42 government entities will have compliance costs greater than 1 percent of base generation revenue in 2015, based on our assumptions of how the affected states implement control measures to meet their emissions budgets as set forth in this rulemaking.

Government entities projected to experience compliance costs in excess of 1 percent of revenues may have some potential for significant impact resulting from implementation of MATS.

ES.5 Limitations and Uncertainties

Every analysis examining the potential benefits and costs of a change in environmental protection requirements is limited to some extent by data gaps, limitations in model capabilities (such as geographic coverage), and variability or uncertainties in the underlying scientific and economic studies used to configure the benefit and cost models. Despite the uncertainties, we believe this benefit-cost analysis provides a reasonable indication of the expected economic benefits and costs of the final MATS Rule.

For this analysis, such uncertainties include possible errors in measurement and projection for variables such as population growth and baseline incidence rates; uncertainties associated with estimates of future-year emissions inventories and air quality; variability in the estimated relationships between changes in pollutant concentrations and the resulting changes in health and welfare effects; and uncertainties in exposure estimation.

Below is a summary of the key uncertainties of the analysis:

Costs

- Compliance costs are used to approximate the social costs of this rule. Social costs may be higher or lower than compliance costs and differ because of preexisting distortions in the economy, and because certain compliance costs may represent shifts in rents.

- Analysis does not capture employment shifts as workers are retrained at the same company or re-employed elsewhere in the economy.

- We do not include the costs of certain relatively small permitting costs associated with updating Title V permits.

- Technological innovation is not incorporated into these cost estimates. Thus, these cost estimates may be potentially higher than what may occur in the future, all other things being the same.

Benefits

- The mercury concentration estimates for the analysis come from several different sources.

- The mercury concentration estimates used in the model were based on simple temporal and spatial averages of reported fish tissue samples. This approach assumes that the mercury samples are representative of “local” conditions (i.e., within the same HUC 12) in similar waterbodies (i.e., rivers or lakes).

- State-level averages for fishing behavior of recreational anglers are applied to each modeled census tract in the state; which does not reflect within-state variation in these factors.

- Application of state-level fertility rates to specific census tracts (and specifically to women in angler households.

- Applying the state-level individual level fishing participation rates to approximate the household fishing rates conditions at a block level.

- Populations are only included in the model if they are within a reasonable distance of a waterbody with fish tissue MeHg samples. This approach undercounts the exposed population (by roughly 40 to 45%) and leads to underestimates of national aggregate baseline exposures and risks and underestimates of the risk reductions and benefits resulting from mercury emission reductions.

- Assumption of 8 g/day fish consumption rate for the general population in freshwater angler households.

- The dose-response model used to estimate neurological effects on children because of maternal mercury body burden has several important uncertainties, including selection of IQ as a primary endpoint when there may be other more sensitive endpoints, selection of the blood-to-hair ratio for mercury, and the dose-response estimates from the epidemiological literature. Control for confounding from the potentially positive cognitive effects of fish consumption and, more specifically, omega-3 fatty acids.

- Valuation of IQ losses using a lost earning approach has several uncertainties, including (1) there is a linear relationship between IQ changes and net earnings losses, (2) the unit value applies to even very small changes in IQ, and (3) the unit value will remain constant (in real present value terms) for several years into the future. Each unit value for IQ losses has two main sources of uncertainty (1). The statistical error in the average percentage change in earnings as a result of IQ changes and (2) estimates of average lifetime earnings and costs of schooling.

- Based on the modeled interim baseline which is approximately equivalent to the final baseline (see Appendix 5A), 11% and 73% of the estimated avoided premature deaths occur at or above an annual mean $PM_{2.5}$ level of 10 µg/m^3 (the LML of the Laden et al. 2006 study) and 7.5 µg/m^3 (the LML of the Pope et al. 2002 study), respectively. These are the source studies for the concentration-response functions used to estimate mortality benefits. As we model avoided premature deaths among populations exposed to levels of $PM_{2.5}$ that are successively lower than the LML of each study our confidence in the results diminishes. However, studies using data from more recent years, during which time PM concentrations have fallen, continue to report strong associations with mortality.

- There are uncertainties related to the health impact functions used in the analysis. These include: within study variability; across study variation; the application of concentration-response (C-R) functions nationwide; extrapolation of impact functions across population; and various uncertainties in the C-R function, including causality and thresholds. Therefore, benefits may be under- or over-estimates.

- Analysis is for 2016, and projecting key variables introduces uncertainty. Inherent in any analysis of future regulatory programs are uncertainties in projecting atmospheric conditions and source level emissions, as well as population, health baselines, incomes, technology, and other factors.

- This analysis omits certain unquantified effects due to lack of data, time and resources. These unquantified endpoints include other health and ecosystem effects. EPA will continue to evaluate new methods and models and select those most appropriate for estimating the benefits of reductions in air pollution. Enhanced collaboration between air quality modelers, epidemiologists, toxicologists, ecologists, and economists should result in a more tightly integrated analytical framework for measuring benefits of air pollution policies.

- $PM_{2.5}$ mortality co-benefits represent a substantial proportion of total monetized benefits (over 90%), and these estimates have following key assumptions and uncertainties.

- The $PM_{2.5}$ -related co-benefits of the alternative scenarios were derived through a benefit per-ton approach, which does not fully reflect local variability in population density, meteorology, exposure, baseline health incidence rates, or other local factors that might lead to an over-estimate or under-estimate of the actual benefits of this rule.

- We assume that all fine particles, regardless of their chemical composition, are equally potent in causing premature mortality. This is an important assumption, because $PM_{2.5}$ produced via transported precursors emitted from EGUs may differ significantly from direct $PM_{2.5}$ released from diesel engines and other industrial sources, but no clear scientific grounds exist for supporting differential effects estimates by particle type.

- We assume that the health impact function for fine particles is linear within the range of ambient concentrations under consideration. Thus, the estimates include health benefits from reducing fine particles in areas with varied concentrations of $PM_{2.5,}$ including both regions that are in attainment with fine particle standard and those that do not meet the standard down to the lowest modeled concentrations.

- To characterize the uncertainty in the relationship between $PM_{2.5}$ and premature mortality, we include a set of twelve estimates based on results of the expert elicitation study in addition to our core estimates. Even these multiple characterizations omit the uncertainty in air quality estimates, baseline incidence rates, populations exposed and transferability of the effect estimate to diverse locations. As a result, the reported confidence intervals and range of estimates give an incomplete picture about the overall uncertainty in the $PM_{2.5}$ estimates. This information should be interpreted within the context of the larger uncertainty surrounding the entire analysis.

CHAPTER 6
EMPLOYMENT AND ECONOMIC IMPACT ANALYSIS

In this chapter, we estimate select employment effects of the rule, for both the regulated industry (electric power industry) and the environmental control industry.

6.1 Employment Impacts for the MATS

In addition to addressing the costs and benefits of the MATS, EPA has estimated certain impacts of this on employment, which are presented in this section.[1] While a standalone analysis of employment impacts is not included in a standard cost-benefit analysis, such an analysis is of particular concern in the current economic climate of sustained unemployment. Executive Order 13563, states, "Our regulatory system must protect public health, welfare, safety and our environment while promoting economic growth, innovation, competiveness, and job creation " (emphasis added). Therefore, and consistent with recent efforts to characterize the employment effects of economically significant rules, the Agency has provided this analysis to inform the discussion of labor demand and employment impacts.

The analysis includes two sets of estimates. The first involves the employment impacts on the regulated industry over time. The second involves certain short-term and on-going employment impacts (increase in labor demand) associated with the construction of needed pollution control equipment, and other activities, to comply with the regulation. EPA estimates that the net employment effect on the regulated industry will range from −15,000 to +30,000 jobs, with a central estimate of +8,000. This aggregate figure includes potential job losses from increased costs as well as potential job increases as a result of additional hiring for compliance. In the pollution control sector, EPA estimates an increase of 46,000 job-years. EPA also provides a qualitative discussion of other potential employment effects, including both increases and decreases. Because of the uncertainties involved, these sets of estimates should not be added in an attempt to characterize the overall employment effect.

The Agency has not quantified the rule's effects on all labor in other sectors not regulated by the MATS, or the effects induced by changes in workers' incomes. What follows is an overview of the various ways that environmental regulation can affect employment, followed by a discussion of the estimated impacts of this rule. EPA continues to explore the relevant theoretical and empirical literature, which continues to evolve, and to seek public

[1] See the employment impacts appendix included in this RIA.

comments in order to ensure that such estimates are as accurate, useful, and informative as possible.

From an economic perspective, labor is an input into producing goods and services. If regulation leads to more labor being used to produce a given amount of output, the additional labor is reflected by an increase in the cost of production.[2] When an increase in employment occurs as a result of a regulation, it is a cost to firms. Moreover, when the economy is at full employment, we would not expect an environmental regulation to have an impact on overall employment because labor is being shifted from one sector to another. On the other hand, in periods of high unemployment, employment effects (both positive and negative) are possible. For example, an increase in labor demand due to regulation may result in a short-term net increase in overall employment due to the potential hiring of previously unemployed workers by the regulated sector to help meet new requirements (e.g., to install new equipment) or by the pollution control sector to produce new abatement capital. When significant numbers of workers are unemployed, the opportunity costs associated with displacing jobs in other sectors are likely to be smaller. And, in general, if a regulation imposes high costs and does not increase the demand for labor, it may lead to a decrease in employment.

To provide a partial picture of the employment consequences of this rule, EPA investigates the expected consequences for the regulated sector and for the pollution control sector. First, the analysis uses the results of Morgenstern, Pizer, and Shih (2002) to estimate the effects of the regulation on the regulated industry, the electric power industry in this case. This approach has been used by EPA previously in recent Regulatory Impact Analyses. Second, EPA uses information derived from engineering studies and projections of pollution controls from the power sector modeling to generate estimates of employment impacts to the pollution control sector.

Section 6.2 discusses the estimates of the employment consequences in the electricity sectors, using the Morgenstern, et al. approach. Section 6.3 estimates the employment consequences in the pollution control sector.

[2] It should be noted that if more labor must be used to produce a given amount of output, then this implies a decrease in labor productivity. A decrease in labor productivity will cause a short-run aggregate supply curve to shift to the left, and businesses will produce less, all other things being equal.

6.2 Employment Impacts Primarily on the Regulated Industry: Morgenstern, Pizer, and Shih (2002)

EPA examined possible employment effects within the electric utility sector using a peer-reviewed, published study that explores historical relationships between industrial employment and environmental regulations (Morgenstern, Pizer, and Shih, 2002). For context, in 2007, the electric power generation, transmission and distribution sector (NAICS 2211) had approximately 510,000 paid employees (according to the 2007 Economic Census). Estimates from Morgenstern et. al. study have been applied in recent RIAs to derive the employment effects of new regulations within the regulated industry. (See, for example, the Regulatory Impact Analyses for the proposed MATS and final CSAPR regulations). With certain qualifications, we believe that this study is relevant to this employment analysis, as it was for the MATS proposal, since the pollution control strategies or measures that form the basis of the cost inputs in the Morgenstern et al. analysis are primarily add-on or end-of-line pollution controls, in general covering more than 70% of the abatement expenditures in most years and industries analyzed as shown in Table 6-1. The analysis of control strategies presented in Chapter 3 of this RIA are composed entirely of add-on or end-of-line pollution controls. Thus, the cost inputs in the Morgenstern et al. analysis are consistent with the cost inputs that enter into this analysis of employment impacts within the regulated industry for MATS. It should be noted that the electric utility sector is less labor-intensive than the industries examined by Morgenstern et al. (2002). To this extent, it is possible that the positive employment impact estimates are high.

Table 6-1. Percent of Abatement Expenditures in Different PACE Studies from Add-On or End-of-Line Control Measures[3]

	Percent			
Industry	**1979**	**1983**	**1988**	**1991**
Pulp and Paper	84	80	61	47
Plastics	85	88	75	67
Petroleum Refining	72	57	63	61
Iron and Steel	96	93	94	92

[3] U.S. Bureau of the Census. *Pollution Abatement Costs and Expenditures*. Washington, DC: U.S. Government Printing Office, various years. The pulp and paper industry is defined by SIC 2611 & 2621, plastics by SICE 282, petroleum refining by SIC 2911, and iron and steel by SIC 332. For pulp and paper and iron and steel industries in 1983 the data is partially estimated based on non reported data due to disclosure reasons. The 1984 (1989) data for plastics (pulp and paper) is used instead of 1983 (1988) due to a lack of reported data in the original year.

Determining the direction of employment effects in the regulated industry is challenging due to competing effects. A regulation that imposes costs may, for that reason, have an adverse effect on employment, but if a regulation leads to the hiring of additional workers, it may, for that reason, have a positive effect on employment. The fundamental insight of Morgenstern, et al. is that environmental regulations can be understood as requiring regulated firms to add a new output (environmental quality) to their product mixes. Although legally compelled to satisfy this new demand, regulated firms have to finance this additional production with the proceeds of sales of their other (market) products. Satisfying this new demand requires additional inputs, including labor, and may alter the relative proportions of labor and capital used by regulated firms in their production processes. Thus, Morgenstern et al. decompose the overall effect of a regulation on employment into the following three subcomponents:

- The "Demand Effect": higher production costs raise market prices, reducing consumption (and production), thereby reducing demand for labor within the regulated industry (an unambiguously negative effect);
- The "Cost Effect": Assuming that the capital/labor ratio in the production process is held fixed, as production costs increase, plants use more of all inputs, including labor, to maintain a given level of output. For example, in order to reduce pollutant emissions while holding output levels constant, regulated firms may require additional labor (an unambiguously positive effect) ;
- The "Factor-Shift Effect": Regulated firms' production technologies may be more or less labor intensive after complying with a regulation (i.e., more/less labor is required per dollar of output). "Environmental activities may be more labor intensive than conventional production," meaning that "the amount of labor per dollar of output will rise." However, activities may, instead, be less labor intensive because "cleaner operations could involve automation and less employment, for example." (p. 416) (ambiguous effect)

Decomposing the overall employment impact of environmental regulation into three subcomponents clarifies the conceptual relationship between environmental regulation and employment in regulated sectors, and permitted Morgenstern, et al. to provide an empirical estimate of the net impact. For present purposes, the net effect is of particular interest, and is the focus of our analysis.

The demand effect is expected to have an unambiguously negative effect on employment, the cost effect to have an unambiguously positive effect on employment, and the factor-shift effect to have an ambiguous effect on employment. Without more information with respect to the magnitudes of these three competing effects, it is not possible to predict the net employment effect in the regulated sector.

Using plant-level Census information between the years 1979 and 1991, Morgenstern et al. estimate the size of each effect for four highly polluting and regulated industries (petroleum, plastic material, pulp and paper, and steel). On average across the four industries, each additional $1 million ($1987) spending on pollution abatement results in a (statistically insignificant) net increase of 1.55 (+/- 2.24) jobs. As a result, the authors conclude that increases in pollution abatement expenditures can have positive effects on employment and do not necessarily cause economically significant employment changes. The conclusion is similar to Berman and Bui (2001), who found that increased air quality regulation in Los Angeles did not cause in large employment changes.

Ideally, the EPA would first apply the methodology of Morgenstern et al. to current pollution expenditure and market data for the regulated firms to identify the relationship between abatement costs and employment, then use this relationship to extrapolate the effect of new projected abatement costs on these firms. Unfortunately, current firm-level abatement cost and market characteristics are not available. Therefore, the EPA has used the estimated relationship from the Morgenstern et al. data to extrapolate the employment impact of the new projected abatement costs without accounting for the industry and firm differences.

Since the Morgenstern, et al. parameter estimates are expressed in jobs per million ($1987)[4] of environmental compliance expenditures, their study offers a transparent and simple way to transfer estimates for other employment analysis. For each of the three job effects outlined above, EPA used the Morgenstern et. al. four industry average parameters and standard errors along with the estimated private compliance costs to provide a range (based on the 95th percentile of results) of employment effects in the electricity sector associated with the rule. By applying these estimates to annualized cost for the final rule for the electric power sector as shown in Chapter 3 of this RIA ($9.60 billion in 2007$) , the Agency estimated each effect. The results are:

- Demand effect: −39,000 to +2,000 jobs in the directly affected sector with a central estimate of −18,000;

[4] The Morgenstern et al. analysis uses "production worker" as defined in the US Census Bureau's Annual Survey of Manufactures (ASM) in order to define a job. This definition can be found on the Internet at http://www.census.gov/manufacturing/asm/definitions/index.html

- Cost effect: +4,000 to +21,000 jobs in the directly affected sector with a central estimate of +12,000; and
- Factor-shift effect: +200 to +27,000 jobs in the directly affected sector with a central estimate of +14,000.

EPA estimates the net employment effect to range from −15,000 to +30,000 jobs in the directly affected sector with a central estimate of +8,000.[5,6] EPA recognizes there will be other employment effects that are not considered in the Morgenstern et al. study. For example, employment in pollution control industries may increase as firms purchase more pollution control equipment and services to meet the rule's requirements. EPA does provide such an estimate of employment change later in this section in a separate analysis.

A defensible methodology for evaluating the employment impacts beyond the pollution control and regulated sectors is not yet available, though as noted before, net effects on employment are expected to be at or very close to zero for the economy overall under full employment. Attempts to estimate such effects usually rely on input-output methodologies that hold technologies and the proportion of various inputs constant over time, making them inappropriate for estimating long run impacts of regulation.

6.2.1 Limitations

The Morgenstern et al. approach to employment analysis has the advantage of carefully controlling for many possibly confounding effects in order to separate the effect of changes in regulatory costs on employment. Although the Morgenstern et al. paper provides information about the potential job effects of environmental protection programs, however, there are several caveats associated with using those estimates to analyze the final rule. First, the Morgenstern et al. estimates presented in Table 6-2 and used in EPA's analysis represent the weighted average parameter estimates for a set of manufacturing industries (pulp and paper, plastics, petroleum, and steel). Unfortunately this set of industries does not overlap directly with the electric utility sector. Second, relying on Morgenstern et al. implicitly assumes that the employment estimates derived from 1979–1991 data are still applicable. Third, the methodology used in Morgenstern et al. assumes that regulations affect plants in proportion to

[5] Since Morgenstern's analysis reports environmental expenditures in $1987, we make an inflation adjustment the IPM costs using the ratio of the annual consumer price index, U.S. city, all items reported by the U.S. Bureau of Labor Statistics: CPI_{1987}/ CPI_{2007} = (113.6/207.3) = 0.55.

[6] Net employment effect = 1.55× $9,600 million × 0.55. Given the 95% confidence interval for this effect, this estimated net result is not statistically different from zero.

their total costs. In other words, each additional dollar of regulatory burden affects a plant by an amount equal to that plant's total costs relative to the aggregate industry costs. By transferring the estimates, EPA assumes a similar distribution of regulatory costs by plant size and that the regulatory burden does not disproportionately fall on smaller or larger plants. EPA also assumes that the net employment impact can be linearly extrapolated from the abatement cost (i.e., that every million 1987 dollars generates a central estimate of 1.55 jobs). Fourth, the Morgenstern et al. analysis makes particular assumptions about the role of imports and the effect of previous regulation on plant closures. While imports are not an issue for MATS, the stringency of the current regulation is expected to result in a number of power plant closures due to early retirement of coal-fired EGU capacity in 2015, as indicated in Chapter 3 of this RIA.

Finally, the Morgenstern et.al. methodology does not examine the effects of regulation on employment in sectors related to, but outside of the regulated sector. However, it does suggest that the relationship between the employment impact in any sector and increased costs due to regulation is ambiguous.

Table 6-2. Employment Impacts Within the Regulated Industry Using Peer-Reviewed Study Estimates using Morgenstern et al. (2002)

	Estimates Using Morgenstern, et. al (2002)			
	Demand Effect	**Cost Effect**	**Factor Shift Effect**	**Net Effect**
Change in Full-Time Jobs per Million Dollars of Environmental Expenditure[a]	−3.56	2.42	2.68	1.55
Standard Error	2.03	0.83	1.35	2.24
EPA Estimate for Rule[b]	−39,000 to +2,000	+4,000 to +21,000	+200 to +27,000	−15,000 to +30,000[c]

[a] Expressed in 1987 dollars. Adjustment of dollars from 2007 to 1987 is accomplished through use of the annual Consumer Price Index – All Urban Consumers, found on the Internet at ftp://ftp.bls.gov/pub/special.requests/cpi/cpiai.txt. U.S. Department of Labor, Bureau of Labor Statistics. Washington, D.C.

[b] According to the 2007 Economic Census, the electric power generation, transmission and distribution sector (NAICS 2211) had approximately 510,000 paid employees. Both the midpoint and range for each effect are reported in the last row of the table.

[c] EPA has used this study to estimate the mean net employment impact of this rule, and provided the 95% confidence interval results to reflect the high degree of uncertainty regarding the effect on employment within the regulated industry. The confidence interval includes zero indicating we are uncertain as to the sign of the effect, but the interval itself does reveal information on the magnitude of the effect.

6.3 Employment Impacts of the MATS-Pollution Control Sector Approach by 2015[7]

Regulations set in motion new orders for pollution control equipment and services. New categories of employment have been created in the process of implementing environmental regulations. When a regulation is promulgated, one typical response of industry is to order pollution control equipment and services in order to comply with the regulation when it becomes effective, while closure of plants that choose not to comply occurs after the compliance date. With such a response by industry as a basis, this section presents estimates for short term employment needed to design, construct, and install the control equipment in the three or four year period leading up to the compliance date. Environmental regulation may increase revenue and employment in the environmental technology industry. While these increases represent gains for that industry, they are costs to the regulated industries required to install the equipment. As with any pool of labor, the gross size of the labor pool does not reflect the net impact on overall employment after adjusting for shifts in other sectors.

Regulated firms hire workers to design and build pollution controls. Once the equipment is installed, regulated firms hire workers to operate and maintain the pollution control equipment – much like they hire workers to produce more output. Of course, these firms may also reassign existing employees to do these activities. Environmental regulations also support employment in many basic industries. In addition to the increase in employment in the pollution control industry (to fill increased orders for pollution control equipment placed by the regulated sector), environmental regulations also support employment in industries that provide intermediate goods to the pollution control industry. For example, an investment in capital expenditures to reduce air pollution involves the purchase of abatement equipment. The equipment manufacturers, in turn, order steel, tanks, vessels, blowers, pumps, and chemicals to manufacture and install the equipment. A study by Bezdek, Wendling, and DiPernab (2008) found that "investments in environmental protection create jobs and displace jobs, but the net effect on employment is positive."[8] The majority of the jobs associated with added pollution controls (e.g., boilermakers, general construction workers, etc.) will provide domestic employment opportunities, but some goods and services demanded and/or provided to the pollution control industry (e.g., steel, cement, etc.) are internationally traded goods.

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[7] EPA expects that the installation of retrofit control equipment in response to the requirements of this proposal will primarily take place within 3 years of the effective date of the final rule, but there may be a possibility that some installations may occur within 4 years of the effective date.

[8] Environmental protection, the economy, and jobs: National and regional analyses, Roger H. Bezdek, Robert M. Wendling and Paula DiPerna, Journal of Environmental Management Volume 86, Issue 1, January 2008, Pages 63-79.

The focus of this part of the employment analysis is on short-term employment related to the compliance actions of the affected entities. This analysis estimates the employment impacts due to the increased demand for pollution control equipment in response to MATS.[9] Results indicate that the MATS has the potential to result in a net increase of labor in these industries, driven by the high demand for new pollution controls. Overall, the results of the pollution control sector approach indicate that the MATS could support an increase of about 46,000 job-years[10] by 2015.

6.3.1 Overall Approach and Methodology for Pollution Control Sector Approach

EPA developed estimates of the potential employment changes for the Pollution Control Sector using a bottom-up engineering based methodology combined with macroeconomic data on industrial output and productivity, to estimate employment impacts. The approach relies heavily on the projections and costing analysis from the IPM model, which uses industry specific data and assumptions to derive compliance costs and energy impacts (See Chapter 3). Central to the approach are prior EPA studies on similar issues, and in particular, data and information from extensive engineering studies that the Agency has commissioned.[11] The analysis develops employment estimates by relying on IPM projections from the MATS analysis for the specific types of pollution control technologies expected to be installed to comply with the rule.[12] More specifically, the analysis includes estimates for the labor needed to design, manufacture and install the needed pollution control equipment over the 3 to 4 years leading up to compliance in 2015.

For construction labor, the labor needs are derived from an update to a 2002 EPA resource analysis for building various pollution controls (FGD – Flue Gas Desulfurization or scrubbers, SCR- selective catalytic reduction, ACI – activated carbon injection, DSI - dry sorbent injection, and FF - Fabric Filters) and are further classified into different labor categories. These categories include boilermakers, engineers and a catch-all “other” installation labor. For the inputs needed (e.g., steel), the updated 2002 resource study was used to determine the steel

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[9] For more detail on methodology, approach, and assumptions, see Appendix 6A.

[10] Numbers of job years are not the same as numbers of individual jobs, but represents the amount of work that can be performed by the equivalent of one full-time individual for a year (or FTE). For example, 25 job years may be equivalent to five full-time workers for five years, twenty-five full-time workers for one year, or one full-time worker for twenty-five years.

[11] Engineering and Economic Factors Affecting the Installation of Control Technologies for Multipollutant Strategies EPA-600/R-02/073 (2002) and Engineering and Economic Factors Affecting the Installation of Control Technologies – An Update (2011).

[12] Detailed results from IPM for the MATS can be found in Chapter 3 of the RIA.

demand for each MW of additional pollution control, combined with labor productivity data from the Economic Census and BLS for relevant industries. More detail on methodology, assumptions, and data sources can be found in Appendix 6A for this RIA. Projections from IPM were used to estimate the incremental retrofit capacities projected in response to the final rule. These additional pollution controls are shown in Table 6-3, and reflect the added pollution controls needed to meet the requirements of the rule. Additional information on the power sector impacts can be found in Chapter 3 of the RIA.

Table 6-3. Increased Pollution Control Installations due to MATS, by 2015 (GW)

Retrofit Type	IPM Projected Additional Pollution Control
FGD	17
ACI	99
DSI	44
FF	102

6.3.2 Summary of Employment Estimates from Pollution Control Sector Approach

Table 6-4 shows the results of employment impacts resulting from the additional demand for the aforementioned pollution controls. The results indicate that MATS could support or create roughly 46,000 one-time job-years of increased cost of direct labor, driven by the need to design and build the pollution control retrofits.

Table 6-4. Employment Effects Using the Pollution Control Sector Approach for the MATS (in Job-Years)[13]

Employment	Incremental Employment
One-Time Employment Changes for Construction	
1. Boilermakers	20,000
2. Engineers	5,000
3. General Construction	21,000
Total	**46,000**

[13] Numbers are rounded to nearest thousand. MATS is not anticipated to result in any notable new capacity in response to the rule, and thus is not considered as part of this analysis.

6.3.3 Other Employment Impacts of MATS

In addition to the employment impacts estimated for the regulated sector and pollution control sectors, there are likely to be other employment impacts associated with MATS. These include changes resulting from labor needed to operate the needed pollution controls, increased demand for materials used in pollution control operation, shifts in demand for fuel in response to the rule, changes in employment resulting from additional coal retirements, and changes in other industries due to changes in the price of electricity and natural gas.[14] The EPA has provided estimates of some of these effects below, which are discussed in more detail in Appendix 6A. The most notable of those that the Agency is unable to estimate are the impacts on employment as a result of the increase in electricity and other energy prices in the economy. Nor is the Agency able to quantify all the employment changes in industries that support and supply the pollution control industry. Because of this inability to estimate all the important employment impacts, EPA neither sums the impacts that the Agency is able to estimate for these other employment impacts or make any inferences of whether there is a net gain or loss of employment across these categories. A summary of the other employment impacts can be found in Table 6-5, with additional detail provided in Appendix 6A.

Table 6-5. Other Employment Impacts of MATS (in Job-Years)

Employment Impacts from Increased Demand for Pollution Control Operating Inputs	
Lime (FGD)	280
Activated Carbon (ACI)	460
Trona (DSI)	3,130
Baghouse material (FF)	20
Employment Impacts from Pollution Control Operation	4,320
Employment Impacts from Retirements of Existing Coal Capacity	(2,500)
Employment Impacts from Changes in Coal Demand	(430)
Employment Impacts from Changes in Natural Gas Demand	670

Note: See Appendix 6A for more detail.

6.4 Summary of Employment Impacts

The employment approaches used by EPA rely on different analytical techniques and are applied to different industries during different time periods, and they use different units of

[14] The employment approaches used by EPA rely on different analytical techniques and are applied to different industries during different time periods, and they use different units of analysis. These estimates should not be summed because of the different metrics, length and methods of analysis. The Morgenstern estimates are used for the ongoing employment impacts for the regulated entities (the electric power sector).

analysis. These estimates should not be summed because of the different metrics, length and methods of analysis. The Morgenstern estimates are used for the ongoing employment impacts for the regulated entities (the electric power sector). The short term estimates for employment needed to design, construct, and install the control equipment in the three or four year period leading up to the compliance date are also provided. Finally some of the other types of employment impacts that will be ongoing are estimated.

In Table 6-6, we show the employment impacts of the MATS as estimated by the pollution control sector approach and by the Morgenstern approach.

Table 6-6. Estimated Employment Impact Table for the MATS

	Annual (Reoccurring)	One Time (Construction During Compliance Period)
Pollution Control Sector approach[a]	Not Applicable	46,000
Net Effect on Electric Utility Sector Employment from Morgenstern et al. approach[c]	8,000[b] -15, 000 to +30,000[d]	Not Applicable

[a]These one-time impacts on employment are estimated in terms of job-years. These employment estimates should not be summed because of the different metrics, length and methods of analysis.

[b]This estimate is not statistically different from zero.

[c]These annual or recurring employment impacts are estimated in terms of production workers as defined by the US Census Bureau's Annual Survey of Manufacturers (ASM).

[d]95% confidence interval

6.5 Potential Effect of Electricity Price Increase on Economy-Wide Production Costs

As with any input into production, the new price of electricity, reflecting the costs of MATS, will be absorbed in some fraction by industries that use electricity in their operations. Firms can respond to price changes by making changes to their processes, raising their prices, reducing production, etc. However, electricity expenditures are only a modest component of overall economic activity.

On an expenditures-weighted basis, electricity comprises only 0.75% of total production expenditures across all sectors in 2002 (BEA, 2007b, 2007c).[15] As reported in Chapter 3, the Retail Electricity Price Model forecasts a 3.1% increase in the contiguous U.S. electricity price in 2015 (see Table 3-12) as a result of MATS. Therefore, the upper estimate of the initial increase

[15] The BEA's benchmark I/O summary-level data includes information on the share of expenditures by industry spent on 135 commodity categories for 133 different sectors. These data provide a "comprehensive picture of inner workings of the economy" (Stewart et al., 2007). For more detail, see BEA 2007a and 2009.

in production costs across all sectors from direct electricity expenses is 0.023% (=[0.031 * 0.0075]*100%).[16] This 0.023% increase in average production expenditures represents a credible upper estimate of the average direct effect of higher electricity expenses because it assumes that production, consumption, and input levels do not change in the economy.[17] In reality, we know that producers and consumers can often use less electricity-intensive substitute goods and services to avoid a significant portion of these costs even in the short-run, which would mitigate these production cost increases. We also know that producers of intermediate goods and services that adjust to higher electricity prices can also make changes that lead to price adjustments for final goods and services sectors (as discussed below, indirect electricity price effects are not included in this illustrative estimate). Taking into account the fact that these numbers represent an upper estimate of initial production costs from the direct increase in electricity expenditures, EPA does not expect that increases in average production expenses from direct electricity price changes in this range are sufficient to cause significant shifts in overall economic activity outside the electricity sector and its major input markets. Note that this per unit percent cost increase does not reflect other potential economic effects of this rule. For example, the increased expenditures on pollution abatement equipment could create more demand for labor in those industries. Alternatively, as producers switch away from electricity-intensive inputs, the demand for other inputs may increase, changing the cost of production for those factors of production.

This estimate has a number of limitations. First, as mentioned above, it reflects an upper estimate on the initial change to the average production cost of goods and services from direct electricity expenses because the calculation used to estimate these changes assumes that production, consumption and input use will not change in response to higher electricity prices. Second, as mentioned above, this analysis also does not account for the effect that higher electricity prices have on the factors used by other sectors (e.g. the cost of components and other inputs). For sectors that use both electricity and other energy-intensive inputs, the effect of higher electricity prices on input prices can be important but applying the BEA data to account for the indirect effect of electricity price pass-through on factors relies even more

[16] Note that we are only performing simple calculations for upper estimate increases in per unit production costs as a direct consequence of higher electricity prices. A modeling approach would require assumptions about behavioral response to price changes, and we are assuming for this analysis that there is no behavioral response to higher electricity prices.

[17] This means that all other inputs, including capital, labor, and materials are assumed to be fixed when generating an upper estimate per unit production expense from direct electricity prices for the industries included in this analysis.

heavily on assumptions about the inability of sectors to change their factor mix in response to relative factor prices changes. Third, important differences across sectors, regions and consumer classes may be masked by the nationwide estimated average expenditure changes. However, because the Retail Electricity Price Model does not estimate price changes for different customer classes, and because the BEA data does not provide a regional decomposition of the economic accounts suitable to calculating regional upper estimates on per unit production expenses, regional and consumer class price differences cannot be calculated. Similarly, there are sectors that will have a meaningfully higher or lower maximum increase in average production expenditures within the context of the national average. Fourth, the share of electricity used may have changed since 2002. In general, electricity consumption per dollar of gross domestic product fell from 2002 through 2009, but electricity expenditures relative to gross domestic product rose slightly over this time (EIA, 2011; BEA 2011). Not accounting for this change over time in expenditures on electricity may lead to a slight underestimate of the increase in average production expenditures, averaged across the entire economy, as a result of this rule.

While there are several caveats to this approach, this calculation suggests that electricity prices under MATS are not expected to have a large impact on production costs for the economy as a whole. Initial production cost impacts of less than 0.023% from direct electricity expenditures are unlikely to lead to significant impacts on the overall economy and would fall within the normal variability range of input price variation observed by producers in the past. This is consistent with the overall history of the implementation of the Clean Air Act (Jaffe et al., 1995).

This upper estimate of average initial production cost increases from direct electricity expenditures cannot be used to estimate changes in employment as a result of the regulation, either nationally or for individual sectors. First, as noted above, these calculations do not account for the ability of the real economy to adjust to changes in price through input substitution, technological innovation, or other means. It is necessary to account for changes in production, consumption, and input use to estimate the change in total employment. Second, this approach does not account for changes in consumer and producer behavior as they adjust the quantity of goods and services supplied or demanded in all of the markets affected by the regulation. Changes in employment (both increases and decreases) in downstream sectors will reflect the balance of all of these interactions.

An evaluation of the employment impacts beyond the pollution control and regulated sectors is not yet available, though as noted before, net effects on employment are expected to be at or very close to zero for the economy overall under full employment. In the case of this rule, labor may be a complement or a substitute to electricity in production, depending on the sector. It is also the case that environmental regulation may increase labor productivity by improving health, which may increase employment (via an increase in overall economic productivity, see the discussion in Chapter 5). Attempts to estimate such economy-wide effects by holding technologies and the proportion of various inputs constant over time are inappropriate for estimating long run impacts of regulation and an inaccurate representation of the behavior of real-world firms.

6.6 Estimating Social Cost and Economic Impacts

In the Transport Rule proposed in the summer of 2010 and in other rulemakings, EPA used a different model to estimate the social cost and economic impacts of the regulatory approach than the model applied in this RIA. That model, EPA's EMPAX, is a CGE model that dynamically cascades the cost of a regulation through the entire economy. Since that rule was proposed, a different version of EMPAX was used to estimate the social cost of the Clean Air Act in a new EPA report entitled "The Benefits and Costs of the Clean Air Act from 1990 to 2020" (EPA, 2010, herein referred to as the Section 812 report). This version of EMPAX accounts for the benefits of reducing pollution on labor productivity and on the demand for health care, which significantly influenced the model's estimates of the social cost and economic impacts of the Clean Air Act relative to an analysis using EMPAX in which these benefits-related effects were not accounted for. In December 2010, in its review of the 812 Report EPA's Science Advisory Board (SAB) found that "The inclusion of benefit-side effects (reductions in mortality, morbidity, and health-care expenditures) in a computable general equilibrium (CGE) model represents a significant step forward in benefit-cost analysis" (SAB, 2010). A description of the changes to the model and implications are described in detail in chapter 8 of the Section 812 report. EPA has determined that it needs to update the EMPAX model version used for RIAs to account for these beneficial effects of reducing pollution prior to its use in any additional regulatory analysis. The EMPAX model version used for the Section 812 report cannot be used for this rulemaking because it contains energy and economic data that are consistent with the multi-year timeframes and energy scenarios of the 812 study but not with the single target year, analysis timeframe, and energy scenario most appropriate for this current rulemaking analysis. For example, much of the energy data in the EMPAX model employed in the Section 812 report is from the Energy Information Administration's Annual Energy Outlook 2005. With these impacts of reducing pollution on labor productivity and the demand for health care now in the process of being incorporated into the model, the SAB's perspective on the desirability of accounting for these effects in the CGE analysis for the 812 study, and the typical practice by

EPA's Office of Air and Radiation of having analyses within RIAs to be consistent in design with those included in the most recent available Section 812 report, EPA will not use EMPAX for this RIA.

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APPENDIX 6A

EMPLOYMENT ESTIMATES OF DIRECT LABOR IN RESPONSE TO THE MERCURY AND AIR TOXICS STANDARDS IN 2015

This appendix presents the short-term employment estimates of the Mercury and Air Toxics Standards (MATS), henceforth referred to as the final MATS. The focus of the employment analysis in this study is only on the first order employment impacts related to the compliance actions of the affected coal-fired entities within the power sector.[18] It does not include the ripple effects of those impacts on the broader economy (i.e., the "multiplier" effect), nor does it include the wider economy-wide effects of the changes to energy markets (such as higher electricity prices).[19] Moreover, this study provides only a static snapshot of the impacts for 2015 and does not account for the dynamic adjustments of the affected entities as they adapt to the final MATS, such as those arising from technological innovation and learning-by-doing. This analysis is also independent of other techniques used by the U.S. EPA to estimate certain employment effects of particular regulations.

The estimates of the employment impacts are divided into several categories: job gains due to the increased demand for pollution control equipment; job losses due to retirements of coal capacity; and job shifts due to changes in demand for fuels. The various employment metrics can also be distinguished by one-time employment changes (e.g., pollution control construction), and ongoing employment changes (e.g., fuel use changes and pollution control operation or coal retirements). Results indicate that the final MATS has the potential to provide significant short-term employment opportunities, primarily driven by the high demand for new pollution control equipment. The employment gains related to the new pollution controls are likely to be tempered by some losses due to certain coal retirements, although, as discussed below, some of these workers who lose their jobs due to plant retirements could find replacement employment operating the new pollution controls at nearby units. Finally, job losses due to reduced coal demand are expected to be offset by job gains due to increased natural gas demand, resulting in very small positive (i.e., less than three hundred) net change in employment due to fuel demand changes. Overall, the preliminary results indicate that the final MATS could support a net of slightly over 46,000 one-time job-years and a net of about 6,000 ongoing job-years in 2015. These results are summarized in Table 6A-1 below.

[18] This analysis does not include potential employment effects resulting from projected impacts on oil/gas-fired units.

[19] For more detail on the economic impacts of the proposed rule, see Chapter 3 of the Regulatory Impact Analysis accompanying final MATS.

Table 6A-1: Net Employment Changes for 2015 (job-years)[a,b]

	One Time	Ongoing
New Pollution Control Equipment	46,120	8,210
Retirements of Generating Units	-	(2,500)
Changes in Fuel Use	-	240
Net Effect	**46,120**	**5,950**

[a] Total job years of labor for controls projected to be installed by 2015. MATS is not anticipated to result in any notable new capacity in response to the rule, and thus is not considered as part of this analysis.
[b] Totals may not add due to rounding.

The job-years estimated here is a snapshot of the first order employment effect of the final MATS in 2015. While there is no temporal dimension to this study, some of these jobs are likely to be spread over several years, and some will last longer. Most of the construction related labor demand, for example, is expected to provide a short-term, temporary boost to employment that could last two or three years, along with any "multiplier effects" (i.e., secondary employment supported in upstream sectors) that are not included in these job-year estimates. Most of the operational labor needs and labor shifts resulting from fuel changes are likely to be longer term. Thus, in terms of the impacts of the final MATS on economy-wide employment over time, this analysis shows there could be a significant temporary increase to employment levels starting well before 2015, which would likely recede thereafter as the construction phases for the needed pollution controls wind down. Over time, the operational jobs will continue to provide a small boost to employment over "business as usual" baseline employment levels. Note that this synopsis does not account for other employment impacts of the final MATS, such as those resulting from higher energy prices.

6A.1 Overall Approach

The estimates for the near-term employment effects of the final MATS utilize studies conducted by EPA on engineering and resource requirements for various compliance activities, such as installing pollution control equipment, switching fuels, or ceasing plant operations as they become uneconomic. Some of the information used here was obtained from a 2002 EPA engineering study for multi-pollutant control strategies.[20] This study was also the basis for the employment analysis for the proposed MATS. For the final MATS, EPA has undertaken a separate study to update the 2002 analysis in order to refine and update the Agency's understanding of the resource requirements (labor and materials) of various compliance

[20] *Engineering and Economic Factors Affecting the Installation of Control Technologies for Multi-pollutant Strategies*. EPA-600/R-02/073 (October, 2002).

activities, including estimates for newer pollution control equipment that were not included in the 2002 analysis.[21] For example, the 2002 study focused on pollution control technologies that directly address SO_2 and NO_x emissions, while the updated study also includes pollution control technologies that reduce mercury emissions and hazardous air pollutants as well. Collectively, these studies are referred to as EPA *pollution control studies* in this appendix. This employment analysis is based on information from the updated study where available, as well as data from the original 2002 study, where updated information was unavailable.

The basic approach involved using power sector projections and various energy market implications under the final MATS from modeling using EPA's data and assumptions with the Integrated Planning Model (IPM), along with data from secondary sources, to estimate the first order employment impacts for 2015. Throughout this analysis, incremental employment is measured in job-years, since there is no temporal dimension to this analysis.[22] Also, this appendix does not include estimates of total employment impacts *over time*, though there is a distinction between short-term construction related labor needs and more long-term operational labor needs for new pollution controls (though these operational labor requirements are also measured in 2015 job-years only).

6A.1.2 Employment Changes due to New Pollution Control Equipment

EPA's IPM projections for the final MATS policy case were used to estimate the incremental pollution control demand. These are shown in Table 6A-2 below:[23] Note that the capacity estimates shown in Table 6A-2 do not include EPA's projections for ESP and FGD upgrades on existing units. Because the engineering studies used in this employment analysis do not include resource estimates for these technologies, EPA chose not to analyze the employment impacts for these technologies. This exclusion is likely to understate the total employment impacts for the final MATS.

[21] *Engineering and Economic Factors Affecting the Installation of Control Technologies – An Update*. Andover Technology Partners and ICF International. October 20, 2011.

[22] A job-year is defined as the amount of work that can be performed by the equivalent of one full-time individual for one year (or FTE).

[23] According to IPM, there is some overlap between the different types of pollution control equipment demand at individual facilities. To the extent that there could be some efficiency gains at plants installing multiple controls due to economies of scale, the job estimates presented here could overstate the impacts.

Table 6A-2: Increased Pollution Control Demand due to the final MATS, 2015 (GW)

Pollution Control Type	IPM Projected Additional Pollution Control
Scrubbers (FGD) [24]	17
Activated Carbon Injection (ACI)	99
Dry Sorbent Injection (DSI)	44
Fabric Filter (FF) [25]	102

The employment impacts due to increased pollution control demand are divided into three categories, one of which is associated with the construction and installation labor requirements, while the remaining two are associated with the resources required for the ongoing operation of the pollution control equipment. The labor needed for constructing and installing these controls are for construction-related sectors, such as boilermakers, engineers, and other installation labor. The two categories of labor needs for ongoing resource requirements include employment in sectors that supply resources needed to run these pollution controls (such as reagents); and utility sector jobs to operate the control equipment. The following sections discuss the approach for each:

- For the construction labor estimates, per-unit labor needs were taken from the pollution control studies, which included man-hours required per MW for each of the control technologies listed above. The total installation labor was then sub-divided into different labor categories, such as boilermakers, engineers and a catch-all "other installation labor", using estimated shares of the different labor types in the EPA pollution control studies.

- For the longer term labor associated with operating the pollution controls, per-unit estimates of the main resources needed for the particular types of equipment (see Table 6A-3 below for a list of the resources) are also taken from EPA's pollution control

[24] In addition to the scrubber capacity shown in Table 2, EPA also projects an additional 2.6 GW of dry scrubbers on units burning waste coal and pet. coke and have existing baghouses. This capacity is not included in the table above, however, employment impacts associated with these controls are included in this appendix as discussed below.

[25] This number includes the total incremental fabric filters, as reported in Chapter 3. For the purpose of estimating the construction jobs from fabric filters this appendix uses an incremental capacity of 84 GW (i.e., incremental fabric filters that are standalone, or installed with DSI or ACI+Toxecon). To avoid double counting, the remaining 18 GW of fabric filters that represent those installed on units with dry scrubbers are excluded from the employment analysis, under the assumption that the labor estimates for dry scrubbers include resources required for both the scrubber as well as the fabric filter that goes with it.

studies. Resources needed for FF (such as the filter bags) were estimated from the incremental Variable Operation and Maintenance (VOM) costs from EPA's IPM modeling results.[26] These were then multiplied by the incremental GW for each pollution control to obtain the total (physical) quantity of resources needed. Total tonnage for each resource was then converted to dollars of increased economic output for these resources using price estimates developed by Sargent & Lundy for EPA's IPM Base Case v4.10 modeling assumptions (see notes at the end of Table 6A-3 below). Finally, the labor productivity for each particular sector was used to estimate the number of job-years these could create in 2015. Labor productivities for each sector were adjusted to account for increased worker productivity in 2015. Data for baseline worker productivity and corresponding growth rates to account for future productivities came from the Economic Census and the Bureau of Labor Statistics (BLS) estimates.[27]

- The final employment vector estimated was for the utility sector labor needed to operate these pollution control equipment. This estimate was based on the incremental Fixed Operation and Maintenance (FOM) costs from EPA's IPM modeling results, excluding costs due to retirements. Thus, this study assumes that the FOM costs are a reasonable proxy for the payroll costs that are part of the FOM costs in EPA's modeling (FOM costs are defined as the operating and maintenance costs incurred by the utility, such as those for payroll, irrespective of whether the equipment is operated). The FOM costs were then translated into employment based on estimates of payroll per worker for the power sector taken from the 2007 Economic Census and BLS estimates.[28]

[26] Because FF requirements are not endogenously determined in IPM, it required a different approach than the other controls.

[27] Total value of shipments in 2007 and total employees were taken from 2007 Economic Census, Statistics by Industry for Mining and Manufacturing sectors. The average annual growth rate of labor productivity was taken from the Bureau of Labor Statistics. Average growth rate calculated for years 1992-2007, applied to 2007 productivity to determine 2015 estimates of productivity. See the Detailed Methodology section at the end for more details about the data used for these calculations.

[28] Same sources as other productivity estimates (2007 Economic Census and BLS), however, uses employees and total payroll rather than revenue or value of shipments.

Table 6A-3: Estimated Pollution Control Resource Needs (Quantity and Prices Used)

	Amount of Resource Used	Price Used ($/unit)
Lime, FGD (tons)	1,490,391	$95[29]
Activated Carbon, ACI (tons)	184,771	$1,500
Trona, DSI (tons)	10,667,613	$150

Price Sources:

- Sargent & Lundy, "IPM Model – Revisions to Cost and Performance for APC Technologies Mercury Control Cost Development Methodology FINAL", March 2011, Project 12301-009, Perrin Quarles Associates, Inc.
- Sargent & Lundy, "IPM Model – Revisions to Cost and Performance for APC Technologies Dry Sorbent Injection Cost Development Methodology FINAL", August 2010, Project 12301-007, Perrin Quarles Associates, Inc.
- Sargent & Lundy, "IPM Model – Revisions to Cost and Performance for APC Technologies SDA FGD Cost Development Methodology FINAL", August 2010, Project 12301-007, Perrin Quarles Associates, Inc.

6A.1.3 Results

Table 6A-4 presents the estimated employment impacts in 2015 resulting from the additional pollution controls needed to meet the final MATS requirements. According to this analysis, these investments could provide the opportunity to support about 54,500 job-years to design, construct, and operate the needed pollution control equipment in 2015. Note, some of these jobs are expected to start before, and continue beyond 2015 (such as the resource related job-years), but this analysis only provides a snapshot for 2015.

[29] For FGD this study uses the price for Lime (Dry FGD) which is significantly greater than the Limestone (Wet FGD) price. This price was used because EPA's modeling indicates most of the incremental FGD units are likely to be dry scrubbers.

Table 6A-4: Jobs Due to Pollution Control Equipment under the final MATS (Job-years in 2015)

Jobs for Construction		Incremental Employment
1. Boilermakers		20,190
2. Engineers		5,060
3. General Construction		20,870
	Sub-Total:	**46,120**
Jobs for Operation		
Jobs from Increased Operating Resource Use		
1. Lime (FGD)		280
2. Activated Carbon (ACI)		460
3. Trona (DSI)		3,130
4. Baghouse material (FF)		20
	Sub-Total:	**3,890**
Jobs for Pollution Control Operation		**4,320**
Total Labor:		**54,330**

Note: Totals may not add due to rounding

The number of job-years estimated for pollution control installation (i.e., "Jobs for Construction" in Table 6A-4 above) is driven in large part by the demand for new FFs used in EPA's modeling. As shown in Table 6A-2, up to 84 GW of new FF capacity is projected to come online in 2015 due to the final MATS that are relevant for this employment analysis. The demand for new FFs is estimated to contribute nearly 70 percent of the new employment resulting from the installation of pollution controls. Moreover, of the labor needed due to increased resource use, the Trona required for DSI is estimated to support higher number of jobs than the other resources. This is because the DSI technology requires significantly higher quantities of reagents than the other pollution controls, based on EPA's engineering estimates and pollution control studies. The second highest resource-related employment gains would likely come from the activated carbon needed in response to the final MATS.

Of the roughly 54,500 job-years estimated in Table 6A-4, about 4,300 job-years, or about 8 percent, are estimated to occur within the utility sector for labor needed to operate the pollution controls (referred to as "Jobs for Pollution Control Operation" in Table 6A-4). The rest of the labor demand will benefit the pollution control industry and other economic sectors. The increased demand for resources and chemicals needed to operate the pollution controls will result in increased employment in sectors such as mining, chemicals, and other manufacturing sectors. The majority of these first order employment effects, however, are likely to benefit construction-related sectors, such as construction, boilermaker, heavy engineering, and other heavy construction sectors, resulting from the construction and installation of the new pollution controls at affected sources throughout the country.

6A.1.3.1 Employment Changes due to Coal Retirements

Employment changes due to incremental coal plant retirements were estimated by first identifying the retiring coal units[30] from EPA's modeling results (for the base and the final MATS policy cases). EPA projects roughly 4.7 GW of additional coal retirements by 2015 with the final MATS in place.[31]

In order to convert the retired coal capacity into potential employment losses, it was assumed that changes in the operating costs for the retired coal units can be used as a proxy for payroll expenditures and the lost economic output due to coal retirements. Thus, the changes in the FOM costs for these particular retiring units were derived using EPA's IPM modeling results, and converted to lost jobs using data from the Economic Census and BLS output/worker estimates for the utility sector.[32] Employment losses due to plant retirements will not only affect those that are directly working at the plant (i.e., plant operators), but would also affect administrative and other "back-office" workers for those utilities and their support organizations. This appendix assumes that the FOM costs related to retiring plants are a good proxy for these types of job losses.

Table 6A-5: Annual Job Losses due to Coal Capacity Retirements for 2015

FOM Decrease from Retirements (million)	$288
Workers Per Million$ in payroll	8.7
Workers lost due to retirements (job-year):	**2,500**

[30] Oil and gas steam unit emissions requirements, and potential retirements, were not directly included in EPA's IPM modeling under the MATS policy scenario. An analysis of these units was conducted separately, and to the extent that there may be some retirements of oil and gas units, then the estimates of potential job losses due to retirements provided here will understate the employment losses.

[31] Retirement estimates are based on IPM System Summary Reports from EPA's modeling runs. Where applicable, data from IPM parsed outputs were adjusted to account for partial retirements reported in the parsed outputs.

[32] The same specific sources as cited before, however, used workers and total payroll.

Results indicate there could potentially be about 2,500 job losses (measured in job-years for 2015, but any *net* job losses under this category are likely to be permanent), due to coal retirements. However, two mitigating factors could reduce the negative employment impacts due to retirements. First, many of the retiring units are at plants that are likely to have other units operating under the policy scenario. In such cases, some of the excess labor pool at the retiring units could well be absorbed at other units within the same firm.

Second, as Table 6A-4 indicates, utilities are expected to have the need to fill about 4,300 additional job slots to operate the pollution controls needed to meet the requirements of the final MATS. If workers with experience at existing coal facilities become available through plant retirements, some of these workers could be absorbed in operating these new pollution controls.

6A.1.3.2 Employment Changes due to Changes in Fuel Use

Employment impacts due to projected fuel use changes (coal and natural gas production shifts) were estimated using EPA's modeling results. First, employment losses due to reductions in coal demand were estimated using an approach similar to EPA's coal employment analyses under Title IV of the Clean Air Act Amendments.[33] Using this approach, EPA's projected coal demand changes (in short tons) for various coal supplying regions were converted to job-years using EIA data on regional coal mining productivity (in short tons per employee hour), using 2008 labor productivity estimates.[34,35]

Results of the coal employment impacts of the final MATS are presented in Table 6A-6 below.

[33] Impacts of the Acid Rain Program on Coal Industry Employment. EPA 430-R-01-002 March 2001.

[34] From US Energy Information Administration (EIA) Annual Energy Review, Coal Mining Productivity Data. Used 2008.

[35] Unlike the labor productivity estimates for various equipment resources which were forecasted to 2015 using BLS average growth rates, we used the most recent historical productivity estimates for fuel sectors. In general, labor productivity for the fuel sectors (both coal and natural gas) showed a significantly higher degree of variability in recent years than the manufacturing sectors, which would have introduced a high degree of uncertainty in forecasting productivity growth rates for future years.

Table 6A-6: Annual Employment Impacts Due To Changes in Coal Use for 2015

Coal by Region	Change in Coal Demand (MM Tons)	Labor Productivity	Job-year Change
Appalachia	(11.8)	2.91	(1,950)
Interior	19.9	4.81	1,990
West	(17.3)	19.91	(420)
Waste Coal	(0.7)	5.96	(60)
Net Total	**(9.9)**	--	**(430)**

Notes: Used US national coal productivity for waste coal
Totals may not add due to rounding

For natural gas production, labor productivity per unit of natural gas was unavailable, unlike coal labor productivities used above. Most secondary data sources (such as Census and EIA) provide estimates for the combined oil and gas extraction sector. This appendix thus uses an adjusted labor productivity estimate for the combined oil and gas sector that accounts for the relative contributions of oil and natural gas in the total sector output (in terms of the value of energy output in MMBtu). This estimate of labor productivity is then used with the incremental natural gas demand for the final MATS to estimate the job-years for 2015.

Table 6A-7: Annual Employment Impact due to Changes in Fuel Use (2015)

Fuel Type	Employment
Coal Job Years Lost	**(430)**
Natural Gas	
Incremental Natural Gas Use (MMBtu)	175,786,505
Labor Productivity (MMBtu/job-year)	261,840
Job-years gained	**670**
Net Employment Effects of Fuel use changes	**240**

Note: Totals may not add due to rounding

Thus, about 430 job losses in the coal mining sector are likely to be offset by about 670 job gains in the natural gas production related sectors, for a net effect of about 240 job-year gains due to the changes in fuel use. The changes in coal mining employment is driven by a significant increase in demand for Interior coal which leads to about the same amount of job gains as is lost due to the decreased demand for Appalachian coal (see Table 6A-6 above). This, coupled with the fact that there is likely to be some job gains due to increased demand for natural gas, results in a small net job gain due to fuel use changes for the final MATS.

6A.2 Results Summary

Overall, the final MATS is expected to provide an increase to short-term employment resulting from substantial investments in new pollution control equipment. For 2015, the results indicate the final MATS could support or create around 46,000 job-years driven by the need to design and construct the needed equipment. While there could be some employment losses due to coal retirements that will likely have a negative effect on some utilities and the coal mining sector, employment gains in pollution control operation activities and the natural gas sector are likely to offset some of those losses. As previously discussed, this assessment does not account for the long-run economy-wide effects of the final MATS.

6A.3 Detailed Methodology

This section provides more details on the data and approaches used to estimate the employment impacts discussed above. The section also details the sources for individual data elements.

6A.3.1 Pollution Control Equipment Labor

6A.3.1.1 Installation Labor

Table 6A-8: Installation Labor Requirement[36]

Pollution Control Type	Incremental GW Installed	Man-hours/MW	Boilermakers (%)	Engineers (%)	Others (%)
FGD [37]	17	1730	40	20	40
ACI	99	10	50	17	33
DSI	44	55	50	17	33

[36] See Chapter 3 for more detail.

[37] EPA also projects 2.6 GW of dry scrubbers on waste coal and pet. coke units with existing baghouses, which are not shown in this table. Employment impacts from these units, however, are included in the pollution control construction figures, calculated using the capital cost for these controls ($220.7 MM) and estimated manhours/$ capital cost (0.00598) developed from the same example dry scrubbers used to find the manhours/MW of capacity.

FF [38]	102	780	45	7	48

Source: Engineering and Economic Factors affecting the Installation of Control Technologies – An Update, Andover Technology Partners, 2011

Installation labor is estimated by using the incremental GW installed for each pollution control type from EPA's modeling using IPM. This was then converted into total man-hours needed for installation using estimates of man-hours/MW primarily from EPA's 2011 update on pollution control technology,. Total man-hours for each pollution control type were then converted into man-years assuming 2,080 working hours per year.

Total man-years for each pollution control type were then broken down into various sectors using the percentages, shown in Table 6A-8. These percentages were estimated from the 2002 study, updated from the 2011 study, where applicable.

6A.3.1.2 Operating Resource Labor

Table 6A-9: Resources Needed for Operation

Pollution Control Type	Incremental Total GW	Resource (Units in parenthesis)	Usage Estimates	Price ($/unit)	Industry Assumed for Productivity Calculations	Productivity*
FGD	17	Lime (Tons/MWh)	0.013	95	Lime Manufacturing	2.0
ACI	99	Activated Carbon (Tons/MWh)	0.00025	1,500	Other Chemical Product Manufacturing	1.6
DSI	44	Trona (Tons/MWh)	0.033	150	Potash Soda and Borate Mineral Mining	2.0
FF	102	Bag-house Resources	*Resource Labor determined Using VOM cost for FFs		Plastics Material and Resin Manufacturing	0.6

**Workers/$Million in Output, Forecasted to 2015*
Sources: Usage:

- Sargent & Lundy, "IPM Model – Revisions to Cost and Performance for APC Technologies Mercury Control Cost Development Methodology FINAL", March 2011, Project 12301-009, Perrin Quarles Associates, Inc.
- Sargent & Lundy, "IPM Model – Revisions to Cost and Performance for APC Technologies Dry Sorbent Injection Cost Development Methodology FINAL", August 2010, Project 12301-007, Perrin Quarles Associates, Inc.
- Sargent & Lundy, "IPM Model – Revisions to Cost and Performance for APC Technologies SDA FGD Cost

[38] This number includes the total incremental fabric filters. For the purpose of estimating the construction jobs from fabric filters, this analysis uses an incremental capacity of 84 GW. The remaining 18 GW represent fabric filters installed with dry FGD units, which are excluded because the labor estimates for dry scrubbers includes the labor for fabric filters that is installed in conjunction.

Development Methodology FINAL", August 2010, Project 12301-007, Perrin Quarles Associates, Inc.

Labor related to resources used in operating pollution control equipment was estimated using the total incremental GW of pollution control capacity which was first converted to total MWh of incremental capacity assuming 85 percent capacity factor. For each pollution control type, the next step involved choosing the primary operating resource. This approach is consistent with prior EPA's analyses on similar topics. The next step involved estimating the resource needs by each control type, generally in tons of material using the resource usage estimates as shown in Table 6A-9. Using the total usage for each pollution control input (in tons) and associated average prices, total expenditure by each resource type was then calculated. This total expenditure was then converted to labor using workers per $Million in total output for the industry associated with producing each respective input material.[39]

6A.3.1.3 Operating Labor

Table 6A-10: Operating Labor Assumptions

Incremental FOM from IPM Parsed ($ Billion)	2.20
FF and other Capital Costs Included in FOM ($ Billion)	1.70
Remaining FOM used to find O&M Labor ($ Million)	496.5
Productivity*	8.7

**Workers per $Million in Payroll for Electricity Generating Sector, Forecast to 2015*
Sources: Productivity from 2007 Economic Census and Growth Rate from BLS.

Labor requirement to operate the controls is estimated for all equipment types combined, using the incremental FOM costs from IPM. The IPM incremental FOM cost estimate included capital costs for fabric filters and scrubber improvement costs, which were first subtracted to obtain the true FOM costs ($496.5 million). Resulting FOM cost estimate was then converted to labor needs using the workers/$ Million in total payroll for the Electric Generating Sector.

6A.3.2 Retirement Labor

Table 6A-11: Inputs to Labor from Retirements

[39] Fabric filters follow a different pattern. Instead of a resource usage estimate, we used the VOM cost for FFs and converted this to jobs using the workers per million dollars output for the relevant manufacturing industry sector.

Capacity of Incremental Retirements in SSR (MW)	4.7
O&M Decrease scaled to SSR Retirements ($MM) (To account for Partial Retirements)	288.2
Workers Per $Million in payroll, forecast to 2015	8.7

Sources: Productivity from 2007 Economic Census and Growth Rate from BLS.

Retirement labor was estimated by first identifying the retiring units from EPA's modeling using IPM parsed outputs (using incremental retirements in the policy case). The next step involved estimating the capacity of incremental retirements as well as the change in the FOM costs due to these retirements. Because of the discrepancies between partial retirements in EPA's parsed outputs and System Summary Reports (SSR), FOM costs were scaled proportionately to reflect the lower SSR-based estimates, as shown in Table 6A-11 above. FOM cost decreases were then converted to job-years lost due to retirements using workers per $Million in payroll.

6A.3.3 Fuel Use Labor

Table 6A-12: Inputs to Labor for Fuel Use

Coal by Region	2015 Incremental Fuel USE (Tons)	2008 Short Tons/Employee hour
Appalachia	-11,770,000	2.9
Interior	19,870,000	4.8
West	-17,260,000	19.9
Waste Coal	-700,000	6.0
Natural Gas		
EIA Total Natural Gas Production 2007 (TCF)		24.664
EIA Total Crude Oil Production 2007 (Barrels)		1,848,450,000
EIA Natural Gas Heat Content 2007 (Btu/cf)		1,027
EIA Petroleum Heat Content (MMBtu/Barrel)		6.151
Total Crude Oil and Natural Gas Production (MMBtu)		36,699,744,000
Economic Census 2007 Oil and Gas Extraction Employees		140,160
MMBtu per Man-year for Oil and Gas Extraction		261,842

Incremental Natural Gas from IPM (TCF)	0.171
Incremental Natural Gas from IPM (Converted to MMBtu)	175,786,505

**Workers per $Million in Payroll for Electricity Generating Sector, Forecast to 2015*
Note: Heat Contents from EIA are assumed to be for fuels used in Electric Power Sector
Sources: Short Tons per hour from US EIA, Coal Industry Annual. Total Production from 2009 EIA Annual Energy Review. Heat Contents from EIA, Heat Content of Natural Gas Consumed and 2009 Annual Energy Review. Employment Data from 2007 Economic Census.

Fuel use related employment impacts were estimated by using IPM results for incremental changes in coal and natural gas use (policy case over the base case). For coal, estimates of coal use in tons by region from IPM were used in conjunction with labor productivity estimates from the EIA for each region (in short tons/ employee hour), to calculate the change in job-hours needed. These were then converted to job-years, assuming 2,080 working hours per year. As discussed above, because of the high variability in coal mining labor productivity in recent years, no attempt was made to forecast coal (and natural gas, for consistency) productivities, instead the most recent historical estimates were used in this appendix (which was the 2008 labor productivity for coal).

For natural gas, the first step was estimating labor productivity since such information was not available directly from any reliable source. EIA production data from the Annual Energy Review for natural gas and crude oil (in TCF and barrels, respectively), along with EIA heat content estimates were used to find total crude oil and natural gas production in MMBtu for 2007. Labor productivity in MMBtu per job-year for the Oil and Gas Extraction sector was then estimated using data from the Census on oil and gas extraction employment. Then, the incremental natural gas demand from EPA's IPM modeling results (in TCF) was converted to MMBtu of natural gas demand using EIA data on natural gas heat content. This was then used with the labor productivity estimated above to calculate the total job-years needed for increased natural gas demand for the final MATS.

6A.4 References

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EXHIBIT 5

April 2010

Regulatory Impact Analysis: National Emission Standards for Hazardous Air Pollutants for Industrial, Commercial, and Institutional Boilers and Process Heaters

Draft Report

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SECTION 1
INTRODUCTION

The U.S. Environmental Protection Agency (EPA) is proposing national emission standards for hazardous air pollutants (NESHAP) for new and existing industrial, commercial, and institutional boilers and process heaters.[1] The proposed rule would require all major sources to meet hazardous air pollutant (HAP) emissions standards reflecting the application of the maximum achievable control technology (MACT). Under a separate action, EPA is also proposing a NESHAP for two area source categories: industrial boilers and institutional and commercial boilers.[2] The proposed emission standards for controlling mercury and polycyclic organic matter (POM) emissions are based on the MACT. The proposed emission standards for controlling other HAPs are based on EPA's proposed determination as to what constitutes the generally available control technology (GACT) or management practices. As part of the regulatory process, EPA is required to develop a regulatory impact analysis (RIA). The RIA includes an economic impact analysis (EIA) and a small entity impacts analysis and documents the RIA methods and results.

1.1 Executive Summary

The key results of the RIA are as follows:

- **Engineering Cost Analysis:** EPA estimates the proposed major source NESHAP's total annualized costs will be $2.9 billion (2008$). For the area source NESHAP, EPA estimates the total annualized costs will be $0.5 billion.
- **Market Analysis:** Under the proposed major source NESHAP, the Agency's economic model suggests the average national prices for industrial sectors could be 0.01% higher with the NESHAP, while average annual domestic production may fall by about 0.01%. Because of higher domestic prices, imports rise by 0.01% per year. Market-level effects for the proposed area source NESHAP are smaller when compared to the proposed major source rule; average price, production, and import changes are less than 0.01%.
- **Social Cost Analysis:** The estimated social cost of the proposed major source rule is just under $2.9 billion (2008$). In the near term, the Agency's economic model suggests that industries are able to pass approximately $0.8 billion of the rule's costs to consumers (e.g., higher market prices). Domestic industries' surplus falls by $2.5 billion, while other countries on net benefit from higher prices (a net increase in rest-of-the world [ROW] surplus of $0.1 billion). Additional costs and fuel savings for

[1] On June 19, 2007, the U.S. Court of Appeals for the District of Columbia Circuit (DC Circuit) vacated the NESHAP for industrial/commercial/institutional boilers and process heaters. This action provides EPA's proposed rule in response to the court's vacatur.

[2] Gas-fired boilers are not part of the area source categories of industrial boilers and institutional/commercial boilers.

new and existing major sources that are not included in the economic model represent a net benefit of $0.4 billion. The estimated social cost of the proposed area source rule is approximately $0.5 billion (2008$). In the near term, the Agency's economic model suggests that industries are able to pass approximately $0.3 billion of the rule's costs to consumers. Domestic industries' surplus falls by $0.3 billion and the net increase in ROW surplus is less than $0.1 billion. Additional costs and fuel savings for unknown, existing, and new area sources not included in the economic model results represent a net benefit of $0.1 billion.

- **Employment Changes:** Near-term employment changes associated with the proposed major source rule are estimated to be less than 8,000 job losses; over a longer time period, net employment effects range between 6,000 job losses to 12,000 job gains. For the area source rule, near-term employment changes associated with the proposed major source rule are estimated to be less than 1,000 job losses; over a longer time period, net employment effects also range between 1,000 job losses to 3,000 job gains.
- **Small Entity Analyses:** EPA performed a screening analysis for impacts on small entities by comparing compliance costs to sales/revenues (e.g., sales and revenue tests). EPA's analysis found the tests were typically higher than 3% for small entities included in the screening analysis. EPA has prepared an Initial Regulatory Flexibility Analysis (IRFA) that discusses alternative regulatory or policy options that minimize the rule's small entity impacts. It includes key information about key results from the Small Business Advocacy Review (SBAR) panel.
- **Benefits Analysis:** In the year of full implementation (2013), EPA estimates the $PM_{2.5}$ co-benefits of the proposed major source rule are $17 billion to $41 billion and $15 billion to $37 billion, at 3% and 7% discount rates respectively. In the year of full implementation (2013), EPA estimates the $PM_{2.5}$ co-benefits of this proposed area source rule are $1.0 billion to $2.4 billion and $910 million to $2.2 billion, at 3% and 7% discount rates respectively. All estimates are in 2008 dollars. Using alternate relationships between $PM_{2.5}$ and premature mortality supplied by experts, higher and lower co-benefits estimates are plausible, but most of the expert-based estimates fall between these estimates. The benefits from reducing other air pollutants have not been monetized in this analysis, including reducing 370,000 tons of carbon monoxide, 37,000 tons of HCl, and 1,000 tons of HF, 8.3 tons of mercury, 3,400 tons of other metals, and 1,200 grams of dioxins/furans each year from major and area sources. In addition, ecosystem benefits and visibility benefits have not been monetized in this analysis.
- **Net Benefits:** The net benefits for the proposed major source rule only are $14 billion to $38 billion and $12 billion to $34 billion, at 3% and 7% discount rates, respectively in 2013. The net benefits for the area source rule only are $500 million to $1.9 billion and $410 million to $1.7 billion in 2013, at 3% and 7% discount rates, respectively. All estimates are in 2008 dollars.

Table 1-1. Summary of the Monetized Benefits, Social Costs, and Net Benefits for the Boiler MACT (Major Sources) in 2013 (millions of 2008$)[1]

Proposed Option		
	3% Discount Rate	7% Discount Rate
Total Monetized Benefits[2]	$17,000 to $41,000	$15,000 to $37,000
Total Social Costs[3]	$2,900	$2,900
Net Benefits	$14,000 to $38,000	$12,000 to $34,000
Option 1N and 1E		
	3% Discount Rate	7% Discount Rate
Total Monetized Benefits[4]	$17,000 to $41,000	$15,000 to $37,000
Total Social Costs[3]	$12,000	$12,000
Net Benefits	$5,000 to $30,000	$3,400 to $26,000
Proposed Option with Alternate Solid Waste Definition		
	3% Discount Rate	7% Discount Rate
Total Monetized Benefits[5]	$3,100 to $7,700	$2,800 to $6,900
Total Social Costs[3]	$2,200	$2,200
Net Benefits	$930 to $5,500	$640 to $4,700

[1] All estimates are for the implementation year (2013), and are rounded to two significant figures.

[2] The total monetized benefits reflect the human health benefits associated with reducing exposure to $PM_{2.5}$ through reductions of 29,000 tons of directly emitted $PM_{2.5}$ and $PM_{2.5}$ precursors such as 1,700 tons of VOC and 340,000 tons of SO_2. The benefits from reducing 340,000 tons of carbon monoxide, 37,000 tons of HCl, 1,000 tons of HF, and 7.5 tons of mercury, 3,200 tons of other metals, and 720 grams of dioxins/furans each year are not included in these estimates. In addition, the benefits from reducing ecosystem effects and visibility impairment are not included.

[3] The methodology used to estimate social costs for one year in the multimarket model using surplus changes results in the same social costs for both discount rates.

[4] The total monetized benefits reflect the human health benefits associated with reducing exposure to $PM_{2.5}$ through reductions of 29,000 tons of directly emitted $PM_{2.5}$ and $PM_{2.5}$ precursors such as 6,700 tons of VOC and 350,000 tons of SO_2. The benefits from reducing 390,000 tons of carbon monoxide, 42,000 tons of HCl, 8,600 tons of HF, and 8.1 tons of mercury, 3,200 tons of other metals, and 760 grams of dioxins/furans each year are not included in these estimates. In addition, the benefits from reducing ecosystem effects and visibility impairment are not included.

[5] The total monetized benefits reflect the human health benefits associated with reducing exposure to $PM_{2.5}$ through reductions of 8,000 tons of directly emitted $PM_{2.5}$ and $PM_{2.5}$ precursors such as 4,700 tons of VOC and 44,000 tons of SO_2. The benefits from reducing 280,000 tons of carbon monoxide, 5,100 tons of HCl, 1,100 tons of HF, and 7.1 tons of mercury, 1,600 tons of other metals, and 290 grams of dioxins/furans each year are not included in these estimates. In addition, the benefits from reducing ecosystem effects and visibility impairment are not included.

Table 1-2. Summary of the Monetized Benefits, Social Costs, and Net Benefits for the Boiler Area Source Rule in 2013 (millions of 2008$)[1]

Proposed Option		
	3% Discount Rate	7% Discount Rate
Total Monetized Benefits[2]	$1,000 to $2,400	$910 to $2,200
Total Social Costs[3]	$500	$500
Net Benefits	$500 to $1,900	$410 to $1,700
Option 1N and 1E		
	3% Discount Rate	7% Discount Rate
Total Monetized Benefits[4]	$8,300 to $20,000	$7,500 to $18,000
Total Social Costs[3]	$35,000	$35,000
Net Benefits	$-27,000 to $-15,000	$-28,000 to $-17,000

[1] All estimates are for the implementation year (2013), and are rounded to two significant figures.

[2] The total monetized benefits reflect the human health benefits associated with reducing exposure to $PM_{2.5}$ through reductions of 2,700 tons of directly emitted $PM_{2.5}$ and $PM_{2.5}$ precursors such as 1,200 tons of VOC and 1,500 tons of SO_2. The benefits from reducing 39,000 tons of carbon monoxide, 130 tons of HCl, 5 tons of HF, and 0.75 tons of mercury, 250 tons of other metals, and 470 grams of dioxins/furans each year are not included in these estimates. In addition, the benefits from reducing ecosystem effects and visibility impairment are not included.

[3] The methodology used to estimate social costs for one year in the multimarket model using surplus changes results in the same social costs for both discount rates.

[4] The total monetized benefits reflect the human health benefits associated with reducing exposure to $PM_{2.5}$ through reductions of 23,000 tons of directly emitted $PM_{2.5}$ and $PM_{2.5}$ precursors such as 2,100 tons of VOC and 1,700 tons of SO_2. The benefits from reducing 58,000 tons of carbon monoxide, 140 tons of HCl, 6.4 tons of HF, and 1.5 tons of mercury, 6,200 tons of other metals, and 530 grams of dioxins/furans each year are not included in these estimates. In addition, the benefits from reducing ecosystem effects and visibility impairment are not included.

1.2 Organization of this Report

The remainder of this report supports and details the methodology and the results of the EIA:

- Section 2 presents the affected industry profiles.
- Section 3 describes the engineering cost analysis.
- Section 4 describes the economic impact analysis.
- Section 5 describes the small entity analyses.
- Section 6 presents the benefits estimates.
- Section 7 presents supplemental economic analyses for an alternative non-hazardous solid waste definition
- Appendix A describes the multimarket model used in the economic analysis.
- Appendix B provides additional economic model result tables by sector.

SECTION 4
ECONOMIC IMPACT ANALYSIS

EPA prepares an RIA to provide decision makers with a measure of the social costs of using resources to comply with a program (EPA, 2000). The social costs can then be compared with estimated social benefits (as presented in Section 6). As noted in EPA's (2000) *Guidelines for Preparing Economic Analyses*, several tools are available to estimate social costs and range from simple direct compliance cost methods to the development of a more complex market analysis that estimates market changes (e.g., price and consumption) and economic welfare changes (e.g., changes in consumer and producer surplus).

The Office of Air Quality Planning and Standards (OAQPS) adopted a standard market analysis as described in the Office's resource manual (EPA, 1999). The approach uses a single-period multimarket partial equilibrium model to compare pre-policy market baselines with expected post-policy market outcomes. The analysis' time horizon is the intermediate run; some production factors are fixed and some are variable and is distinguished from the very short run where all factors are fixed and producers cannot adjust inputs or outputs (EPA, 1999, 5-6). The intermediate time horizon allows us to capture important transitory stakeholder outcomes. Key measures in this analysis include industry-level changes in price levels, production and consumption, jobs, international trade, and social costs (changes in producer and consumer surplus).

4.1 Partial Equilibrium Analysis (Multiple Markets)

The partial equilibrium analysis develops a market model that simulates how stakeholders (consumers and industries) might respond to the additional regulatory program costs. In this section, we provide an overview of the economic model. Appendix A provides additional details on the behavioral assumptions, data, parameters, and model equations.

4.1.1 Overview

Although several tools are available to estimate social costs, current EPA guidelines suggest that multimarket models "…are best used when potential economic impacts and equity effects on related markets might be considerable" and modeling using a computable general equilibrium model is not available or practical (EPA, 2000, p. 146). Other guides for environmental economists offer similar advice (Berck and Hoffmann, 2002; Just, Hueth, and Schmitz, 2004). Multimarket models focus on "short-run" time horizons and measure a policy's near-term or transition costs (EPA, 1999). The multimarket model contains the following features:

- Industry sectors and benchmark data set
  - 100 industry sectors
  - a single benchmark year (2010)
  - estimates of industry employment
- Economic behavior
  - industries respond to regulatory costs by changing production rates
  - market prices rise and fall to reflect higher energy and other non-energy material costs and changes in demand
  - customers respond to these price increases and consumption falls
- Model scope
  - 100 sectors are linked with each other based on their use of energy and other non-energy materials. For example, the construction industry is linked with the petroleum, cement, and steel industries and is influenced by price changes that occur in each sector. The links allow EPA to account for indirect effects the regulation has on related markets.
  - production adjustments influence employment levels
  - international trade (imports/exports) responds to domestic price changes
- Model time horizon (“short run”) for a single period (2013)
  - fixed production resources (e.g., capital) lead to an upward-sloping industry supply function
  - firms cannot alter input mixes; there is no substitution among production inputs (capital, labor, energy intermediates, and other intermediate goods and services)
  - price of labor (i.e., wage) is fixed
  - investment and government expenditures are fixed

4.1.2 Economic Impact Analysis Results

4.1.2.1 Market-Level Results

Market-level impacts include price and quantity adjustments including the changes in international trade (Figure 4-1). Under the proposed major source NESHAP, the Agency’s economic model suggests the average national prices for industrial sectors could be 0.01% higher with the NESHAP, while average annual domestic production may fall by about 0.01%. Because of higher domestic prices, imports rise by 0.01% per year. Market-level effects for the proposed area source NESHAP are smaller when compared to the proposed major source rule; average

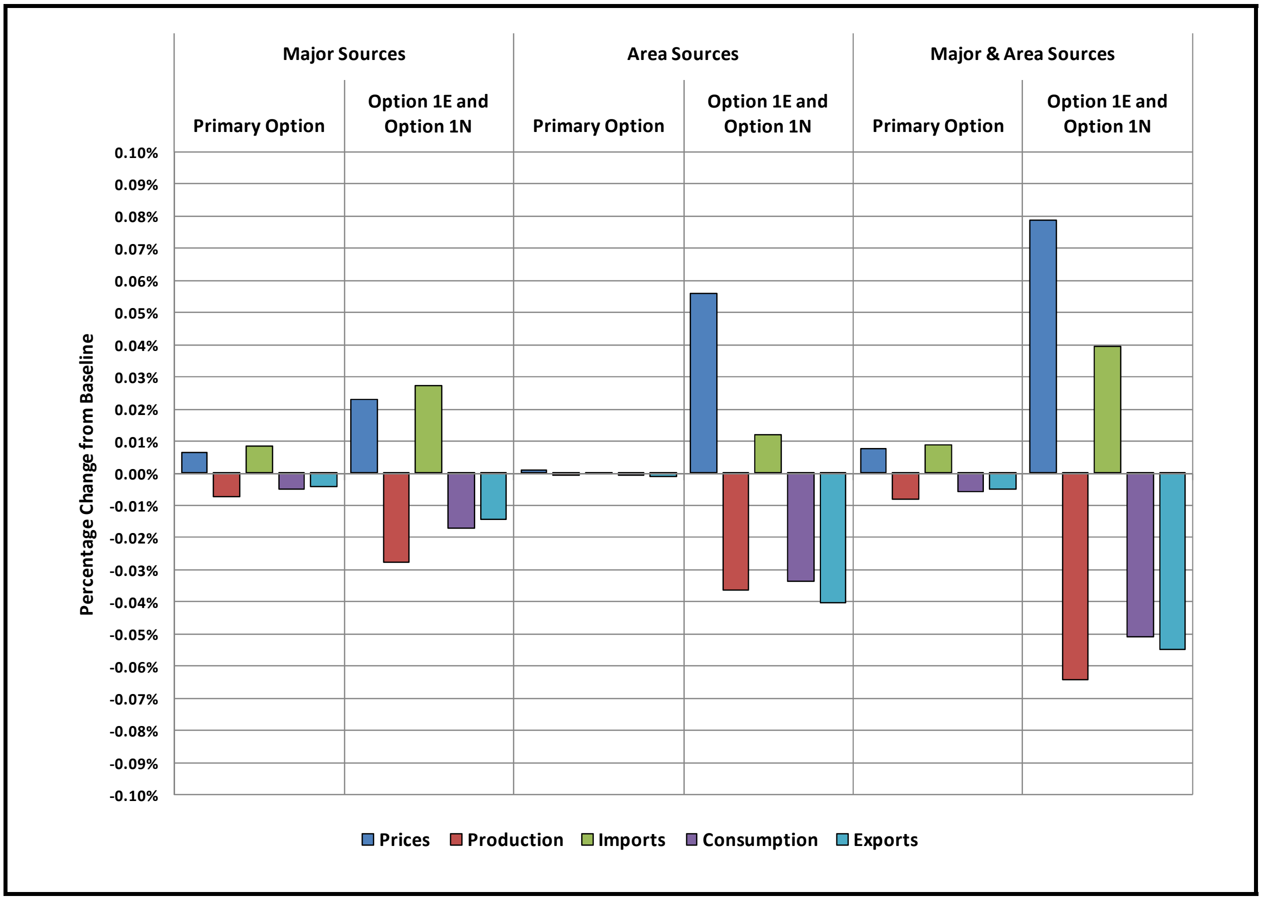

Figure 4-1. Market-Level Changes by Source and Option

price, production, and import changes are less than 0.01%. Industrial sector details are provided in Appendix B.

4.1.2.2 Social Cost Estimates Major Source Rule

In the near term, the Agency's economic model suggests that industries are able to pass on $0.8 billion (2008$) of the proposed area source rule's costs to U.S. households in the form of higher prices (Table 4-1). Existing U.S. industries' surplus falls by $2.5 billion and the net loss in aggregate is $3.3 billion. As U.S. prices rise, other countries are affected through international trade relationships. The price of goods produced in the United States increase slightly and domestic production declines, replaced to a certain degree by imports; the model estimates a net gain of $0.1 billion to foreign companies. After accounting for international trade effects, the Agency's economic model projects the net surplus loss associated with the proposed rule is $3.2 billion. As shown in Figure 4-2, the surplus losses are concentrated in other services (20 percent); lumber, paper, and printing (19 percent); and chemicals (16 percent)

Table 4-1. Distribution of Social Costs Major Sources (billion, 2008$): 2013

Approach	Primary Option	Option 1E and Option 1N
Partial Equilibrium Model (Multiple Markets)		
Change in U.S. consumer surplus	−$0.8	−$3.8
Change in U.S. producer surplus	−$2.5	−$8.9
Change in U.S. surplus	−$3.3	−$12.7
Net change in rest of world surplus	$0.1	$0.5
Net change in total surplus	−$3.2	−$12.2
Direct Compliance Costs Method		
Total annualized costs, new major sources (not modeled)	Less than −$0.1	Less than −$0.1
Fuel savings, existing major sources (not modeled)	$0.4	$0.3
Fuel savings, new major sources (not modeled)	Less than $0.1	Less than $0.1
Change in Total Surplus	−$2.9	−$11.9

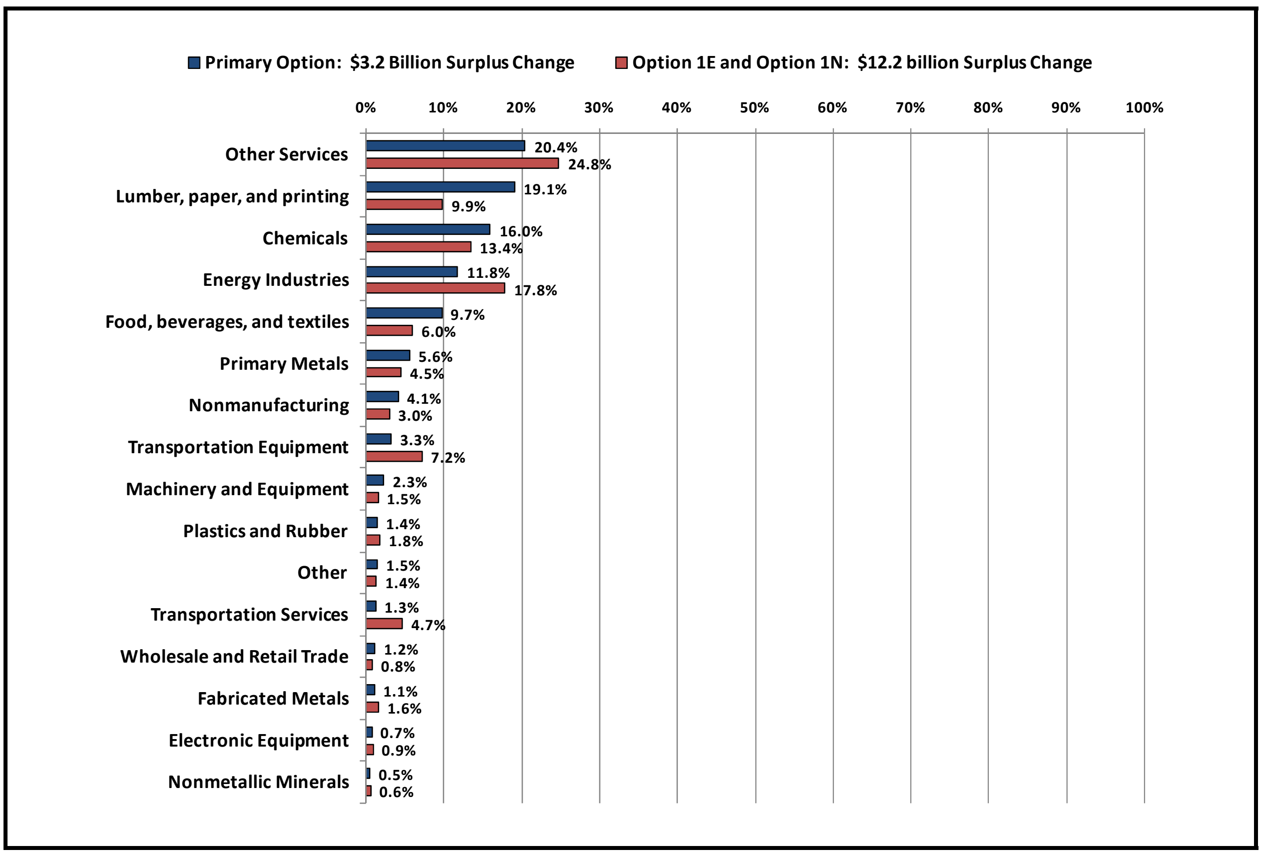

Figure 4-2. Distribution of Total Surplus Changes by Sector: Major Sources

The Agency also considered other elements of the engineering cost analysis that could not be modeled within the multimarket model (e.g., fuel savings benefits [existing and new major sources] and total annualized compliance costs [new major sources]). The net effect of the adjustments is a total surplus loss estimate of $2.9 billion.

4.1.2.3 Social Cost Estimates Area Source Rule

In the near term, the Agency's economic model suggests that industries are able to pass on $0.3 billion (2008$) of the proposed area source rule's costs to U.S. households in the form of higher prices (Table 4-2). Existing U.S. industries' surplus falls by $0.3 billion and the net loss for U.S. stakeholders is $0.6 billion. As U.S. prices rise, other countries are affected through international trade relationships. Households that buy U.S. exports pay higher prices and purchase fewer U.S. produced goods. Other countries that that sell goods to the United States benefit; the model estimates a net rest of the world gain of less than $0.1 billion. After accounting for international trade effects, the Agency's economic model projects the net surplus (consumer and producer) loss associated with the proposed rule is $0.6 billion. As shown in Figure 4-3, the surplus losses are concentrated in the other services (86 percent).

Table 4-2. Distribution of Social Costs Area Sources (billion, 2008$): 2013

Approach	Primary Option	Option 1E and Option 1N
Partial Equilibrium Model (Multiple Markets)		
Change in U.S. consumer surplus	−$0.3	−$16.5
Change in U.S. producer surplus	−$0.3	−$16.5
Change in U.S. surplus	−$0.6	−$33.1
Net change in rest of world surplus	Less than $0.1	−$0.1
Net change in total surplus	−$0.6	−$33.2
Direct Compliance Costs Method		
Total annualized costs, unknown existing area sources (not modeled)	Less than $0.1	−$0.3
Total annualized costs, new area sources (not modeled)	−$0.3	−$2.3
Fuel savings, existing area sources (not modeled)	$0.4	$0.4
Fuel savings, new area sources (not modeled)	Less than $0.1	Less than $0.1
Change in Total Surplus	−$0.5	−$35.3

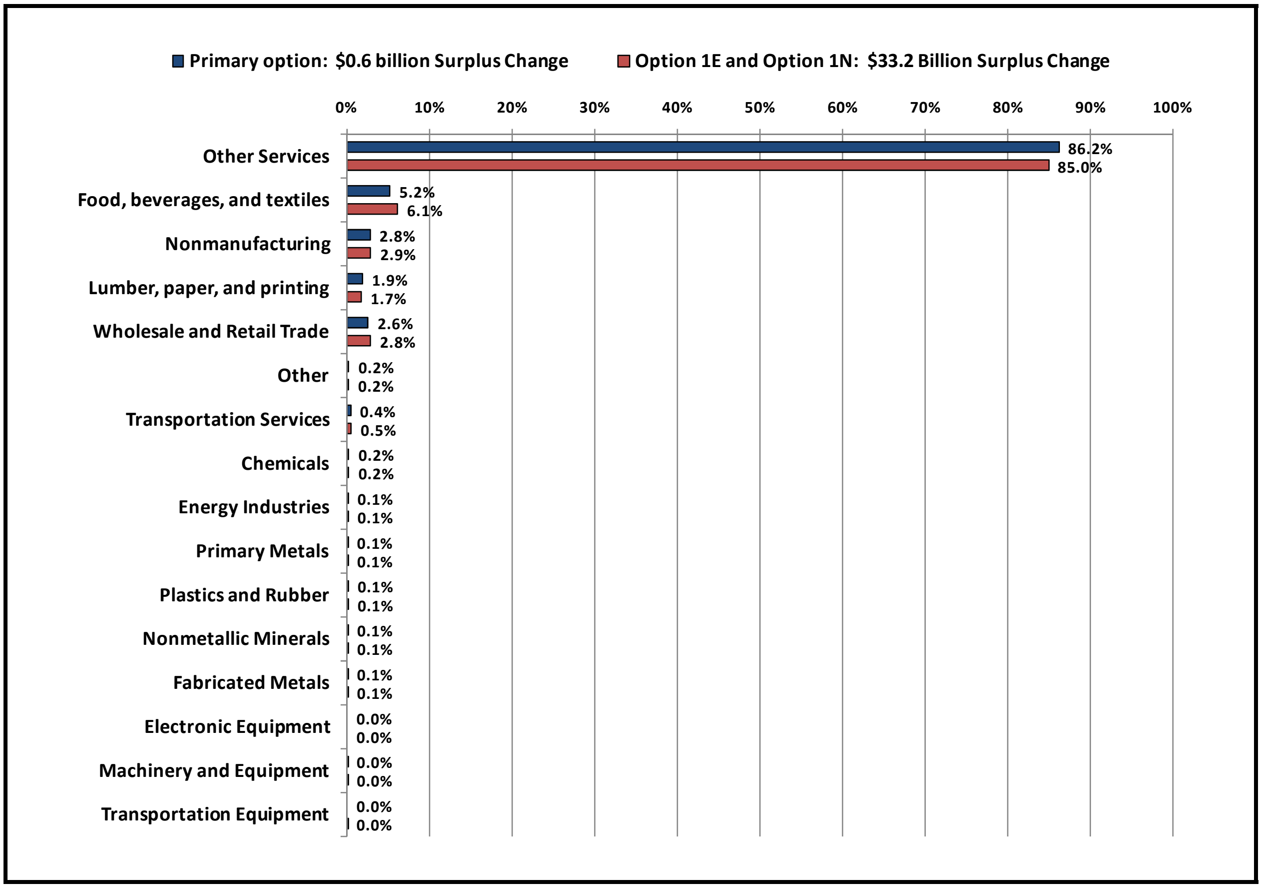

Figure 4-3. Distribution of Total Surplus Changes by Sector: Area Sources

The Agency also considered other elements of the engineering cost analysis that could not be modeled within the multimarket model (e.g., fuel-savings benefits [existing and new area sources] and total annualized compliance costs [unknown existing and new area sources]). The net effect of the adjustments is a total surplus loss estimate of $0.5 billion.

4.1.2.4 Job Effects

Precise job effect estimates cannot be estimated with certainty. Morgenstern et al. (2002) identify three economic mechanisms by which pollution abatement activities can indirectly influence jobs:

- higher production costs raise market prices, higher prices reduce consumption, and employment within an industry falls ("demand effect");
- pollution abatement activities require additional labor services to produce the same level of output ("cost effect"); and

- post regulation production technologies may be more or less labor intensive (i.e., more/less labor is required per dollar of output) ("factor-shift effect").

Several empirical studies, including Morgenstern et al. (2002), suggest the net employment decline is zero or economically small (e.g., Cole and Elliot, 2007; Berman and Bui, 2001). However, others show the question has not been resolved in the literature (Henderson, 1996; Greenstone, 2002). Morgenstern et al. use a six-year panel (U.S. Census data for plant-level prices, inputs (including labor), outputs, and environmental expenditures) to econometrically estimate the production technologies and industry-level demand elasticities. Their identification strategy leverages repeat plant-level observations over time and uses plant-level and year fixed effects (e.g., plant and time dummy variables). After estimating their model, Morgenstern show and compute the change in employment associated with an additional $1 million ($1987) in environmental spending. Their estimates cover four manufacturing industries (pulp and paper, plastics, petroleum, and steel) and Morgenstern, et al. present results separately for the cost, factor shift, and demand effects, as well as the net effect. They also estimate and report an industry-wide average parameter that combines the four industry-wide estimates and weighting them by each industry's share of environmental expenditures.

EPA has most often estimated employment changes associated with plant closures due to environmental regulation or changes in output for the regulated industry (EPA, 1999a; EPA, 2000). This analysis goes beyond what EPA has typically done in two ways. First, because the multimarket model provides estimates for changes in output for sectors not directly regulated, we were able to estimate a more comprehensive "demand effect." Secondly, parameters estimated in the Morgenstern paper were used to estimate all three effects ("demand," "cost," and "factor shift"). This transfer of results from the Morgenstern study is uncertain but avoids ignoring the "cost effect" and the "factor-shift effect."

We calculated "demand effect" employment changes by assuming that the number of jobs declines proportionally with multi-market model's simulated output changes. These results were calculated for all sectors in the EPA model that show a change in output.

We also calculated a similar "demand effect" estimate that used the Morgenstern paper. EPA selected this paper because the parameter estimates (expressed in jobs per million ($1987) of environmental compliance expenditures) provide a transparent and tractable way to transfer estimates for an employment effects analysis. Similar estimates were not available from other studies. To do this, we multiplied the point estimate for the total demand effect (−3.56 jobs per million ($1987) of environmental compliance expenditure) by the total environmental compliance expenditures used in the partial equilibrium model. For example, the jobs effect estimate for the Major Source Rule is estimated to be 7,000 jobs (−3.56× \$3.2 billion × 0.60).[1] Demand effect results are provided in Figure 4-4.

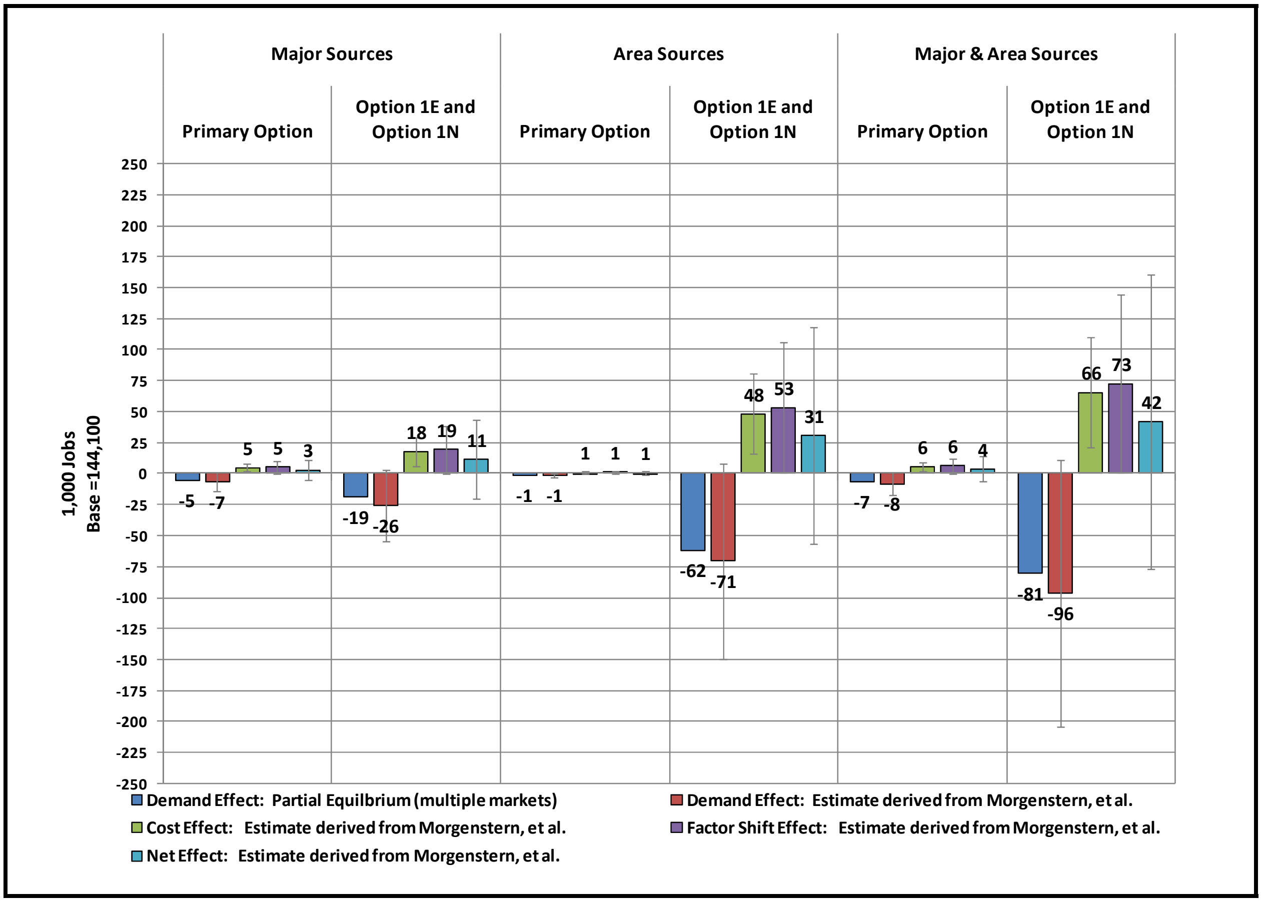

Figure 4-4. Job Losses/Gains Associated with the Proposed Rules: 2013

We also present the results of using the Morgenstern paper to estimate employment "cost" and "factor-shift" effects. Although using the Morgenstern parameters to estimate these "cost" and "factor-shift" employment changes is uncertain, it is helpful to compare the potential job gains from these effects to the job losses associated with the "demand" effect. Figure 4-4 shows that using the Morgenstern point estimates of parameters to estimate the "cost" and "factor shift" employment gains may be greater than the employment losses using either of the two ways of estimating "demand" employment losses. The 95% confidence intervals are shown for all of the

[1] Since Morgenstern's analysis reports environmental expenditures in \$1987, we make an inflation adjustment the engineering cost analysis using GDP implicit price deflator (64.76/108.48) = 0.60)

estimates based on the Morgenstern parameters. As shown, at the 95% confidence level, we cannot be certain if net employment changes are positive or negative.

Although the Morgenstern paper provides additional information about the potential job effects of environmental protection programs, there are several qualifications EPA considered as part of the analysis. First, EPA has used the weighted average parameter estimates for a narrow set of manufacturing industries (pulp and paper, plastics, petroleum, and steel). Absent other data and estimates, this approach seems reasonable and the estimates come from a respected peer-reviewed source. However, EPA acknowledges the proposed rule covers a broader set of industries not considered in original empirical study. By transferring the estimates to other industrial sectors, we make the assumption that estimates are similar in size. In addition, EPA assumes also that Morgenstern et al.'s estimates derived from the 1979-1991 still applicable for policy taking place in 2013, almost 20 years later. Second, the multi-market model only considers near term employment effects in a U.S. economy where production technologies are fixed. As a result, the modeling system places more emphasis on the short term "demand effect" whereas the Morgenstern paper emphasizes other important long term responses. For example, positive job gains associated with "factor shift effects" are more plausible when production choices become more flexible over time and industries can substitute labor for other production inputs. Third, the Morgenstern paper estimates rely on sector demand elasticities that are different from the demand elasticity parameters used in the multi-market model. As a result, the demand effects are not directly comparable with the demand effects estimated by the multi-market model. Fourth, Morgenstern identifies the industry average as economically and statistically insignificant effect (i.e., the point estimates are small, measured imprecisely, and not distinguishable from zero.) EPA acknowledges this fact and has reported the 95 percent confidence intervals in Figure 4-4. Fifth, Morgenstern's methodology assumes large plants bear most of the regulatory costs. By transferring the estimates, EPA assumes a similar distribution of regulatory costs by plant size and that the regulatory burden does not disproportionately fall on smaller plants.

EXHIBIT 6

February 2011

Regulatory Impact Analysis: National Emission Standards for Hazardous Air Pollutants for Industrial, Commercial, and Institutional Boilers and Process Heaters

U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards (OAQPS)
Air Economics Group
Risk and Benefits Group
Air Quality Modeling Group
Research Triangle Park, NC 27711

SECTION 1
INTRODUCTION

The U.S. Environmental Protection Agency (EPA) is promulgating two rules for national emission standards for hazardous air pollutants (NESHAP) for new and existing industrial, commercial, and institutional boilers and process heaters.[1] One rule requires all major sources to meet hazardous air pollutant (HAP) emissions standards reflecting the application of the maximum achievable control technology (MACT). In the other rule, EPA is promulgating a NESHAP for two area source categories: industrial boilers and institutional and commercial boilers.[2] The emission standards for controlling mercury and polycyclic organic matter (POM) emissions are based on the MACT. The emission standards for controlling other HAPs are based on EPA's determination as to what constitutes the generally available control technology (GACT) or management practices. As part of the regulatory process, EPA is required to develop a regulatory impact analysis (RIA). The RIA includes an economic impact analysis (EIA) and a small entity impacts analysis and documents the RIA methods and results.

1.1 Executive Summary

The key results of the RIA are as follows:

- **Engineering Cost Analysis:** EPA estimates the major source NESHAP's total annualized costs will be $1.4 billion (2008$). For the area source NESHAP, EPA estimates the total annualized costs will be $0.5 billion.
- **Market Analysis:** Under the major source NESHAP, the Agency's economic model suggests the average national prices for industrial sectors could be small (less than 0.01% higher). Average annual domestic production may also fall by less than 0.01%. Because of higher domestic prices, imports rise by less than 0.01% per year. Market-level effects for the area source NESHAP are smaller when compared to the major source rule; average price, production, and import changes are less than 0.01%.
- **Social Cost Analysis:** The estimated social cost of the major source rule is just under $1.5 billion (2008$). The Agency's economic model suggests that industries are able to pass approximately $0.5 billion of the rule's costs to consumers (e.g., higher market prices). Domestic industries' surplus falls by $1.4 billion, while other countries on net benefit from higher prices (a net increase in rest-of-the world [ROW] surplus of less than $0.1 billion). Additional costs and fuel savings for new and existing major sources that are not included in the

[1] On June 19, 2007, the U.S. Court of Appeals for the District of Columbia Circuit (DC Circuit) vacated the NESHAP for industrial/commercial/institutional boilers and process heaters. This action provides EPA's rule in response to the court's vacatur.

[2] Gas-fired boilers are not part of the area source categories of industrial boilers and institutional/commercial boilers.

economic model represent a net benefit of $0.4 billion.[1] The estimated social cost of the area source rule is approximately $0.5 billion (2008$). The Agency's economic model suggests that industries are able to pass approximately $0.2 billion of the rule's costs to consumers. Domestic industries' surplus falls by $0.3 billion and the net increase in ROW surplus is less than $0.1 billion. Additional costs and fuel savings for unknown, existing, and new area sources not included in the economic model results represent a net benefit of less than $0.1 billion.

- **Employment Changes**: The estimated employment changes range between −3100 to 6,500 employees, with a central estimate of +1,700 employees for the major source NESHAP. The estimated employment changes range between −1,000 to 2,000 employees, with a central estimate of +500 employees for the area source NESHAP.

- **Small Entity Analyses: EPA performed a scre**ening analysis for impacts on small entities by comparing compliance costs to sales/revenues (e.g., sales and revenue tests). EPA's analysis found the tests were typically higher than 3% for small entities included in the screening analysis. Pursuant to section 603 of the RFA, EPA prepared an initial regulatory flexibility analysis (IRFA) for the proposed rule and convened a Small Business Advocacy Review Panel to obtain advice and recommendations of representatives of the regulated small entities. A detailed discussion of the Panel's advice and recommendations is found in the final Panel Report (Docket ID No. EPA-HQ-OAR-2002-0058-0797). A summary of the Panel's recommendations is also presented in the preamble to the proposed rule at 75 FR 32044-32045 (June 4, 2010). In the proposed rule, EPA included provisions consistent with four of the Panel's recommendations. As required by section 604 of the RFA, we also prepared a final regulatory flexibility analysis (FRFA) the final rule (see Section 5).

- **Benefits Analysis:**

– The benefits from reducing some air pollutants have not been monetized in this analysis, including reducing a combined 113,000 tons of carbon monoxide, 30,000 tons of HCl, 830 tons of HF, 2,900 pounds of mercury, 3,000 tons of other metals, and 23 grams of dioxins/furans (TEQ) each year. We assess the benefits of these emission reductions qualitatively in this analysis.

– We have monetized the benefits from reducing PM (as a surrogate for metal HAP), as well as the co-benefits that result from the HAP emissions reductions (e.g., the pollution control equipment for HCl also reduces sulfur dioxide, a pre-cursor to $PM_{2.5}$). Thus all monetized benefits reported reflect improvements in ambient $PM_{2.5}$ and ozone concentrations. As such, although the monetized benefits likely underestimate the total benefits, the extent of the underestimate is unclear.

– Using a 3% discount rate, we estimate the total monetized benefits of the Boiler MACT to be $22 billion to $54 billion in the implementation year (2014). Using a 7% discount rate, we estimate the total monetized benefits of the Boiler MACT to

[1] See additional details in Chapter 3 and Cost Appendices.

be \$20 billion to \$49 billion in the implementation year. Using alternate relationships between $PM_{2.5}$ and premature mortality supplied by experts, higher and lower benefits estimates are plausible, but most of the expert-based estimates fall between these estimates.

– Using a 3% discount rate, we estimate the total monetized benefits of the Boiler Area Source Rule to be \$210 million to \$520 million in the implementation year (2014). Using a 7% discount rate, we estimate the total monetized of the Boiler Area Source Rule to be \$190 million to \$470 million in the implementation year.

– Using a 3% discount rate, we estimate the total monetized benefits of the combined Boiler MACT and Boiler Area Source Rule to be \$22 billion to \$58 billion in the implementation year (2014). Using a 7% discount rate, we estimate the total monetized benefits of the combined Boiler MACT and Boiler Area Source Rule to be \$20 billion to \$50 billion in the implementation year. All estimates are in 2008\$.

- **Net Benefits:** For the Boiler MACT, the net benefits are \$21 billion to \$53 billion at a 3% discount rate for the benefits and \$19 million to \$48 billion at a 7% discount rate. For the Boiler Area Source Rule, the net benefits are −\$280 million to \$30 million at a 3% discount rate for the benefits and −\$300 million to −\$20 million at a 7% discount rate. These results are shown in Tables 1-1 and 1-2.

1.2 Organization of this Report

The remainder of this report supports and details the methodology and the results of the EIA:

- Section 2 presents the affected industry profiles.
- Section 3 describes the engineering cost analysis.
- Section 4 describes the economic impact analysis.
- Section 5 describes the small entity analyses.
  - Section 6 describes the air quality modeling performed by EPA.
  - Section 7 presents the benefits estimates.
  - Section 8 presents the net benefits.
  - Appendix A describes the multimarket model used in the economic analysis.
  - Appendix B provides additional economic model result tables by sector.

Table 1-1. Summary of the Monetized Benefits, Social Costs, and Net Benefits for the Boiler MACT (Major Sources) in 2014 (millions of 2008$)[a]

	3% Discount Rate			7% Discount Rate		
Selected						
Total Monetized Benefits[b]	$22,000	to	$54,000	$20,000	to	$49,000
Total Social Costs[3]		$1,500			1,500	
Net Benefits	$20,500	to	$52,500	$18,500	to	$47,500
Non-monetized Benefits	112,000 tons of carbon monoxide					
	30,000 tons of HCl					
	820 tons of HF					
	2,800 pounds of mercury					
	2,700 tons of other metals					
	23 grams of dioxins/furans (TEQ)					
	Health effects from SO_2 exposure					
	Ecosystem effects					
	Visibility impairment					
Alternative						
Total Monetized Benefits[b]	$18,000	to	$43,000	$16,000	to	$39,000
Total Social Costs[b]		$1,900			$1,900	
Net Benefits	$16,100	to	$41,100	$14,100	to	$37,100
Non-monetized Benefits	112,000 tons of carbon monoxide					
	22,000 tons of HCl					
	620 tons of HF					
	2,400 pounds of mercury					
	2,600 tons of other metals					
	23 grams of dioxins/furans (TEQ)					
	Health effects from SO_2 exposure					
	Ecosystem effects					
	Visibility impairment					

[a] All estimates are for the implementation year (2014), and are rounded to two significant figures. These results include units anticipated to come online and the lowest cost disposal assumption.

[b] The total monetized benefits reflect the human health benefits associated with reducing exposure to $PM_{2.5}$ through reductions of directly emitted $PM_{2.5}$ and $PM_{2.5}$ precursors such as SO_2, as well as reducing exposure to ozone through reductions of VOCs. It is important to note that the monetized benefits include many but not all health effects associated with $PM_{2.5}$ exposure. Benefits are shown as a range from Pope et al. (2002) to Laden et al. (2006). These models assume that all fine particles, regardless of their chemical composition, are equally potent in causing premature mortality because the scientific evidence is not yet sufficient to allow differentiation of effect estimates by particle type. These estimates include energy disbenefits associated with the increased emissions from additional energy usage valued at $22 million for the selected option and $37 million for the alternative option. Ozone benefits are valued at $3.6 to $15 million for both options.

[c] The methodology used to estimate social costs for one year in the multimarket model using surplus changes results in the same social costs for both discount rates.

Table 1-2. Summary of the Monetized Benefits, Social Costs, and Net Benefits for the Boiler Area Source Rule in 2014 (millions of 2008$)[a]

	3% Discount Rate			7% Discount Rate		
Final MACT/GACT Approach: Selected						
Total Monetized Benefits[b]	$210	to	$520	$190	to	$470
Total Social Costs[c]		$490			$490	
Net Benefits	−$280	to	$30	−$300	to	−$20
Non-monetized Benefits	1,100 tons of carbon monoxide					
	340 tons of HCl					
	8 tons of HF					
	90 pounds of mercury					
	320 tons of other metals					
	<1 gram of dioxins/furans (TEQ)					
	Health effects from SO_2 exposure					
	Ecosystem effects					
	Visibility impairment					
Proposed MACT Approach: Alternative						
Total Monetized Benefits[b]	$200	to	$490	$180	to	$440
Total Social Costs[c]		$850			$850	
Net Benefits	−$650	to	−$360	−$670	to	−$410
Non-monetized Benefits	1,100 tons of carbon monoxide					
	340 tons of HCl					
	8 tons of HF					
	90 pounds of mercury					
	320 tons of other metals					
	<1 gram of dioxins/furans (TEQ)					
	Health effects from SO_2 exposure					
	Ecosystem effects					
	Visibility impairment					

[a] All estimates are for the implementation year (2014), and are rounded to two significant figures. These results include units anticipated to come online and the lowest cost disposal assumption.

[b] The total monetized benefits reflect the human health benefits associated with reducing exposure to $PM_{2.5}$ through reductions of directly emitted $PM_{2.5}$ and $PM_{2.5}$ precursors such as SO_2. It is important to note that the monetized benefits include many but not all health effects associated with $PM_{2.5}$ exposure. Benefits are shown as a range from Pope et al. (2002) to Laden et al. (2006). These models assume that all fine particles, regardless of their chemical composition, are equally potent in causing premature mortality because the scientific evidence is not yet sufficient to allow differentiation of effect estimates by particle type. These estimates include energy disbenefits associated with the increased emissions from additional energy usage valued at less than $1 million.

[c] The methodology used to estimate social costs for one year in the multimarket model using surplus changes results in the same social costs for both discount rates.

1.3 Section 1 References

Laden, F., J. Schwartz, F.E. Speizer, and D.W. Dockery. 2006. "Reduction in Fine Particulate Air Pollution and Mortality." *American Journal of Respiratory and Critical Care Medicine* 173:667-672.

Pope, C.A., III, R.T. Burnett, M.J. Thun, E.E. Calle, D. Krewski, K. Ito, and G.D. Thurston. 2002. "Lung Cancer, Cardiopulmonary Mortality, and Long-term Exposure to Fine Particulate Air Pollution." *Journal of the American Medical Association* 287:1132-1141.

SECTION 4
ECONOMIC IMPACT ANALYSIS

EPA prepares an RIA to provide decision makers with a measure of the social costs of using resources to comply with a program (EPA, 2000). The social costs can then be compared with estimated social benefits (as presented in Section 6). As noted in EPA's (2010) *Guidelines for Preparing Economic Analyses*, several tools are available to estimate social costs and range from simple direct compliance cost methods to the development of a more complex market analysis that estimates market changes (e.g., price and consumption) and economic welfare changes (e.g., changes in consumer and producer surplus).

The Office of Air Quality Planning and Standards (OAQPS) adopted a standard market analysis as described in the Office's resource manual (EPA, 1999). The approach uses a single-period multimarket partial equilibrium model to compare pre-policy market baselines with expected post-policy market outcomes. The analysis' time horizon is the short run; some production factors are fixed and some are variable and is distinguished from the very short run where all factors are fixed and producers cannot adjust inputs or outputs (EPA, 1999, 5-6). The time horizon allows us to capture important transitory stakeholder outcomes. Key measures in this analysis include industry-level changes in price levels, production and consumption, jobs, international trade, and social costs (changes in producer and consumer surplus).

4.1 Partial Equilibrium Analysis (Multiple Markets)

The partial equilibrium analysis develops a market model that simulates how stakeholders (consumers and industries) might respond to the additional regulatory program costs. In this section, we provide an overview of the economic model. Appendix A provides additional details on the behavioral assumptions, data, parameters, and model equations.

4.1.1 Overview

Although several tools are available to estimate social costs, current EPA guidelines suggest that multimarket models "…are best used when potential impacts on related markets might be considerable" and modeling using a computable general equilibrium model is not available or practical (EPA, 2010, p. 9-21). Other guides for environmental economists offer similar advice (Berck and Hoffmann, 2002; Just, Hueth, and Schmitz, 2004). Multimarket models focus on "short-run" time horizons and measure a policy's near-term or transition costs (EPA, 1999). Note that the multimarket model is not designed to directly estimate employment impacts. Job effects are discussed later, in section 4.1.2.4. The multimarket model contains the following features:

- Industry sectors and benchmark data set
  - 100 industry sectors
  - a single benchmark year (2010)
  - industry employment data
- Economic behavior
  - industries respond to regulatory costs by changing production rates
  - market prices rise and fall to reflect higher energy and other non-energy material costs and changes in demand
  - customers respond to these price increases and consumption falls
- Model scope
  - 100 sectors are linked with each other based on their use of energy and other non-energy materials. For example, the construction industry is linked with the petroleum, cement, and steel industries and is influenced by price changes that occur in each sector. The links allow EPA to account for indirect effects the regulation has on related markets.
  - production adjustments influence employment levels
  - international trade (imports/exports) responds to domestic price changes
- Model time horizon ("short run") for a single period (2014)
  - fixed production resources (e.g., capital) lead to an upward-sloping industry supply function
  - firms cannot alter input mixes; there is no substitution among intermediate production inputs
  - price of labor (i.e., wage) is fixed
  - investment and government expenditures are fixed

4.1.2 Economic Impact Analysis Results

4.1.2.1 Market-Level Results

Market-level impacts include price and quantity adjustments including the changes in international trade (Figure 4-1). Under the major source NESHAP, the Agency's economic model suggests the average national price increases for industrial sectors are less than 0.01%, while average annual domestic production may fall by less than 0.01%. Because of higher domestic prices, imports slightly rise. Market-level effects for the area source NESHAP are smaller when compared to the major source rule; average price, production, and import changes are less than 0.01%. Industrial sector details are provided in Appendix B.

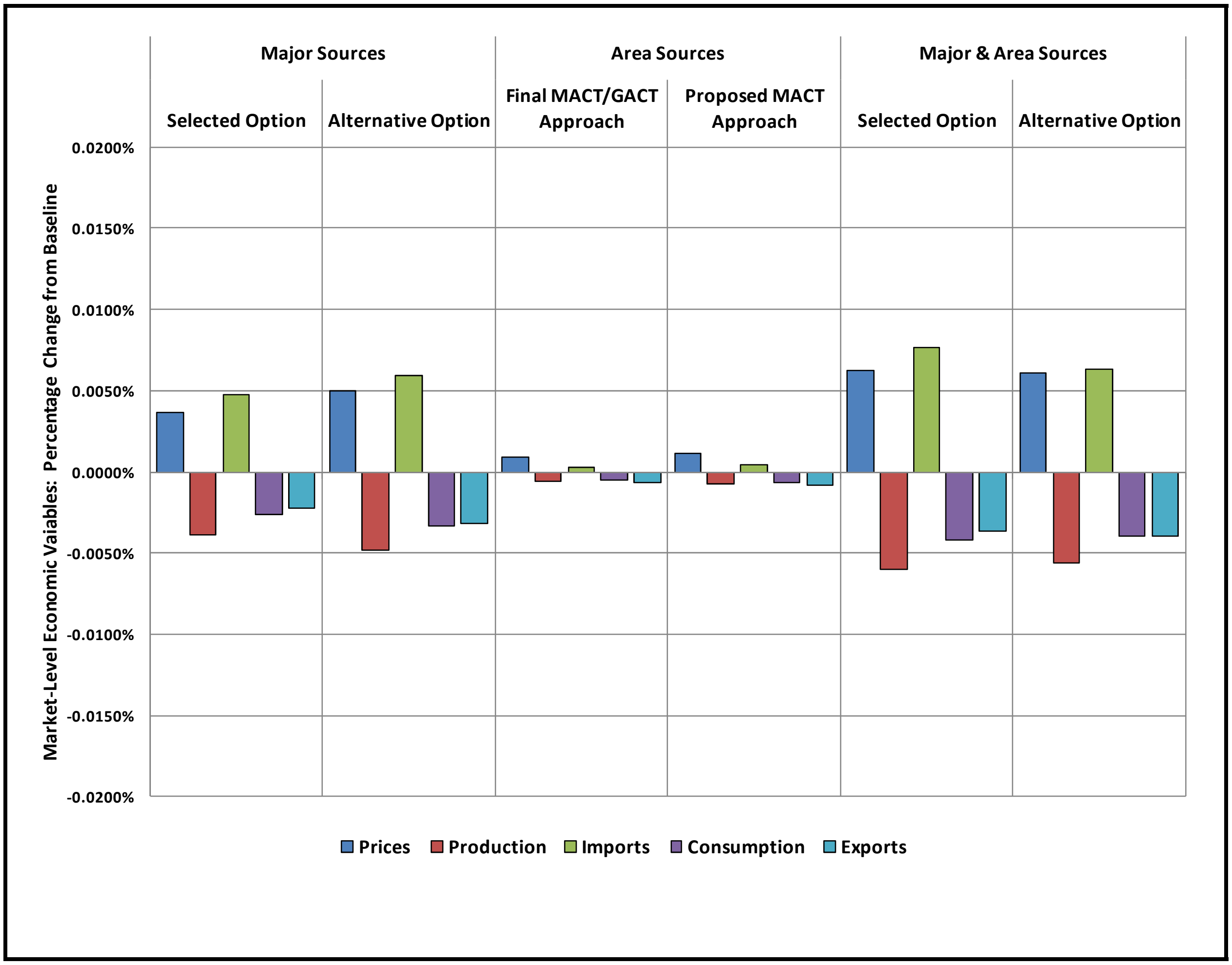

Figure 4-1. Market-Level Changes by Source and Option

4.1.2.2 Social Cost Estimates Major Source Rule

In the near term, the Agency's economic model suggests that industries are able to pass on $0.5 billion (2008$) of the major source rule's costs to U.S. households in the form of higher prices (Table 4-1). Existing U.S. industries' surplus falls by $1.4 billion and the net U.S. loss in aggregate is $1.9 billion. As U.S. prices rise, other countries are affected through international trade relationships. The price of goods produced in the United States increase slightly and domestic production declines, replaced to a certain degree by imports; the model estimates a net gain of less than $0.1 billion to foreign companies. As shown in Figure 4-2, the U.S. surplus losses are concentrated in other services (23 percent), lumber, paper, and printing (16 percent), energy industries (15 percent), and chemicals (13 percent).

Table 4-1. Distribution of Social Costs Major Sources (billion, 2008$): 2014

Method	Selected Option	Alternative Option
Partial Equilibrium Model (Multiple Markets)		
Change in U.S. consumer surplus	−$0.530	−$0.600
Change in U.S. producer surplus	−$1.360	−$1.730
Change in U.S. surplus	−$1.890	−$2.330
Direct Compliance Costs Method (Not Modeled)		
Total annualized costs, new major sources[a]	−$0.006	−$0.920
Fuel savings, existing major sources	$0.430	$0.400
Fuel savings, new major sources[a]	Less than $0.001	Less than $0.001
Net Change in U.S. Surplus[b]	**−$1.470**	**−$1.940**
Net change in rest of world surplus	$0.060	$0.090
Net change in total surplus	−$1.410	−$1.850

[a] Estimates for the Alternative option are assumed to be the same as the Selected option.

[b] U.S. surplus changes add the partial equilibrium model estimates and the direct compliance estimates not included in the partial equilibrium model. For example, the selected option's net change in U.S. surplus is $1.890 + (0.430 – 0.006) = –$1.470 billion.

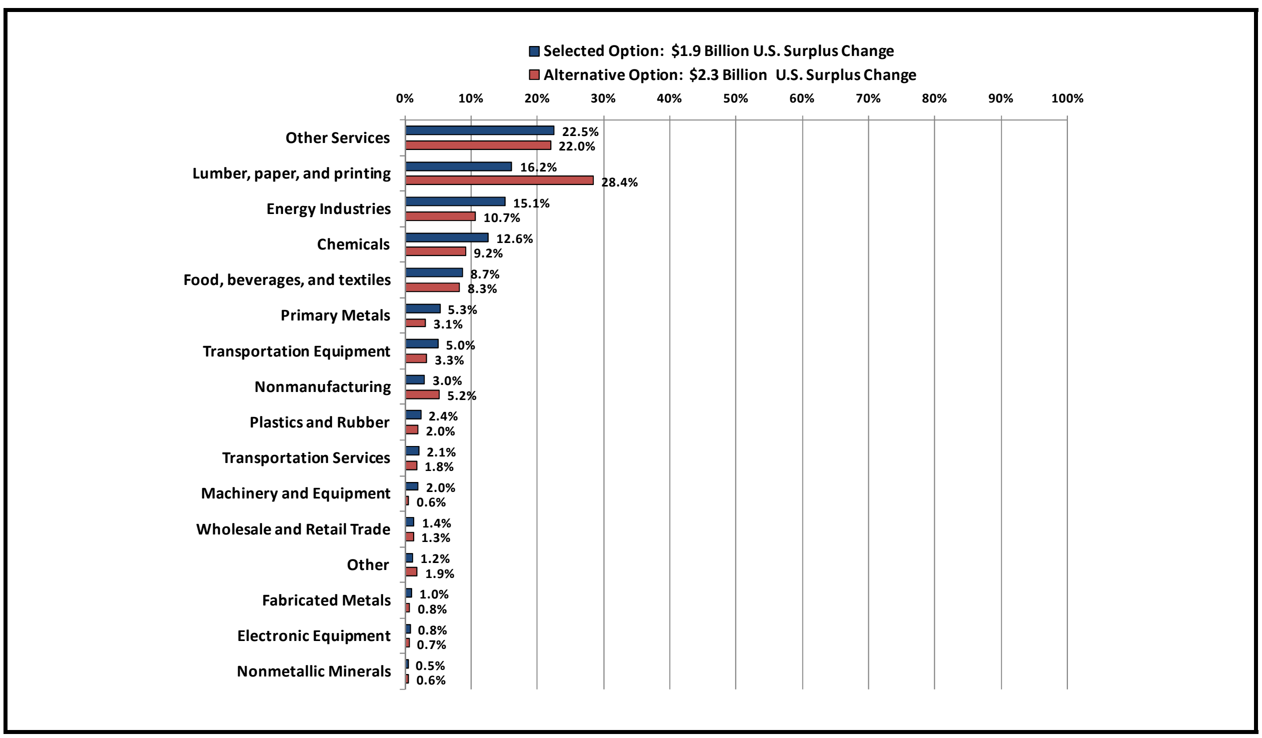

Figure 4-2. Distribution of U.S. Surplus Changes by Sector: Major Sources

The Agency also considered other elements of the engineering cost analysis that could not be modeled within the multimarket model (e.g., fuel savings benefits [existing and new major sources] and total annualized compliance costs [new major sources]). The net effect of the adjustments is a U.S. surplus loss estimate of $1.5 billion.

4.1.2.3 Social Cost Estimates Area Source Rule

In the near term, the Agency's economic model suggests that industries are able to pass on $0.2 billion (2008$) of the area source rule's costs to U.S. households in the form of higher prices (Table 4-2). Existing U.S. industries' surplus falls by $0.3 billion and the net loss for U.S. stakeholders is $0.5 billion. As U.S. prices rise, other countries are affected through international trade relationships. Households that buy U.S. exports pay higher prices and purchase fewer U.S. produced goods. Other countries that that sell goods to the United States benefit; the model estimates a net rest of the world gain of less than $0.01 billion. As shown in Figure 4-3, the U.S. surplus losses are concentrated in the other services (82 percent). Other services include information, finance and insurance, real estate, professional services, management, administrative services, education, health care, arts, accommodations, and public services.

Table 4-2. Distribution of Social Costs Area Sources (billion, 2008$): 2014

Method	Final MACT/GACT Approach	Proposed MACT Approach
Partial Equilibrium Model (Multiple Markets)		
Change in U.S. consumer surplus	−$0.240	−$0.300
Change in U.S. producer surplus	−$0.250	−$0.330
Change in U.S. surplus	−$0.490	−$0.630
Direct Compliance Costs Method (Not Modeled)		
Total annualized costs, unknown existing area sources	−$0.003	−$0.008
Total annualized costs, new area sources	−$0.050	−$0.270
Fuel savings, existing and new area sources)	$0.050	$0.050
Net Change in U.S. Surplus [a]	**−$0.490**	**−$0.850**
Net change in rest of world surplus	$0.004	$0.005
Net change in total surplus	−$0.480	−$0.850

[a] U.S. surplus changes add the partial equilibrium model estimates and the direct compliance estimates not included in the partial equilibrium model. For example, the Final MACT/GACT net change in U.S. surplus is $0.490 + (0.050 – 0.050–0.003) = –$0.490 billion.

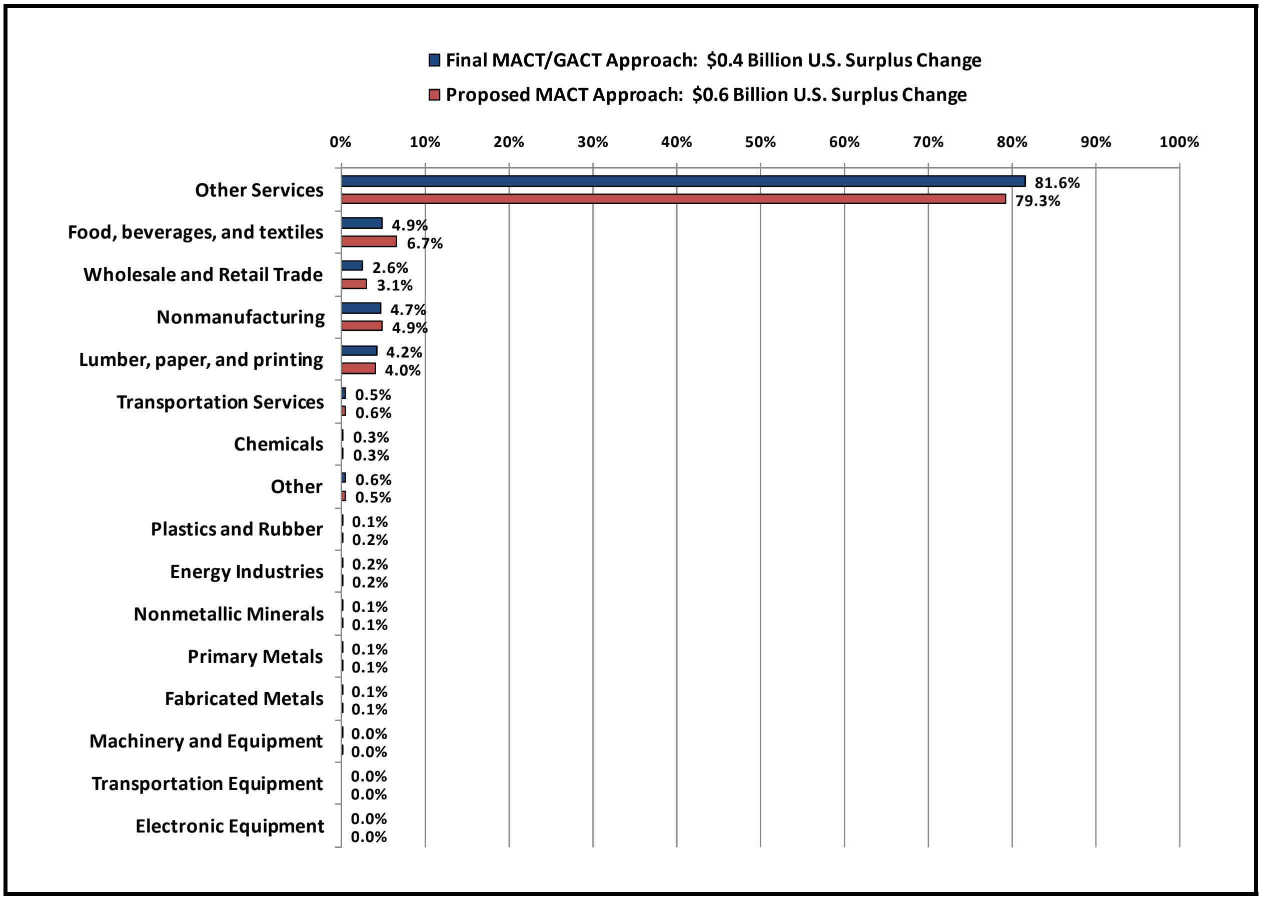

Figure 4-3. Distribution of Total Surplus Changes by Sector: Area Sources

[a] Other services include information, finance and insurance, real estate, professional services, management, administrative services, education, health care, arts, accommodations, and public services.

The Agency also considered other elements of the engineering cost analysis that could not be modeled within the multimarket model (e.g., fuel-savings benefits [existing and new area sources] and total annualized compliance costs [unknown existing and new area sources]). The net effect of the adjustments is a total surplus loss estimate of $0.5 billion.

4.1.2.4 Job Effects

4.1.2.4.1 Background

In addition to estimating this rule's social costs and benefits, EPA has estimated the employment impacts of the final rule based on Morgenstern, Pizer and Shih (2002). A stand-alone analysis of jobs is not included in a standard cost-benefit analysis. Executive Order 13563 however, states, "Our regulatory system must protect public health, welfare, safety, and our environment while promoting economic growth, innovation, competitiveness, and job creation" (emphasis added). Therefore, we have provided this analysis to inform the discussion of job impacts. EPA continues to explore the relevant theoretical and empirical literature and to seek public comments in order to ensure that such estimates are as accurate as possible.

From an economic perspective labor is an input into producing goods and services; if regulation requires that more labor be used to produce a given amount of output, that additional labor is reflected in an increase in the cost of production. Moreover, when the economy is near full employment, jobs created in one industry as a result of regulation displace jobs in other industries. On the other hand, in periods of high unemployment, an increase in labor demand due to regulation may have a stimulative effect that results in a net increase in overall employment. With significant numbers of workers unemployed, the opportunity costs associated with displacing jobs in other sectors are likely to be much smaller.

For this reason, this RIA looks carefully at a subset of the employment consequences of this final rule. It is important to note that EPA has estimated only a portion of the employment effects -- namely, those associated with the direct impacts on employment in the regulated industry. A full analysis would include estimates of the direct impacts on other industries (e.g. suppliers of pollution control equipment) as well as the indirect and induced effects on employment throughout the economy as a whole in response to changes in output and factor prices.

We expect that the rule's direct impact on employment will be small. The Agency's analysis does not include all the direct effects of this regulation. For example, EPA is currently exploring ways to quantify the job impacts in the pollution control sector that result from these and future regulations. Furthermore, we have not quantified the rule's indirect or induced impacts. What follows is an overview of the various ways that environmental regulation can affect employment, followed by a discussion of the estimated impacts of this rule. An environmental regulation can affect the demand for labor in several ways:

- **Direct Effects**:
  - **Increased prices for industry output may reduce the demand for labor:** Environmental regulations increase production costs causing firms to increase prices; higher prices reduce consumption (and production), thus reducing demand for labor within the regulated industry. The extent of this effect will depend on the extent of the price increase and the elasticity of the demand curve.
  - **Regulated firms demand labor workers to operate and maintain pollution controls within those firms.** Once pollution control equipment is installed, regulated firms may hire workers to operate and maintain it, just as they would hire

workers to produce more output. The extent of this effect will depend in part on whether the operation and maintenance of pollution controls are labor intensive

- **Increased demand for pollution control equipment and services:** When a regulation requiring emission reductions is promulgated, affected sources must immediately place orders for pollution control equipment and services. Filling these orders will require a scale-up in manufacturing of pollution control equipment, performance of engineering analyses and significant expenditures for assembly and installation of such equipment. These activities will be job-creating during the period before firms must comply with the rule, at which point all pollution control equipment must be installed and operating.

Indirect and Induced Effects:

- **Environmental regulations create employment in many basic industries**. In addition to the increase in employment in the environmental protection industry (increased orders for pollution control equipment), environmental regulations also create employment in industries that provide intermediate goods to the environmental protection industry. For example, capital expenditures to reduce air pollution involve the purchase of abatement equipment. The equipment manufacturers, in turn, order steel, tanks, vessels, blowers, pumps, and chemicals to manufacture and install the equipment. On the other hand, demand for labor will decrease in sectors that supply inputs for, or demand the outputs of the regulated industry. None of these impacts is accounted for in the current analysis. We also do not estimate employment impacts "induced" by increased output of the environmental protection sector, or decreased output of the regulated sectors.

4.1.2.4.2 Methodology and Results

The estimated impacts of the final rule on employment in affected sources are based on an empirically derived relationship reported in Morgenstern, Pizer and Shih (2002), a peer-reviewed, published study. Estimates of the employment impacts of the capital investments and other non-recurring requirements of the rule are derived from the cost analysis developed for the regulation.[1]

Morgenstern, Pizer and Shih (2002): Overview of Conceptual Approach

The fundamental insight of Morgenstern, Pizer and Shih (2002) is that environmental regulations can be understood as requiring regulated firms to add a new output (environmental quality) to their product mixes. Although legally compelled to satisfy this new demand, regulated firms have to finance this additional production with the proceeds of sales of their other (market) products. Satisfying this new demand requires additional inputs, including labor, and may alter the relative proportions of labor and capital used by regulated firms in their production processes.

[1] Richard D. Morgenstern, William A. Pizer, and Jhih-Shyang Shih, *Journal of Environmental Economics and Management* | May 2002 | Vol. 43, no. 3 | pp. 412-436.

Thus, Morgenstern et al., decompose the overall effect of a regulation on employment into the following three subcomponents:

- The "Demand Effect": higher production costs raise market prices,reducing consumption (and production), thereby reducing demand for labor within the regulated industry [2;]
- The "Cost Effect": As production costs increase, plants use more of all inputs, including labor, to maintain a given level of output. For example, in order to reduce pollutant emissions while holding output levels constant, regulated firms may require additional labor;
- The "Factor-Shift Effect": Regulated firms' production technologies may be more or less labor intensive after complying with a regulation (i.e., more/less labor is required per dollar of output).

Decomposing the overall employment impact of environmental regulation into three subcomponents clarifies the conceptual relationship between environmental regulation and employment in regulated sectors, and permitted Morgenstern, et al. to provide an empirical estimate of the net impact. For present purposes, the net effect is of particular interest, and is the focus of our analysis.

Morgenstern, Pizer and Shih (2002): Empirical Results

Morgenstern et al. empirically estimate a model for four highly polluting, regulated industries (pulp and paper, plastics, petroleum refining and steel) to examine the effect of higher abatement costs from regulation on employment. They conclude that increased abatement expenditures generally do not cause a significant change in employment. More specifically, their results show that, on average across the four industries, each additional $1 million spending on pollution abatement results in a (statistically insignificant) net increase of 1.55 (+/- 2.24) jobs.[3] "In plastics and petroleum, [Morgenstern et al] find that increased regulation raises employment by a small but statistically significant amount: 6.9 and 2.2 jobs per million dollars of regulatory expense, respectively. In pulp and paper and steel, the estimates are even smaller and insignificantly different from zero."[4] By applying these estimates to pollution abatement costs, we estimated the

[2] The Morgenstern et al. results rely on industry demand and supply elasticities to determine cost pass-through and reductions in output.

[3] These results are similar to Berman and Bui, who find that while sharply increased air quality regulation in Los Angeles to reduce NOx emissions resulted in large abatement costs they did not result in substantially reduced employment. "Environmental regulation and labor demand: evidence from the South Coast Air Basin." *Journal of Public Economics* 79(2): 265-295.

[4] Morgenstern, Pizer and Shih, p. 413.

net employment effect for major and areas sources to range from -4,100 to +8,500 jobs in the directly affected sectors with a central estimate of +2,200 (Table 4-3).[5, 6]

[5] Since Morgenstern's analysis reports environmental expenditures in $1987, we make an inflation adjustment the engineering cost analysis using GDP implicit price deflator (64.76/108.48) = 0.60)

[6] Net employment effect = 1.55× $2,400 million × 0.60

Table 4-3. Employment Impacts Using Morgenstern, Pizer, Shih (2002) (FTE)

	Demand Effect	Cost Effect	Factor Shift Effect	Net Effect
Change in Full-Time Jobs per Million Dollars of Environmental Expenditure[a]	−3.56	2.42	2.68	1.55
Standard Error	2.03	1.35	0.83	2.24
EPA estimate for Major Sources Rule	−3,900 −8,200 to +500	2,600 +900 to +4,400	2,900 0 to +5,800	1,700 −3,100 to +6,500
EPA estimate for Area Source Rule	−1,200 −2,600 to +100	800 +300 to +1,400	900 0 to +1,800	500 −1,000 to +2,000
EPA estimate for both Rules [b]	−5,100 −10,800 to +600	3,500 +1,100 to +5,800	3,900 0 to 7,700	2,200 −4,100 to +8,500

[a] Estimates from Morgenstern, Pizer, and Shih (2002) expressed in 2010 dollars using the GDP price deflator (see footnote 7).
[b]Totals may not add due to independent rounding.

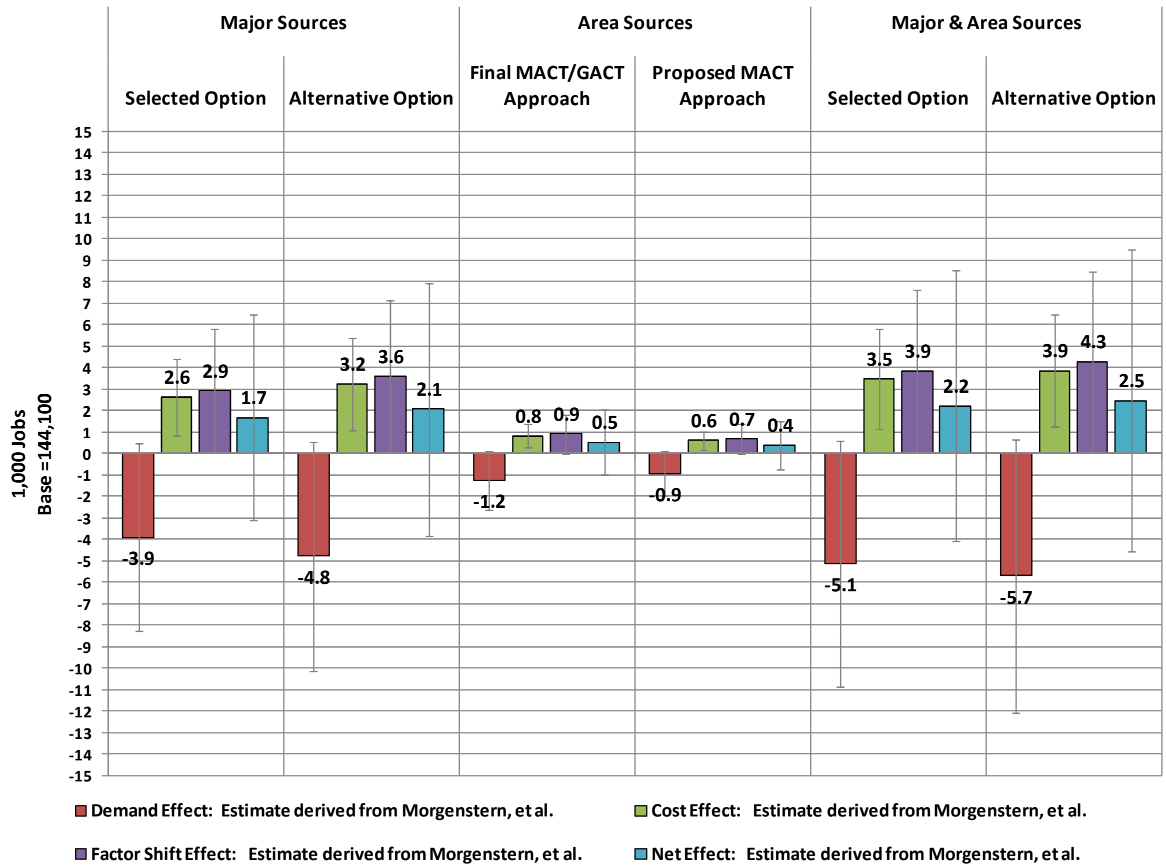

Figure 4-3. Employment Impacts Using Morgenstern, Pizer, Shih (2002) (1,000 FTEs)

Limitations of the Analysis

Although the Morgenstern et al. paper provides information about the potential job effects of environmental protection programs, there are several caveats associated with using those estimates to analyze the final rule. First, the Morgenstern et al. estimates presented in Table 4-3 and used in EPA's analysis represent the weighted average parameter estimates for a set of manufacturing industries (pulp and paper, plastics, petroleum, and steel). This set of industries only partially overlaps with the sectors affected by this rule. Second, relying on Morgenstern et al. implicitly assumes that estimates derived from 1979–1991 data are still applicable. Third, the methodology used in Morgenstern et al. assumes that regulations affect plants in proportion to their total costs. In other words, each additional dollar of regulatory burden affects a plant by an amount equal to that plant's total costs relative to the aggregate industry costs. By transferring the estimates, EPA assumes a similar distribution of regulatory costs by plant size and that the regulatory burden does not disproportionately fall on smaller or larger plants. Further, Morgenstern et al. does not include most indirect effects and all induced effects.

EXHIBIT 7

December 1, 2011

MEMORANDUM

SUBJECT: Regulatory Impact Results for the Reconsideration Proposal for National Emission Standards for Hazardous Air Pollutants for Industrial, Commercial, and Institutional Boilers and Process Heaters at Major Sources

FROM: Tom Walton
Economist
AEG (C439-02)

TO: Brian Shrager
Environmental Engineer
ESG (D243-01)

The EPA analyzed the economic impacts and benefits of this proposed rule using the identical methodology as the RIA for the boiler rules finalized in February 2011 and included as Attachment A to this memo. Therefore, all changes to the costs, benefits, and economic impacts for this proposed rule are due to changes in the proposed rule for major source boilers, which are fully described in the preamble to the proposed rule. There are no changes to the area source boiler impacts. The following table shows an approximation of the changes in monetized benefits and engineering costs due to changes in the major source boilers reconsideration proposal, and includes values that show a comparison based on the final rule inventory.

	Benefits	Annual Engineering Costs (considering fuel savings)
Boiler Final Rule	$22 to $54 billion	$1.40 billion
Changes due to addition of about 300 sources to inventory	+$2.4 to $6.0 billion	+$0.16 billion
Changes due to Provision changes in this Proposal	+$2.7 to $6.6 billion	-$0.1 billion
Net Change	+$5.1 to $13 billion	+$0.06 billion

* Monetized benefits are shown at a 3% discount rate. These benefits do not include benefits associated with reduced exposure to HAP, direct exposure to SO_2, visibility impairment, or ecosystem effects.

The market impact results are very similar to the ones in the final rule in the RIA. The agencies economic model suggests the average national price increases for industrial sectors are less than 0.01 percent, while average annual domestic production may fall by less than 0.01 percent. Because of higher domestic prices, imports slightly rise. The change in US surplus is now -1.93 billion dollars (2006$). For the RIA, it was -1.86 billion dollars (2006$). Table 1 shows the price, production, import, and export changes for this proposed rule, which are very close to the estimated changes for the final rule RIA.

Table 1. Price, Production, Import, and Export Changes Resulting from the Boiler MACT and Proposed Reconsideration

Industry Sector	U.S. Prices	U.S. Production	Imports	U.S. Consumption	Exports
Energy	0.027%	-0.012%	0.050%	-0.006%	-0.004%
Coal	0.014%	-0.011%	0.029%	-0.010%	-0.001%
Crude Oil Extraction	-0.001%	-0.021%	-0.003%	-0.008%	0.000%
Electric generation	0.083%	-0.009%	0.164%	-0.009%	-0.013%
Natural Gas	0.002%	-0.014%	0.025%	-0.007%	-0.001%
Refined Petroleum	0.017%	-0.008%	0.016%	-0.003%	-0.001%
Nonmanufacturing	0.001%	-0.003%	0.001%	-0.003%	0.000%
Manufacturing					
Food, beverages, and textiles	0.014%	-0.013%	0.017%	-0.008%	-0.009%
Lumber, paper, and printing	0.114%	-0.050%	0.117%	-0.030%	-0.079%
Chemicals	0.006%	-0.015%	0.007%	-0.010%	-0.006%
Plastics and Rubber	0.010%	-0.012%	0.011%	-0.008%	-0.010%
Nonmetallic Minerals	0.003%	-0.004%	0.001%	-0.003%	-0.003%
Primary Metals	0.018%	-0.021%	0.017%	-0.011%	-0.017%
Fabricated Metals	0.003%	-0.005%	0.004%	-0.004%	-0.002%
Machinery and Equipment	0.006%	-0.008%	0.006%	-0.004%	-0.010%
Electronic Equipment	-0.001%	-0.002%	0.000%	-0.001%	0.001%
Transportation Equipment	0.003%	-0.006%	0.004%	-0.004%	-0.007%
Other	0.004%	-0.009%	0.007%	-0.003%	-0.004%
Wholesale and Retail Trade	-0.002%	-0.001%	-0.001%	-0.001%	0.001%
Transportation Services	-0.001%	-0.003%	-0.001%	-0.003%	0.001%
Other Services	0.000%	-0.001%	0.000%	-0.001%	0.000%

The results for sales tests for small businesses are somewhat lower than those calculated for the final rule. For the sales tests using small companies identified in the Combustion Survey, the mean cost to receipts dropped from 4 percent in the RIA to 2 percent for the proposed rule and the median was 0.2 percent for both. The number of parent companies with sales tests exceeding 3 percent dropped from 8 in the RIA to 6 for the reconsideration proposal. There was no change in the results for small public entities. Median cost is still about $1.1 million and representative small major public entities would have cost-to-revenue ratios above 10 percent.

The change in employment estimates between the RIA and the reconsideration proposal is minimal. The estimated employment changes range between −3,100 to +6,500 employees, with a central estimate of +1,700 employees for the major source NESHAP in the RIA. For the reconsideration proposal, the estimated employment changes range between −3,000 to +6,300 employees, with a central estimate of +1,600.

The benefits estimates increased for the proposal. The range for the RIA was $22 billion (2008$) to 54 billion (2008$) at 3 percent discount rate. The range for the proposal was $27 billion (2008$) to 67 billion (2008$) at 3 percent discount rate. The range for the RIA was $20 billion (2008$) to 49 billion (2008$) at 7 percent discount rate. The range for the proposal was $25 billion (2008$) to 61 billion (2008$) at 7 percent discount rate.

EXHIBIT 8

December 19, 2012

MEMORANDUM

SUBJECT: Regulatory Impact Results for the Reconsideration Final Rule for National Emission Standards for Hazardous Air Pollutants for Industrial, Commercial, and Institutional Boilers and Process Heaters at Major Sources

FROM: Tom Walton
Economist
AEG (C439-02)

TO: Jim Eddinger
Environmental Engineer
ESG (D243-01)

The EPA analyzed the economic impacts and benefits of this final reconsideration using the identical methodology as the Regulatory Impact Analysis (RIA) for the boiler rules finalized in February 2011 and included as Attachment A to this memo. Therefore, all changes to the costs, monetized benefits, and economic impacts for this final reconsideration are due to changes in the final reconsideration for major source boilers, which are fully described in the preamble to the final reconsideration. There are no changes to the area source boiler impacts.

Changes Since 2010 Final Rule to Emission Reductions and Engineering Costs

There were two major changes to the March 2011 final rule for major source boilers and process heaters (i.e., Boiler MACT). First, an increase in the inventory of affected units and, second, changes in the provisions (generally less stringent) of the rule. Since the March 2011 final rule, 72 major source facilities were identified that were not previously in the Boiler MACT inventory database. Adding the boilers and process heaters located at these newly identified major source facilities resulted in 73 additional coal-fired units, 32 additional biomass-fired units, 82 additional oil-fired units, and 149 additional gas-fired units. The resulting additional cost impact for these additional existing boilers and process heaters to comply with the final amended rule is $0.6 billion in capital expenditures and $0.21 billion per year in total annual costs, considering fuel savings, with the additional coal-fired units (46%) and the additional oil-fired units (51%) accounting for 97% of the additional capital expenditures and nearly all of the additional total annual costs. The additional emission reductions from the additional coal-fired and oil-fired units alone (excluding the additional emission reductions from biomass and gas-fired units) are 73,400 tons of SO_2 per year and 1,300 tons of $PM_{2.5}$ per year

The second major change to the March 2011 final rule is differences in the rule provisions. The changes in emission reductions and annual engineering costs are due to provision changes in this final reconsideration are mainly the result of revisions made to the emission limits due to new data, corrections to old data, and subcategories changes. For existing subcategories in the final amended rule, for the HCl emission limits, 10 are more stringent, 3 are less stringent and 1 remained the same from the March 21, 2011 final rule; for the mercury emission limits, 3 are more stringent and 11 are less stringent from the March 21, 2011 final rule; for the PM emission limits, 2 are more stringent, 7 are less stringent and 5 are unchanged from the March 21, 2011 final rule; and for the CO emission limits, 4 are more stringent and 10 are less stringent from the March 21, 2011 final rule. Overall, these changes to the emission limits resulted in a decrease in annual engineering costs but the decrease in annual engineering costs is mainly the results of less stringent emission limits for units in the liquid fuel subcategories. For the liquid fuel subcategories, the cost reduction was due to less oil-fired units estimated to install fabric filters since the PM emission limit was revised from 0.0075 lb/MMBtu for all oil-fired units to 0.062 lb/MMBtu for units firing heavy oil. One of the provision changes was splitting the liquid fuel subcategories into two subcategories, heavy liquid subcategory and light liquid subcategory. In addition, less oil-fired units were estimated to install wet scrubbers to comply with the revised HCl emission limit which changed from 0.00033 lb/MMBtu to 0.0011 lb/MMBtu. Also, less oil-fired units were estimated to install oxidation catalysts to comply with the revised CO emission limits which changed from 4 ppm to 130 ppm. These changes to the emission limits for liquid-fired units resulted in a reduction of about 350 million dollars per year in total annual costs. This total annual costs reduction was offset somewhat by the increase in total annual costs due to the more stringent HCl standard for coal-fired units which resulted in higher estimated costs for installing wet scrubbers to comply with the revised HCl emission limit. The additional emission reductions resulting from these provision changes are mainly due to the additional SO_2 reductions resulting from the revised HCl emission limit for coal-fired units.

Table 1 shows the changes in emission reductions of directly emitted $PM_{2.5}$ and SO_2. Table 2 shows an estimate of the changes in monetized benefits associated with the emission reductions and engineering costs in the major source boilers final reconsideration.

Table 1. Changes in Emission Reductions for final Boiler Reconsideration[a]

	Direct $PM_{2.5}$ (tons per year)	**SO_2 (tons per year)**
Major Boiler Final Rule (March 2011)	28,990	439,619
Changes due to increase in scope (addition of 336 units)	+1,314	+74,152
Changes due to provision changes in this final reconsideration	-13,753	+57,956
Net changes since final rule	-12,439	+132,108
Major Boiler Final Reconsideration	16,593	571,727

[a] We provide only the emission changes associated with these 2 pollutants in this table because the other pollutants (e.g., Hg, HCl, CO, D/F, HF, and THC) were not monetized in the RIA.

Table 2. Changes in Benefits and Costs for final Boiler Reconsideration

	Monetized Benefits in 2015[a]		Annual Engineering Costs[b] (considering fuel savings)
	3% discount rate	**7% discount rate**	
Major Boiler Final Rule (March 2011)	$25 to $54 billion	$20 to $49 billion	$1.40 billion
Changes due to increase in scope (addition of 336 units)	+$3.5 to $8.6 billion	+$3.2 to $7.7 billion	+$0.219 to $0.224 billion
Changes due to provision changes in this final reconsideration[c]	+$1.7 to $4.1 billion	+$1.5 to $3.7 billion	-$0.24 to -$0.042 billion
Net changes since final rule	+$5.1 to $13 billion	+$4.7 to $11 billion	-$0.02 to + $0.18 billion
Major Boiler Final Reconsideration	$27 to $67 billion	$25 to $61 billion	+$1.4 to $1.6 billion

[a] These benefits do not include benefits associated with reduced exposure to HAP, direct exposure to SO_2, visibility impairment, or ecosystem effects

[b] Minimum and maximum fuel savings reflect a range of fuel prices for the final reconsideration.

[c] The change in benefits due to provision changes in this final reconsideration is positive because the solid fuel HCl limit is somewhat lower, which resulted in increased SO_2 reductions and increased benefits. The costs are negative because the cost decrease for liquid-fired units is greater than the cost increase for coal-fired units.

The monetized benefits estimates for the final reconsideration are very similar to the monetized benefits for the proposed reconsideration, which are both slightly higher than the monetized benefits for the final Boiler RIA (March 2011). We estimated the total monetized benefits for the final Boiler RIA (March 2011) to be $22 billion to $54 billion at 3 percent discount rate and $20 billion to $49 billion at 7 percent discount rate. For this final reconsideration, we estimate the total monetized benefits to be $27 billion to $67 billion at 3 percent discount rate and $25 billion to $61 billion at 7 percent discount rate. All estimates are in 2008$.

While it may seem hard to understand why changes due to the provision changes result in increased benefits and decreased costs, the fact that some emission limits are more stringent and other limits are less stringent is the key to understanding this. The increase in SO_2 reductions has more benefits associated with it than the decrease in $PM_{2.5}$ reductions. Similarly, the increase in SO_2 reductions has a smaller cost increase associated with it than the cost savings associated with the decrease in $PM_{2.5}$ reductions.

Revised Economic Impacts

The market impact results are very similar to the ones in the final rule in the RIA. The agencies economic model suggests the average national price increases for industrial sectors are less than 0.01 percent, while average annual domestic production may fall by less than 0.01 percent. Because of higher domestic prices, imports slightly rise. Table 3 shows the price, production, import, and export changes for this final reconsideration, which are very close to the estimated changes for the final rule RIA.

Table 3. Price, Production, Import, and Export Changes Resulting from the Boiler MACT Final Reconsideration

Industry Sector	U.S. Prices	U.S. Production	Imports	U.S. Consumption	Exports
Energy	0.033%	-0.019%	0.070%	-0.006%	-0.005%
Coal	0.015%	-0.012%	0.033%	-0.010%	-0.002%
Crude Oil Extraction	0.001%	-0.043%	0.005%	-0.008%	0.000%
Electric generation	0.101%	-0.010%	0.199%	-0.010%	-0.016%
Natural Gas	0.008%	-0.033%	0.098%	-0.008%	-0.002%
Refined Petroleum	0.017%	-0.008%	0.016%	-0.003%	-0.001%
Nonmanufacturing	0.001%	-0.003%	0.001%	-0.003%	0.000%
Manufacturing					
Food, beverages, and textiles	0.012%	-0.013%	0.015%	-0.007%	-0.008%
Lumber, paper, and printing	0.084%	-0.037%	0.086%	-0.023%	-0.058%
Chemicals	0.005%	-0.012%	0.006%	-0.008%	-0.005%
Plastics and Rubber	0.007%	-0.009%	0.008%	-0.006%	-0.007%
Nonmetallic Minerals	0.003%	-0.004%	0.001%	-0.003%	-0.003%
Primary Metals	0.019%	-0.022%	0.018%	-0.011%	-0.018%
Fabricated Metals	0.004%	-0.005%	0.004%	-0.004%	-0.002%
Machinery and Equipment	0.008%	-0.010%	0.007%	-0.004%	-0.013%
Electronic Equipment	-0.001%	-0.002%	0.000%	-0.001%	0.001%
Transportation Equipment	0.003%	-0.006%	0.004%	-0.003%	-0.006%
Other	0.004%	-0.008%	0.006%	-0.002%	-0.003%
Wholesale and Retail Trade	-0.002%	-0.001%	-0.001%	-0.001%	0.001%
Transportation Services	0.000%	-0.003%	-0.001%	-0.003%	0.000%
Other Services	0.000%	-0.001%	0.000%	-0.001%	0.000%

The results for sales tests for small businesses are somewhat lower than those calculated for the final rule. For the sales tests using small companies identified in the Combustion Survey, the mean cost to receipts dropped from 4 percent in the RIA to 3 percent for the final reconsideration and the median was 0.2 percent for in the RIA and also 0.2 percent in the final reconsideration. The number of parent companies with sales tests exceeding 3 percent dropped from 8 in the RIA to 5 for the final reconsideration. There was no change in the results for small public entities. Median cost is still about $1.1 million and representative small major public entities would have cost-to-revenue ratios above 10 percent.

The change in employment estimates between the RIA and the final reconsideration is minimal. The estimated employment changes range between −3,100 to +6,500 employees, with a central estimate of +1,700 employees for the major source NESHAP in the RIA. For the final reconsideration, the estimated employment is a central estimate of +1,400 with the range between −2,600 to +5,400 employees.

Revised Benefits

The health benefits were calculated using the methodology described in the final Boiler RIA (March 2011), using the revised emission reductions estimated for the final reconsideration.

In addition, we fixed an error in the 95^{th} confidence intervals reported in the proposal reconsideration memo for the incidence estimates, and added the 95^{th} percentile confidence intervals for the monetized benefits by mortality estimate. We were unable to estimate the benefits from reducing exposure to HAPs and ozone, ecosystem impairment, and visibility impairment, including reducing 180,000 tons of carbon monoxide, 39,000 tons of HCl, 500 tons of HF, 2,500 tons of other metals, and 3,100 to 5,300 pounds of mercury. Energy disbenefits due to increased CO_2 emissions from increased electricity usage were estimated to be $5.8 million to $75 million depending on the discount rate for the final boiler RIA (March 2011), and thus do not affect the rounded monetized benefits and have not been re-estimated here. Please refer to the full description in the final Boiler RIA of the unquantified benefits as well as technical details of the analysis and its limitations and uncertainties. These monetized benefits are approximately 23% higher than the final Boiler MACT due to the increase in SO_2 emission reductions. These benefit-per-ton estimates were calculated for a 2014 analysis year (i.e., using population and income growth for 2014), which slightly underestimates the 2015 benefits. Since the reconsideration proposal, we have made several updates to the approach we use to estimate mortality and morbidity benefits in the PM NAAQS RIAs (U.S. EPA, 2012a,b)[1,2], including updated epidemiology studies, health endpoints, and population data. Although we have not re-estimated the benefits for this rule to apply this new approach, these updates generally offset each other, and we anticipate that the rounded benefits estimated for this rule are unlikely to be different than those provided below. See Tables 4 to 6 and Figures 1 and 2 for the updated benefits results.

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[1] U.S. Environmental Protection Agency (U.S. EPA). 2012a. *Regulatory Impact Analysis for the Proposed Revisions to the National Ambient Air Quality Standards for Particulate Matter*. EPA-452/R-12-003. Office of Air Quality Planning and Standards, Health and Environmental Impacts Division. June. Available at http://www.epa.gov/ttnecas1/regdata/RIAs/PMRIACombinedFile_Bookmarked.pdf.

[2] U.S. Environmental Protection Agency (U.S. EPA). 2012b. *Regulatory Impact Analysis for the Final Revisions to the National Ambient Air Quality Standards for Particulate Matter*. EPA-452/R-12-003. Office of Air Quality Planning and Standards, Health and Environmental Impacts Division. December. Available at http://www.epa.gov/pm/2012/finalria.pdf.

Table 4: Summary of Monetized Benefits Estimates for the Final Boiler MACT Reconsideration in 2015

Pollutant	Emissions Reductions (tons)	Benefit per ton (Pope, 3%)	Benefit per ton (Laden, 3%)	Benefit per ton (Pope, 7%)	Benefit per ton (Laden, 7%)	Total Monetized Benefits (billions 2008$ at 3%)	Total Monetized Benefits (billions 2008$ at 7%)
Direct $PM_{2.5}$	16,593	$72,000	$180,000	$65,000	$160,000	$1.2 to $2.9	$1.1 to $2.7
SO_2	571,727	$46,000	$110,000	$42,000	$100,000	$26 to $64	$24 to $58
					Total	**$27 to $67**	**$25 to $61**

*All estimates are for the implementation year (2015), and are rounded to two significant figures so numbers may not sum across columns. These models assume that all fine particles, regardless of their chemical composition, are equally potent in causing premature mortality because the scientific evidence is not yet sufficient to allow differentiation of effect estimates by particle type. The benefit per ton estimates vary because each ton of precursor reduced has a different propensity to become $PM_{2.5}$. The monetized benefits incorporate the conversion from precursor emissions to ambient fine particles. These estimates do not include benefits from reducing HAP emissions, nor energy disbenefits associated with the increased emissions from additional energy usage, or ozone benefits. These benefits reflect existing boilers and new boilers anticipated to come online by 2015.

Table 5: Summary of Estimated Reductions in Health Incidences from $PM_{2.5}$ for the Final Boiler MACT Reconsideration in 2015 (95th percentile confidence interval)*

	Final Reconsideration
Avoided Premature Mortality	
Pope et al.	3,100 (1,000 -- 5,200)
Laden et al.	7,900 (4,000 -- 12,000)
Woodruff (Infant mortality)	13 (0 -- 37)
Avoided Morbidity	
Chronic Bronchitis	2,000 (220 -- 3,800)
Acute Myocardial Infarction	5,000 (1,500 -- 8,400)
Hospital Admissions, Respiratory	750 (330 -- 1,200)
Hospital Admissions, Cardiovascular	1,600 (1,100 -- 1,900)
Emergency Room Visits, Respiratory	3,000 (1,600 -- 4,300)
Acute Bronchitis	4,600 (0 -- 9,800)
Work Loss Days	390,000 (330,000 -- 440,000)
Asthma Exacerbation	51,000 (3,700 -- 160,000)
Minor Restricted Activity Days	2,300,000 (1,900,000 -- 2,700,000)
Lower Respiratory Symptoms	55,000 (24,000 -- 86,000)
Upper Respiratory Symptoms	41,000 (10,000 -- 72,000)

*All estimates are for the analysis year (2015) and are rounded to whole numbers with two significant figures. These models assume that all fine particles, regardless of their chemical composition, are equally potent in causing premature mortality because the scientific evidence is not yet sufficient to allow differentiation of effect estimates by particle type. These estimates do not include benefits from reducing HAP emissions, VOC emissions and ozone exposure, nor energy disbenefits associated with the increased emissions from additional energy usage. These confidence intervals only reflect the standard errors within the epidemiology studies, but they do not reflect other sources of uncertainty inherent within the boiler-specific BPT estimates. These benefits reflect existing boilers and new boilers anticipated to come online by 2015.

Table 6: Summary of Monetized Benefits Estimates from PM2.5 for the Final Boiler MACT Reconsideration in 2015 (95th percentile confidence interval)*

	3%	7%
Based on Epidemiology Literature		
Pope et al.	$27,000 ($2,300 -- $83,000)	$25,000 ($2,000 -- $76,000)
Laden et al.	$67,000 ($6,000 -- $200,000)	$61,000 ($5,300 -- $180,000)
Based on Expert Elicitation		
Expert A	$71,000 ($4,200 -- $230,000)	$64,000 ($3,700 -- $210,000)
Expert B	$54,000 ($2,100 -- $220,000)	$49,000 ($1,800 -- $200,000)
Expert C	$54,000 ($3,200 -- $200,000)	$49,000 ($2,800 -- $190,000)
Expert D	$38,000 ($2,600 -- $120,000)	$35,000 ($2,200 -- $110,000)
Expert E	$88,000 ($7,700 -- $260,000)	$80,000 ($6,800 -- $240,000)
Expert F	$49,000 ($4,800 -- $140,000)	$45,000 ($4,300 -- $130,000)
Expert G	$32,000 ($310 -- $120,000)	$29,000 ($200 -- $110,000)
Expert H	$41,000 ($380 -- $160,000)	$37,000 ($260 -- $140,000)
Expert I	$54,000 ($3,100 -- $180,000)	$49,000 ($2,700 -- $160,000)
Expert J	$44,000 ($3,400 -- $170,000)	$40,000 ($2,900 -- $150,000)
Expert K	$10,000 ($310 -- $67,000)	$9,600 ($200 -- $61,000)
Expert L	$36,000 ($1,500 -- $140,000)	$33,000 ($1,200 -- $130,000)

*All estimates are for the analysis year (2015) and are rounded to whole numbers with two significant figures. These models assume that all fine particles, regardless of their chemical composition, are equally potent in causing premature mortality because the scientific evidence is not yet sufficient to allow differentiation of effect estimates by particle type. These estimates do not include benefits from reducing HAP emissions, nor energy disbenefits associated with the increased emissions from additional energy usage. These confidence intervals only reflect the standard errors within the epidemiology studies and valuation functions, but they do not reflect other sources of uncertainty inherent within the boiler-specific BPT estimates. These benefits reflect existing boilers and new boilers anticipated to come online by 2015.

Figure 1: Breakdown of Monetized Benefits by Fuel Subcategory

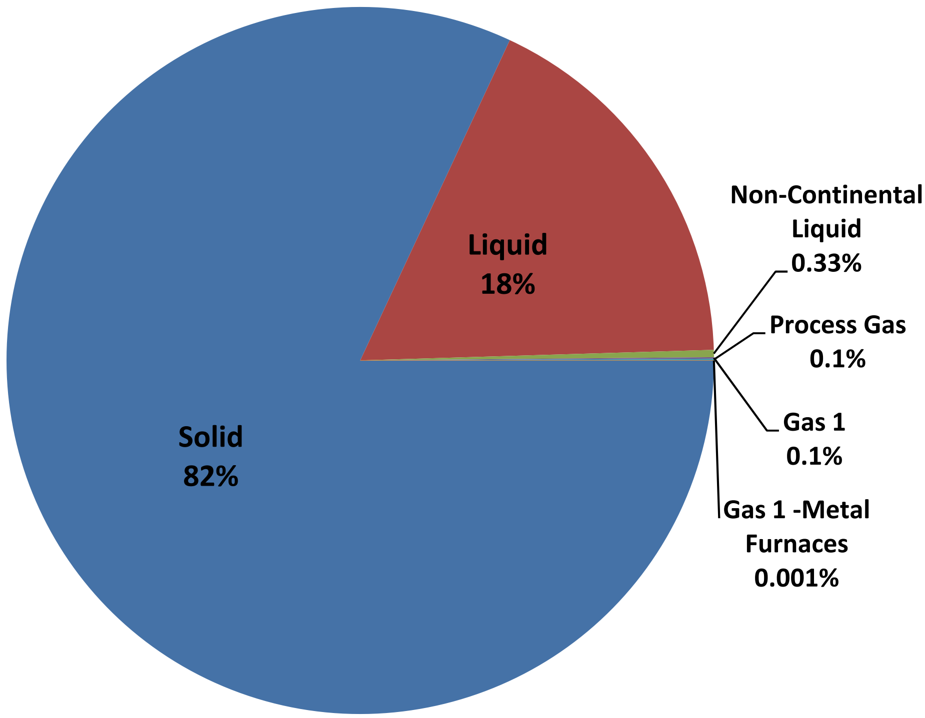
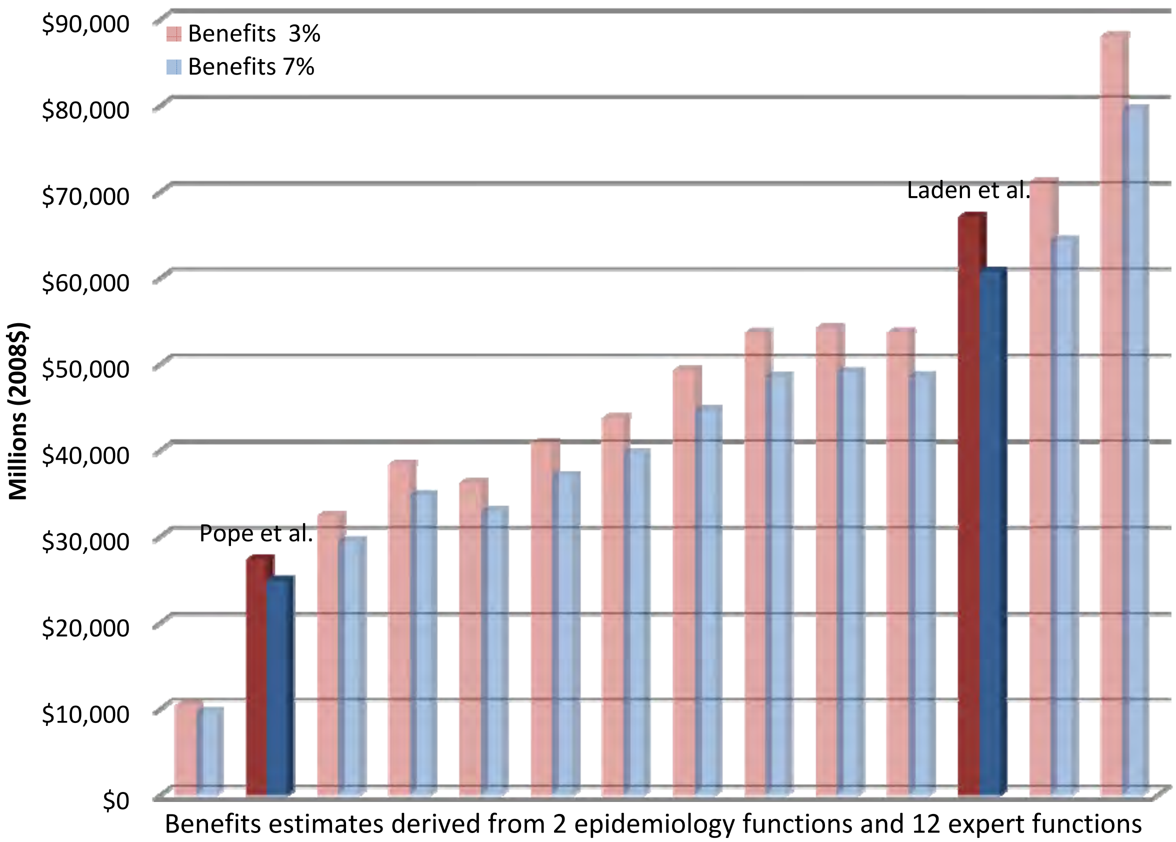


Figure 2: Total Monetized $PM_{2.5}$ Benefits Estimates for the Final Boiler MACT Reconsideration in 2015



Revised Net Benefits

Table 7 shows the estimated costs and benefits for the boiler MACT and the reconsideration proposal. The estimated net benefits are greater than the range for the RIA, which was $18.5 billion to $47.5 billion at a 7 percent discount rate and was $20.5 billion to $52.5 billion at 3 percent.

Table 7. Summary of Estimated Social Costs and Benefits*

Category	Low Estimate	High Estimate	Year Dollar	Discount Rate	Period Covered
Benefits					
Annualized Monetized ($millions/year)	$25,000	$61,000	2008	7%	2015
	$27,000	$67,000	2008	3%	2015
Costs					
Annualized Monetized ($millions/year)	$1,400	$1,600	2008	7%	2015
	$1,400	$1,600	2008	3%	2015
Net Benefits					
Annualized Monetized ($millions/year)	$23,000	$59,000	2008	7%	2015
	$26,000	$65,000	2008	3%	2015

*All estimates are for the analysis year (2015) and are rounded to two significant figures.

EXHIBIT 9

April 2010

Regulatory Impact Analysis: Standards of Performance for New Stationary Sources and Emission Guidelines for Existing Sources: Commercial and Industrial Solid Waste Incineration Units

Draft Report

Prepared for
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SECTION 1
INTRODUCTION

The U.S. Environmental Protection Agency (EPA) is proposing new standards of performance and emission guidelines based on a review of the standards and guidelines as part of the Clean Air Act Section 129(a)(5) requirement to review the new source performance standards and emission guidelines every 5 years. Additionally, when revising the standards of performance and emission guidelines we considered the District of Columbia Circuit Court rulings on maximum achievable control technology standards that were issued after promulgation of the new source performance standards and emission guidelines for commercial and industrial solid waste incineration units in 2000 and a concurrently proposed definition of nonhazardous secondary materials as solid waste under the Resource Conservation and Recovery Act. EPA also proposes other amendments that EPA believes are necessary to adequately address air emissions from commercial and industrial solid waste incineration units and to clarify certain portions of the rules. As part of the regulatory process, EPA is required to develop a regulatory impact analysis (RIA). The RIA includes an economic impact analysis (EIA) and a small entity impacts analysis and documents the RIA methods and results.

1.1 Executive Summary

The key results of the RIA are as follows:

- **Engineering Cost Analysis:** EPA estimates the proposed rule's total annualized costs will be $216 million (2008$). However, the estimates in this RIA reflect a previous annualized engineering cost estimate of $224 million (2008$), which results in a slight overestimate of the economic impacts.

- **Market Analysis:** Under the proposed rule, the Agency's economic model suggests the average national market-level variables (prices, production-levels, consumption, international trade) will not change significantly (e.g., are less than 0.1%).

- **Social Cost Analysis:** The estimated social cost is just under $224 million (2008$). In the near term, the Agency's economic model suggests that industries are able to pass approximately $62 million of the rule's costs to consumers (e.g., marginally higher market prices). Domestic industries' surplus falls by $166 million, while other countries on net benefit from higher prices (a net increase in rest-of-the world [ROW] surplus of $4 million). Additional costs and savings that are not included in the economic model represent a net benefit of less than $1 million.

- **Employment Changes:** Near-term employment changes associated with the proposed rule are estimated to be less than 500 job losses; over a longer time period, net employment effects range between 400 job losses to 800 job gains.

- **Small Entity Analyses:** EPA performed a screening analysis for impacts on small entities by comparing compliance costs to sales/revenues (e.g., sales and revenue tests). EPA's analysis found the tests were below 1% for small entities included in the screening analysis.

- **Benefits Analysis:** In the year of full implementation (2015), EPA estimates the monetized $PM_{2.5}$ benefits of the proposed NSPS and Emission Guidelines are $240 million to $580 million and $210 million to $520 million, at 3% and 7% discount rates respectively. All estimates are in 2008$ for the year 2015. Using alternate relationships between $PM_{2.5}$ and premature mortality supplied by experts, higher and lower benefits estimates are plausible, but most of the expert-based estimates fall between these estimates. The benefits from reducing other air pollutants have not been monetized in this analysis, including reducing 24,000 tons of carbon monoxide, 560 tons of HCl, 6.0 tons of lead, 5.4 tons of cadmium, 280 pounds of mercury, and 230 grams of total dioxins/furans each year. In addition, ecosystem benefits and visibility benefits have not been monetized in this analysis

- **Net Benefits:** The net benefits for the NSPS and Emission Guidelines are $19 million to $360 million and $-2.4 million to $310 million, at 3% and 7% discount rates respectively (Table 1-1). All estimates are in 2008$ for the year 2015.

1.2 Organization of this Report

The remainder of this report supports and details the methodology and the results of the EIA:

- Section 2 presents the affected industry profiles.
- Section 3 describes the engineering cost analysis.
- Section 4 describes the economic impact analysis.
- Section 5 describes the small entity analyses.
- Section 6 presents the benefits estimates.
- Section 7 presents supplemental economic analyses for the alternate approach
- Appendix A describes the multimarket model used in the economic analysis.

Table 1-1. Summary of the Monetized Benefits, Social Costs, and Net Benefits for the CISWI NSPS and Emissions Guidelines in 2015 (millions of 2008$)[1]

	3% Discount Rate	7% Discount Rate
Proposed Option		
Total Monetized Benefits[2]	$240 to $580	$210 to $520
Total Social Costs[3]	$220	$220
Net Benefits	$19 to $360	$-2.4 to $310
Proposed Option with Alternate Approach		
	3% Discount Rate	7% Discount Rate
Total Monetized Benefits[4]	$2,700 to $6,700	$2,500 to $6,000
Total Social Costs[3]	$480	$480
Net Benefits	$2,300 to $6,200	$2,000 to $5,600

[1] All estimates are for the implementation year (2015), and are rounded to two significant figures.

[2] The total monetized benefits reflect the human health benefits associated with reducing exposure to $PM_{2.5}$ through reductions of 660 tons of directly emitted $PM_{2.5}$ and $PM_{2.5}$ precursors such as 1,400 tons of NO_x and 2,700 tons of SO_2. The benefits from reducing 24,000 tons of carbon monoxide, 560 tons of hydrochloric acid, 5.4 tons of cadmium, 6.0 tons of lead, and 280 pounds of mercury, and 230 grams of total dioxins/furans each year are not included in these estimates. In addition, the benefits from reducing ecosystem effects and visibility impairment are not included.

[3] The methodology used to estimate social costs for one year in the multimarket model using surplus changes results in the same social costs for both discount rates.

[4] The total monetized benefits reflect the human health benefits associated with reducing exposure to $PM_{2.5}$ through reductions of 12,000 tons of directly emitted $PM_{2.5}$ and $PM_{2.5}$ precursors such as 520 tons of NO_x and 205 tons of SO_2. The benefits from reducing 128,000 tons of carbon monoxide, 430 tons of hydrochloric acid, 4.3 tons of cadmium, 3.4 tons of lead, 1.2 tons of mercury, and 85 grams of total dioxins/furans each year are not included in these estimates. In addition, the benefits from reducing ecosystem effects and visibility impairment are not included.

SECTION 4
ECONOMIC IMPACT ANALYSIS

EPA prepares an EIA to provide decision makers with a measure of the social costs of using resources to comply with a program (EPA, 2000). The social costs can then be compared with estimated social benefits (as presented in Section 6). As noted in EPA's (2000) *Guidelines for Preparing Economic Analyses*, several tools are available to estimate social costs and range from simple direct compliance cost methods to the development of a more complex market analysis that estimates market changes (e.g., price and consumption) and economic welfare changes (e.g., changes in consumer and producer surplus).

The Office of Air Quality Planning and Standards (OAQPS) adopted a standard market analysis as described in the Office's resource manual (EPA, 1999). The approach uses a single-period multimarket partial equilibrium model to compare pre-policy market baselines with expected post-policy market outcomes. The analysis' time horizon is the intermediate run; some production factors are fixed and some are variable and is distinguished from the very short run where all factors are fixed and producers cannot adjust inputs or outputs (EPA, 1999, 5-6). The intermediate time horizon allows us to capture important transitory stakeholder outcomes. Key measures in this analysis include industry-level changes in price levels, production and consumption, jobs, international trade, and social costs (changes in producer and consumer surplus).

4.1 Partial Equilibrium Analysis (Multiple Markets)

The partial equilibrium analysis develops a market model that simulates how stakeholders (consumers and industries) might respond to the additional regulatory program costs. In this section, we provide an overview of the economic model. Appendix A provides additional details on the behavioral assumptions, data, parameters, and model equations.

4.1.1 Overview

Although several tools are available to estimate social costs, current EPA guidelines suggest that multimarket models "…are best used when potential economic impacts and equity effects on related markets might be considerable" and modeling using a computable general equilibrium model is not available or practical (EPA, 2000, p. 146). Other guides for environmental economists offer similar advice (Berck and Hoffmann, 2002; Just, Hueth, and Schmitz, 2004). Multimarket models focus on "short-run" time horizons and measure a policy's near-term or transition costs (EPA, 1999). Recent studies suggest short-run analyses can complement full dynamic general equilibrium analysis. For example, Morgenstern and colleagues examine carbon price policies with short- and long-term time horizons (Morgenstern and colleagues, 2004; Ho, Morgenstern, and Shih, 2008). Aldy and Pizer (2009) assess near-term competitiveness effects of a domestic cap-and-trade program to address stakeholder concerns about shifts in economic activity and jobs to other countries. The multimarket model contains the following features:

- Industry sectors and benchmark data set
  - 100 industry sectors
  - a single benchmark year (2010)[1]
  - estimates of industry employment
- Economic behavior
  - industries respond to regulatory costs by changing production rates
  - market prices rise to reflect higher energy and other non-energy material costs
  - customers respond to these price increases and consumption falls
- Model scope
  - 100 sectors are linked with each other based on their use of energy and other non-energy materials. For example, the construction industry is linked with the petroleum, cement, and steel industries and is influenced by price changes that occur in each sector. The links allow EPA to account for indirect effects the regulation has on related markets.
  - production adjustments influence employment levels
  - international trade (imports/exports) behavior considered
- Model time horizon ("short run")
  - fixed production resources (e.g., capital) lead to an upward-sloping industry supply function
  - firms cannot alter input mixes; there is no substitution among production inputs (capital, labor, energy intermediates, and other intermediate goods and services)
  - price of labor (i.e., wage) is fixed
  - investment and government expenditures are fixed

[1] For this analysis, we use the model to approximate baseline conditions for 2015.

4.1.2 Economic Impact Analysis Results

4.1.2.1 Market-Level Results

Market-level impacts include price and quantity adjustments including the changes in international trade (Table 4-1). The Agency's economic model suggests the average national market-level variables (prices, production-levels, consumption, international trade) will not significantly change (e.g., are less than 0.1%).

Table 4-1. Market-Level Price and Quantity Changes: 2015 (Selected Approach)

Industry Sector	Prices	Production	Imports	Consumption	Exports
Energy	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%
Nonmanufacturing	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%
Manufacturing					
Food, beverages, and textiles	Less than 0.01%	Less than 0.01%	less than 0.01%	Less than 0.01%	Less than 0.01%
Lumber, paper, and printing	0.02%	Less than 0.01%	0.02%	Less than 0.01%	−0.02%
Chemicals	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%
Plastics and Rubber	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%
Nonmetallic Minerals	0.03%	Less than 0.01%	0.01%	Less than 0.01%	−0.03%
Primary Metals	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%
Fabricated Metals	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%
Machinery and Equipment	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%
Electronic Equipment	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%
Transportation Equipment	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%	less than 0.01%
Other	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%
Wholesale and Retail Trade	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%
Transportation Services	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%
Other Services	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%

4.1.2.2 Social Cost Estimates

In the near term, the Agency's economic model suggests that industries are able to pass on $62 million (2008$) the costs to U.S. households in the form of higher prices (Table 4-2). Existing U.S. industries' surplus falls by $166 million, and the net loss for U.S. stakeholders is $228 million. As U.S. prices rise, other countries are affected through international trade relationships. Households that buy goods from the United States experience losses, while industries that sell goods to the United States benefit; the model estimates a net gain of $4 million. After accounting for international trade effects, the Agency's economic model projects the net surplus loss associated with the proposed rule is $224 million. As shown in Figure 4-1, the surplus losses are concentrated in lumber, paper, and printing (27.1%) and other services (21.1%). The Agency also considered other elements of the engineering cost analysis that could not be modeled within the multimarket model (e.g., fuel savings benefits and total annualized compliance costs [unknown sources]). The net effect of the adjustments is less than $1 million.

Table 4-2. Distribution of Social Costs (million, 2008$): 2015

Method	Selected Approach
Partial Equilibrium Model (Multiple Markets)	
Change in U.S. consumer surplus	−$62
Change in U.S. producer surplus	−$166
Change in U.S. surplus	−$228
Net change in rest of world surplus	$4
Net change in total surplus	−$224
Direct Compliance Costs Method	
Total annualized costs, unknown sources (not modeled)	Less than $1 million
Fuel savings (not modeled)	$1
Change in Total Surplus	−$224

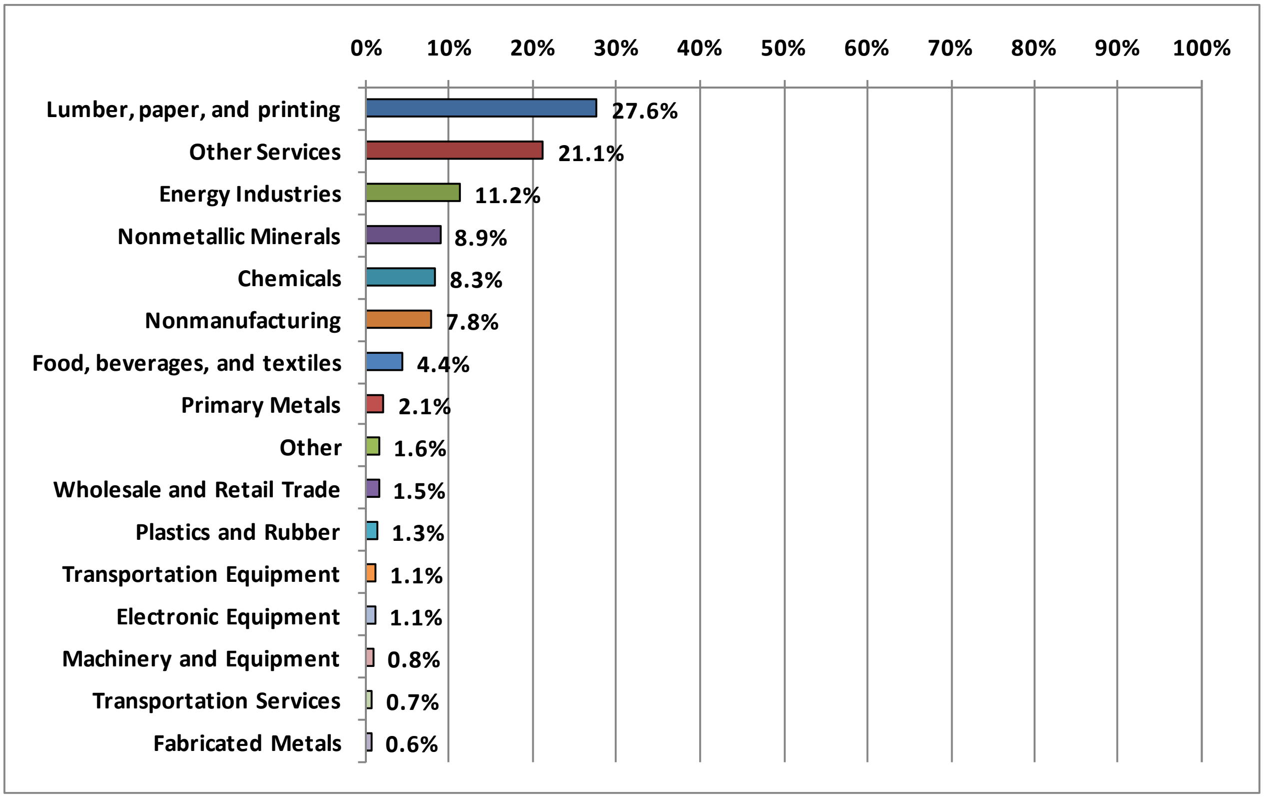

Figure 4-1. Distribution of Total Surplus Changes by Industry (Total Surplus Change = $224 million, 2008$)

4.1.2.3 Job Effects

Precise job effect estimates cannot be estimated with certainty. Morgenstern et al. (2002) identify three economic mechanisms by which pollution abatement activities can indirectly influence jobs:

- higher production costs raise market prices, higher prices reduce consumption, and employment within an industry falls ("demand effect");
- pollution abatement activities require additional labor services to produce the same level of output ("cost effect"); and
- post-regulation production technologies may be more or less labor intensive (i.e., more/less labor is required per dollar of output) ("factor-shift effect").

Several empirical studies, including Morgenstern et al. (2002), suggest the net employment decline is zero or economically small (e.g., Cole and Elliot, 2007; Berman and Bui, 2001). However, others show the question has not been resolved in the literature (Henderson, 1996; Greenstone, 2002). Morgenstern et al. use a six-year panel (U.S. Census data for plant-level prices, inputs (including labor), outputs, and environmental expenditures) to econometrically estimate the production technologies and industry-level demand elasticities. Their identification strategy leverages repeat plant-level observations over time and uses plant-level and year fixed effects (e.g., plant and time dummy variables). After estimating their model, Morgenstern show and compute the change in employment associated with an additional $1 million ($1987) in environmental spending. Their estimates covers four manufacturing industries (pulp and paper, plastics, petroleum, and steel) and Morgenstern, et al present results separately for the cost, factor shift, and demand effects, as well as the net effect. They also estimate and report an industry-wide average parameter that combines the four industry-wide estimates and weighting them by each industry's share of environmental expenditures.

EPA has most often estimated employment changes associated with plant closures due to environmental regulation or changes in output for the regulated industry (EPA, 1999; EPA, 2000). This analysis goes beyond what EPA has typically done in two ways. First, because the multimarket model provides estimates for changes in output for sectors not directly regulated, we were able to estimate a more comprehensive "demand effect." Secondly, parameters estimated in the Morgenstern paper were used to estimate all three effects ("demand," "cost," and "factor shift"). This transfer of results from the Morgenstern study is uncertain (add caveats) but avoids ignoring the "cost effect" and the "factor-shift effect."

We calculated "demand effect" employment changes by assuming that the number of jobs declines proportionally with multi-market model's simulated output changes. These results were calculated for all sectors in the EPA model that show a change in output.

We also calculated a similar "demand effect" estimate that used the Morgenstern paper. EPA selected this paper because the parameter estimates (expressed in jobs per million ($1987) of environmental compliance expenditures) provide a transparent and tractable way to transfer estimates for an employment effects analysis. Similar estimates were not available from other studies. To do this, we multiplied the point estimate for the total demand effect (−3.56 jobs per million ($1987) of environmental compliance expenditure) by the total environmental compliance expenditures used in the partial equilibrium model. For example, the jobs effect estimate for the Major Source Rule is estimated to be 500 jobs (−3.56× $224 million × 0.60).[1] Demand effect results are provided in Figure 4-2.

[1] Since Morgenstern's analysis reports environmental expenditures in $1987, we make an inflation adjustment the engineering cost analysis using GDP implicit price deflator (64.76/108.48) = 0.60)

We also present the results of using the Morgenstern paper to estimate U.S. employment "cost" and "factor-shift" effects. Although using the Morgenstern parameters to estimate these "cost" and "factor-shift" employment changes is uncertain, it is helpful to compare the potential job gains from these effects to the job losses associated with the "demand" effect. Figure 4-2 shows that using the Morgenstern point estimates of parameters to estimate the "cost" and "factor shift" employment gains may be greater than the employment losses using either of the two ways of estimating "demand" employment losses. The 95% confidence intervals are shown for all of the estimates based on the Morgenstern parameters. As shown, at the 95% confidence level, we cannot be certain if net employment changes are positive or negative.

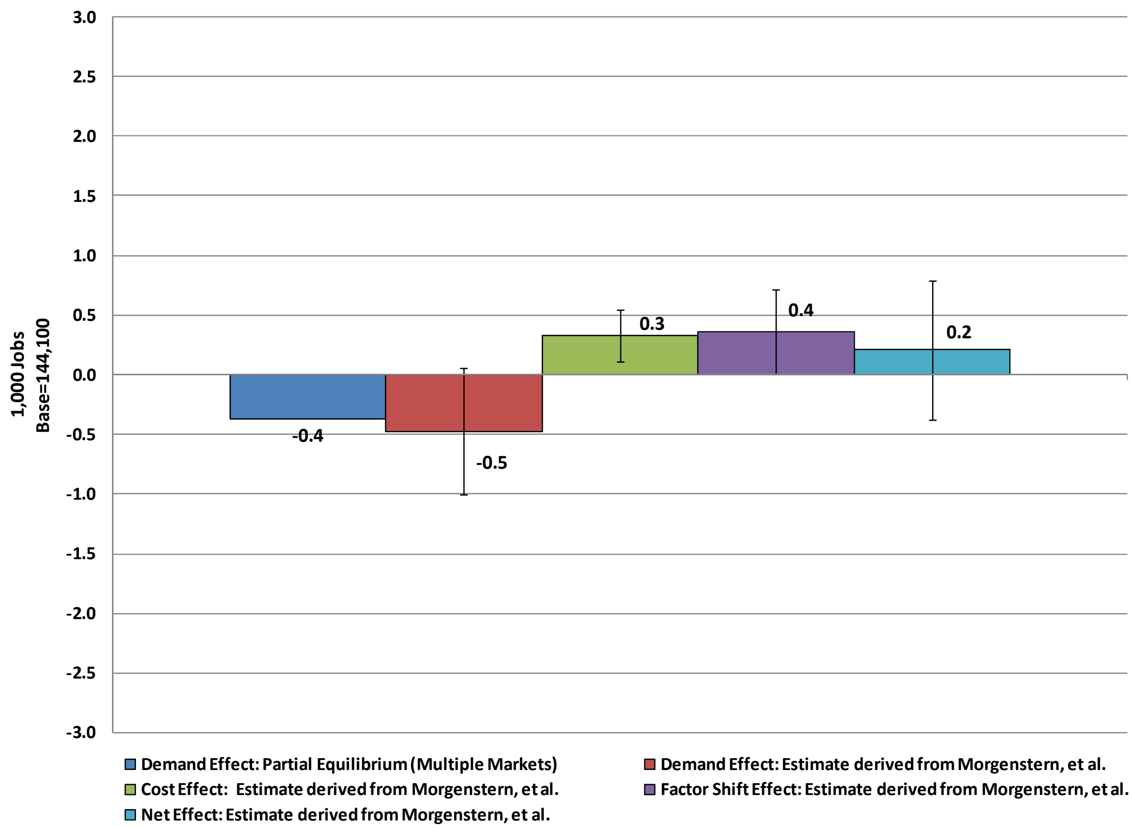

Figure 4-2. Job Losses/Gains Associated with the Proposed Rule: 2015

Although the Morgenstern paper provides additional information about the potential job effects of environmental protection programs, there are several qualifications EPA considered as part of the analysis. First, EPA has used the weighted average parameter estimates for a narrow set of manufacturing industries (pulp and paper, plastics, petroleum, and steel). Absent other data and estimates, this approach seems reasonable and the estimates come from a respected peer-reviewed source. However, EPA acknowledges the proposed rule covers a broader set of industries not considered in original empirical study. By transferring the estimates to other industrial sectors, we make the assumption that estimates are similar in size. In addition, EPA assumes also that Morgenstern et al.'s estimates derived from the 1979–1991 still applicable for policy taking place in 2013, almost 20 years later. Second, the multi-market model only considers near term employment effects in a U.S. economy where production technologies are fixed. As a result, the modeling system places more emphasis on the short term "demand effect" whereas the Morgenstern paper emphasizes other important long term responses. For example, positive job gains associated with "factor shift effects" are more plausible when production choices become more flexible over time and industries can substitute labor for other production inputs. Third, the Morgenstern paper estimates rely on sector demand elasticities that are different from the demand elasticity parameters used in the multi-market model. As a result, the demand effects are not directly comparable with the demand effects estimated by the multi-market model. Fourth, Morgenstern identifies the industry average as economically and statistically insignificant effect (i.e., the point estimates are small, measured imprecisely, and not distinguishable from zero.) EPA acknowledges this fact and has reported the 95 percent confidence intervals in Figure 4-2. Fifth, Morgenstern's methodology assumes large plants bear most of the regulatory costs. By transferring the estimates, EPA assumes a similar distribution of regulatory costs by plant size and that the regulatory burden does not disproportionately fall on smaller plants.

EXHIBIT 10

February 2011

Regulatory Impact Analysis: Standards of Performance for New Stationary Sources and Emission Guidelines for Existing Sources: Commercial and Industrial Solid Waste Incineration Units

U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards (OAQPS)
Air Economics Group
Risk and Benefits Group
(MD-C439-02)
Research Triangle Park, NC 27711

SECTION 1
INTRODUCTION

The U.S. Environmental Protection Agency (EPA) is promulgating new standards of performance and emission guidelines based on a review of the standards and guidelines as part of the Clean Air Act Section 129(a)(5) requirement to review the new source performance standards and emission guidelines every 5 years. Additionally, when revising the standards of performance and emission guidelines we considered the District of Columbia Circuit Court rulings on maximum achievable control technology standards that were issued after promulgation of the new source performance standards and emission guidelines for commercial and industrial solid waste incineration units in 2000 and a concurrently promulgated definition of nonhazardous secondary materials as solid waste under the Resource Conservation and Recovery Act. EPA is also promulgating other amendments that EPA believes are necessary to adequately address air emissions from commercial and industrial solid waste incineration units and to clarify certain portions of the rules. As part of the regulatory process, EPA is required to develop a regulatory impact analysis (RIA). The RIA includes an economic impact analysis (EIA) and a small entity impacts analysis and documents the RIA methods and results.

The RIA does not include the final engineering costs and emission reductions into this RIA (see Chapter 2 for more detail on the engineering costs that were not accounted for). We estimate that incorporating these final estimates would decrease the engineering costs by approximately 22% and increase the monetized benefits by approximately 4% from those shown in this RIA.

1.1 Executive Summary

The key results of the RIA are as follows:

- **Engineering Cost Analysis:** EPA estimates the promulgated rule's total annualized costs will be $280 million (2008$).
- **Market Analysis:** Under the promulgated rule, the Agency's economic model suggests the average national market-level variables (prices, production-levels, consumption, international trade) will not change significantly (e.g., are less than 0.1%).
- **Social Cost Analysis:** The estimated social cost is approximately $280 million (2008$). In the near term, the Agency's economic model suggests that industries are able to pass approximately $76 million of the rule's costs to consumers (e.g., marginally higher market prices). Domestic industries' surplus falls by $207 million, while other countries on net benefit from higher prices (a net increase in rest-of-the

world [ROW] surplus of $3 million). Additional new source costs not included in the economic model represent a net cost of less than $1 million.

- **Employment Changes:** The estimated employment changes range between −500 to 1,000 employees, with a central estimate of +300 employees.

- **Small Entity Analyses:** EPA performed a screening analysis for **i**mpacts on small entities by comparing compliance costs to sales/revenues (e.g., sales and revenue tests). EPA's analysis found the tests exceeded 3% for four of nine small entities included in the screening analysis. After reviewing screening analysis results, EPA has determined the promulgated rule will not have a SISNOSE and presumes that rule is eligible for certification under the RFA as amended by SBREFA. We provide the factual basis for certification in Section 4.

- **Benefits Analysis:** The benefits from reducing some air pollutants have not been monetized in this analysis, including reducing a 25,000 tons of carbon monoxide, 470 tons of HCl, 4.1 tons of lead, 0.95 tons of cadmium, 260 pounds of mercury, and 92 grams of total dioxins/furans each year. We assess the benefits of these emission reductions qualitatively in this analysis. Thus, all monetized benefits reported reflect improvements in ambient $PM_{2.5}$ concentrations. As such, although the monetized benefits likely underestimate the total benefits, the extent of the underestimate is unclear. In the year of full implementation (2016), EPA estimates the monetized $PM_{2.5}$ benefits of the promulgated NSPS and Emission Guidelines are $340 million to $830 million and $310 million to $750 million, at 3% and 7% discount rates respectively. All estimates are in 2008$. Using alternate relationships between $PM_{2.5}$ and premature mortality supplied by experts, higher and lower benefits estimates are plausible, but most of the expert-based estimates fall between these estimates. In addition, ecosystem benefits and visibility benefits have not been monetized in this analysis.

- **Net Benefits:** The net benefits for the NSPS and Emission Guidelines are $60 million to $550 million and $30 million to $470 million, at 3% and 7% discount rates respectively (Table 1-1). All estimates are in 2008$ for the year 2016. These results are shown in Tables 1-1

1.2 Organization of this Report

The remainder of this report supports and details the methodology and the results of the EIA:

- Section 2 describes the engineering cost analysis.
- Section 3 describes the economic impact analysis.
- Section 4 describes the small entity analyses.
- Section 5 presents the benefits estimates.
- Section 6 presents the net benefits.

- Appendix A describes the multimarket model used in the economic analysis.
- Appendix B describes the affected Industry profiles.

Table 1-1. Summary of the Monetized Benefits, Social Costs, and Net Benefits for the CISWI NSPS and Emissions Guidelines in 2016 (millions of 2008$)[a]

	3% Discount Rate			7% Discount Rate		
Option 1: MACT Floor						
Total Monetized Benefits[b]	$340	to	$830	$310	To	$750
Total Social Costs[c]		$280			$280	
Net Benefits	$60	to	$550	$30	To	$470
Non-monetized Benefits	25,000 tons of carbon monoxide					
	470 tons of HCl					
	260 pounds of mercury					
	0.95 tons of cadmium					
	4.1 tons of lead					
	92 grams of dioxins/furans					
	Health effects from NO_2 and SO_2 exposure					
	Ecosystem effects					
	Visibility impairment					
Option 2: Beyond the Floor						
Total Monetized Benefits[b]	$430	to	$1,100	$390	To	$960
Total Social Costs[c]		$300			$300	
Net Benefits	$130	to	$770	$90	To	$660
Non-monetized Benefits	25,000 tons of carbon monoxide					
	470 tons of HCl					
	260 pounds of mercury					
	0.95 tons of cadmium					
	4.1 tons of lead					
	92 grams of dioxins/furans					
	Health effects from NO_2 and SO_2 exposure					
	Ecosystem effects					
	Visibility impairment					

[a] All estimates are for the implementation year (2016), and are rounded to two significant figures. These results include units anticipated to come online and the lowest cost disposal assumption.

[b] The total monetized benefits reflect the human health benefits associated with reducing exposure to $PM_{2.5}$ through reductions of directly emitted $PM_{2.5}$ and $PM_{2.5}$ precursors such as NO_x and SO_2. It is important to note that the monetized benefits include many but not all health effects associated with $PM_{2.5}$ exposure. Benefits are shown as a range from Pope et al. (2002) to Laden et al. (2006). These models assume that all fine particles, regardless of their chemical composition, are equally potent in causing premature mortality because the scientific evidence is not yet sufficient to allow differentiation of effect estimates by particle type. These estimates include energy disbenefits valued at $3.8 million.

[c] The methodology used to estimate social costs for one year in the multimarket model using surplus changes results in the same social costs for both discount rates.

SECTION 3
ECONOMIC IMPACT ANALYSIS

EPA prepares an EIA to provide a measure of the social costs of using resources to comply with a program (U.S. EPA, 2000). The social costs can then be compared with estimated social benefits (as presented in Section 5). As noted in EPA's (2000) *Guidelines for Preparing Economic Analyses*, several tools are available to estimate social costs and range from simple direct compliance cost methods to the development of a more complex market analysis that estimates market changes (e.g., price and consumption) and economic welfare changes (e.g., changes in consumer and producer surplus).

The Office of Air Quality Planning and Standards (OAQPS) adopted a standard market analysis as described in the Office's resource manual (U.S. EPA, 1999). The approach uses a single-period multimarket partial equilibrium model to compare pre-policy market baselines with expected post-policy market outcomes. The analysis' time horizon is the short run; for this analysis, we use the model to approximate baseline conditions for 2016. In this analysis, some production factors are fixed and some are variable and is distinguished from the very short run where all factors are fixed and producers cannot adjust inputs or outputs (U.S. EPA, 1999, 5-6). The intermediate time horizon allows us to capture important transitory stakeholder outcomes. Key measures in this analysis include industry-level changes in price levels, production and consumption, jobs, international trade, and social costs (changes in producer and consumer surplus).

3.1 Partial Equilibrium Analysis (Multiple Markets)

The partial equilibrium analysis develops a market model that simulates how stakeholders (consumers and industries) might respond to the additional regulatory program costs. In this section, we provide an overview of the economic model used in the analysis.

3.1.1 Overview

Although several tools are available to estimate social costs, current EPA guidelines suggest that multimarket models "…are best used when potential economic impacts and equity effects on related markets might be considerable" and modeling using a computable general equilibrium model is not available or practical (U.S. EPA, 2000, p. 146). Other guides for environmental economists offer similar advice (Berck and Hoffmann, 2002; Just, Hueth, and Schmitz, 2004). Multimarket models focus on "short-run" time horizons and measure a policy's near-term or transition costs (U.S. EPA, 1999). Recent studies suggest short-run analyses can complement full dynamic general equilibrium analysis. For example, Morgenstern and colleagues examine carbon price policies with short- and long-term time horizons (Morgenstern and colleagues, 2004; Ho, Morgenstern, and Shih, 2008). Aldy and Pizer (2009) assess near-term competitiveness effects of a domestic cap-and-trade program to address stakeholder concerns about shifts in economic activity and jobs to other countries. A single-period multimarket partial equilibrium model contains the following features:

- Industry sectors and benchmark data set
  - All industries aggregated to 100 industry sectors
  - a single benchmark year (2010)[1]
  - estimates of industry employment
- Economic behavior
  - industries respond to regulatory costs by changing production rates
  - market prices rise to reflect higher energy and other non-energy material costs
  - customers respond to these price increases and consumption falls
- Model scope
  - 100 sectors are linked with each other based on their use of energy and other non-energy materials. For example, the construction industry is linked with the petroleum, cement, and steel industries and is influenced by price changes that occur in each sector. The links allow EPA to account for indirect effects the regulation has on related markets.
  - production adjustments influence employment levels
  - international trade (imports/exports) behavior considered
- Model time horizon ("short run")
  - fixed production resources (e.g., capital) lead to an upward-sloping industry supply function
  - firms cannot alter input mixes; there is no substitution among intermediate production inputs
  - price of labor (i.e., wage) is fixed
  - investment and government expenditures are fixed
  - Appendix A provides additional details on the behavioral assumptions, data, parameters, and model equations.

[1] For this analysis, we use the model to approximate baseline conditions for 2016.

3.1.2 Economic Impact Analysis Results

3.1.2.1 Market-Level Results

Market-level impacts include price and quantity adjustments including the changes in international trade (Table 3-1). The Agency's economic model suggests the average national market-level variables (prices, production-levels, consumption, international trade) will not significantly change (e.g., are less than 0.1%). Similar results are present for the Beyond the MACT floor option and are presented in Table 3-2.

Table 3-1. Market-Level Price and Quantity Changes: 2016 (MACT Floor)

Industry Sector	Prices	Production	Imports	Consumption	Exports
Energy	0.00243%	−0.00086%	0.00508%	−0.00064%	−0.00040%
Nonmanufacturing	0.00239%	−0.00056%	0.00151%	−0.00041%	−0.00184%
Manufacturing					
Food, beverages, and textiles	0.00068%	−0.00093%	0.00114%	−0.00051%	−0.00042%
Lumber, paper, and printing	0.03014%	−0.01259%	0.03070%	−0.00727%	−0.02103%
Chemicals	0.00010%	−0.00136%	0.00014%	−0.00105%	−0.00010%
Plastics and Rubber	0.00046%	−0.00110%	0.00049%	−0.00088%	−0.00045%
Nonmetallic Minerals	0.04871%	−0.01153%	0.01782%	−0.00720%	−0.04026%
Primary Metals	0.00059%	−0.00099%	0.00057%	−0.00058%	−0.00056%
Fabricated Metals	−0.00015%	−0.00041%	−0.00015%	−0.00035%	0.00008%
Machinery and Equipment	−0.00007%	−0.00028%	−0.00006%	−0.00019%	0.00012%
Electronic Equipment	−0.00004%	−0.00043%	−0.00001%	−0.00020%	0.00010%
Transportation Equipment	0.00002%	−0.00019%	0.00004%	−0.00011%	−0.00004%
Other	0.00058%	−0.00130%	0.00098%	−0.00044%	−0.00054%
Wholesale and Retail Trade	−0.00027%	−0.00018%	−0.00018%	−0.00018%	0.00020%
Transportation Services	−0.00052%	−0.00045%	−0.00026%	−0.00031%	0.00043%
Other Services	0.00001%	−0.00018%	−0.00006%	−0.00018%	−0.00002%

Table 3-2. Market-Level Price and Quantity Changes: 2016 (Beyond the MACT Floor)

Industry Sector	Prices	Production	Imports	Consumption	Exports
Energy	0.00254%	−0.00090%	0.00531%	−0.00068%	−0.00042%
Nonmanufacturing	0.00243%	−0.00058%	0.00153%	−0.00043%	−0.00187%
Manufacturing					
Food, beverages, and textiles	0.00071%	−0.00096%	0.00118%	−0.00053%	−0.00044%
Lumber, paper, and printing	0.03158%	−0.01319%	0.03217%	−0.00761%	−0.02204%
Chemicals	0.00022%	−0.00156%	0.00027%	−0.00118%	−0.00021%
Plastics and Rubber	0.00064%	−0.00124%	0.00069%	−0.00097%	−0.00063%
Nonmetallic Minerals	0.04872%	−0.01157%	0.01783%	−0.00723%	−0.04027%
Primary Metals	0.00093%	−0.00128%	0.00089%	−0.00071%	−0.00088%
Fabricated Metals	−0.00010%	−0.00045%	−0.00008%	−0.00038%	0.00005%
Machinery and Equipment	−0.00006%	−0.00031%	−0.00004%	−0.00021%	0.00009%
Electronic Equipment	−0.00004%	−0.00046%	−0.00001%	−0.00022%	0.00010%
Transportation Equipment	0.00003%	−0.00020%	0.00006%	−0.00012%	−0.00006%
Other	0.00063%	−0.00140%	0.00107%	−0.00047%	−0.00059%
Wholesale and Retail Trade	−0.00029%	−0.00019%	−0.00020%	−0.00019%	0.00022%
Transportation Services	−0.00055%	−0.00047%	−0.00028%	−0.00033%	0.00046%
Other Services	0.00001%	−0.00018%	−0.00006%	−0.00018%	−0.00002%

3.1.2.2 Social Cost Estimates

In the short run, 2016, industries are able to pass on $76 million (2008$) the costs to U.S. households in the form of higher prices (Table 3-3). In 2016, existing U.S. industries' surplus falls by $207 million, and the net loss for U.S. stakeholders is $283 million. As U.S. prices rise, other countries are affected through international trade relationships. Households that buy goods from the United States experience losses, while industries that sell goods to the United States benefit; the model estimates a net gain of $3 million. After accounting for international trade effects, the Agency's economic model projects the net total surplus loss associated with the rule is $280 million. Similar results are present for the Beyond the MACT floor option (Table 3-4).

As shown in Figure 3-1, the surplus losses are concentrated in lumber, paper, and printing (29.0%) and other services (21.8%). The Agency also considered other elements of the engineering cost analysis that could not be modeled within the multimarket model (e.g., total annualized cost for new sources). The net effect of the adjustments is approximately $1 million.

Table 3-3. Distribution of Social Costs (million, 2008$): 2016

Method	MACT Floor
Partial Equilibrium Model (Multiple Markets)	
Change in U.S. consumer surplus	−$76
Change in U.S. producer surplus	−$207
Change in U.S. surplus	−$283
Direct Compliance Costs Method	
Total annualized costs, new sources (not modeled)	$1
Change in U.S. Surplus	−$284
Net change in rest of world surplus	$3
Net change in total surplus	−$281

Table 3-4. Distribution of Social Costs (million, 2008$): 2016

Method	Beyond the MACT Floor
Partial Equilibrium Model (Multiple Markets)	
Change in U.S. consumer surplus	−$78
Change in U.S. producer surplus	−$220
Change in U.S. surplus	−$298
Direct Compliance Costs Method	
Total annualized costs, new sources (not modeled)	$1
Total annualized cost savings, unknown sources (not modeled)	Less than $1 million
Change in Total Surplus	−$299
Net change in rest of world surplus	$4
Net change in total surplus	−$295

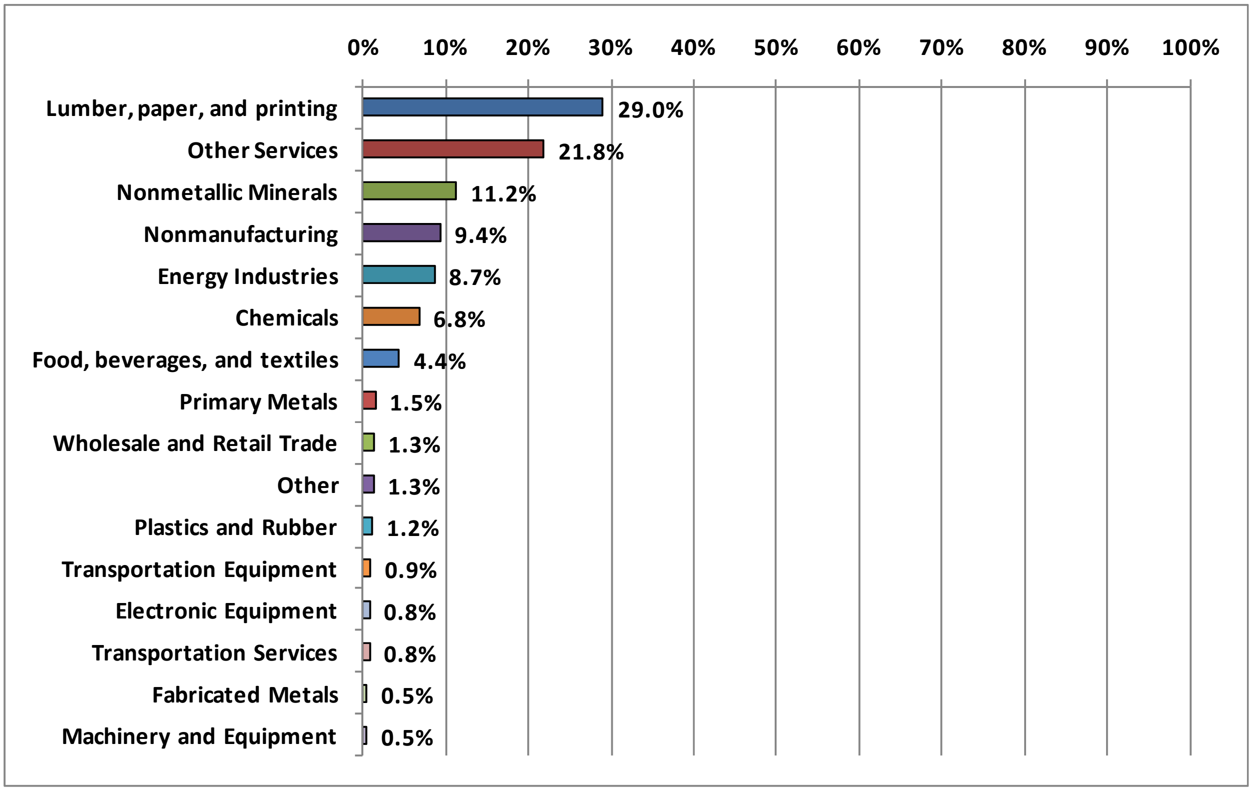

Figure 3-1. Distribution of Total Surplus Changes by Industry (Total Surplus Change = $224 million, 2008$) (MACT Floor)

3.1.2.3 Job Effects

In addition to estimating this rule's social costs and benefits, EPA has estimated the employment impacts of the final rule based on Morgenstern, Pizer and Shih (2002). A stand-alone analysis of jobs is not included in a standard cost-benefit analysis. Executive Order 13563, however, states, "Our regulatory system must protect public health, welfare, safety, and our environment while promoting economic growth, innovation, competitiveness, and job creation" (emphasis added). Therefore, we have provided this analysis to inform the discussion of job impacts. EPA continues to explore the relevant theoretical and empirical literature and to seek public comments in order to ensure that such estimates are as accurate as possible.

From an economic perspective labor is an input into producing goods and services; if regulation requires that more labor be used to produce a given amount of output, that additional labor is reflected in an increase in the cost of production. Moreover, when the economy is near full employment, jobs created in one industry as a result of regulation displace jobs in other industries. On the other hand, in periods of high unemployment, an increase in labor demand due to regulation may have a stimulative effect that results in a net increase in overall employment.

With significant numbers of workers unemployed, the opportunity costs associated with displacing jobs in other sectors are likely to be much smaller.

For this reason, this RIA looks carefully at a subset of the employment consequences of this final rule. It is important to note that EPA has estimated only a portion of the employment effects -- namely, those associated with the direct impacts on employment in the regulated industry. A full analysis would include estimates of the direct impacts on other industries (e.g. suppliers of pollution control equipment) as well as the indirect and induced effects on employment throughout the economy as a whole in response to changes in output and factor prices.

We expect that the rule's direct impact on employment will be small. The Agency's analysis does not include all the direct effects of this regulation. For example, EPA is currently exploring ways to quantify the job impacts in the pollution control sector that result from these and future regulations. Furthermore, we have not quantified the rule's indirect or induced impacts. What follows is an overview of the various ways that environmental regulation can affect employment, followed by a discussion of the estimated impacts of this rule. An environmental regulation can affect the demand for labor in several ways:

- **Direct Effects**:
  - **Increased prices for industry output may reduce the demand for labor:** Environmental regulations increase production costs causing firms to increase prices; higher prices reduce consumption (and production), thus reducing demand for labor within the regulated industry. The extent of this effect will depend on the extent of the price increase and the elasticity of the demand curve.
  - **Regulated firms demand labor workers to operate and maintain pollution controls within those firms.** Once pollution control equipment is installed, regulated firms may hire workers to operate and maintain it, just as they would hire workers to produce more output. The extent of this effect will depend in part on whether the operation and maintenance of pollution controls are labor intensive
  - **Increased demand for pollution control equipment and services:** When a regulation requiring emission reductions is promulgated, affected sources must immediately place orders for pollution control equipment and services. Filling these orders will require a scale-up in manufacturing of pollution control equipment, performance of engineering analyses and significant expenditures for assembly and installation of such equipment. These activities will be job-creating during the period before firms must comply with the rule, at which point all pollution control equipment must be installed and operating.

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Indirect and Induced Effects:

– **Environmental regulations create employment in many basic industries**. In addition to the increase in employment in the environmental protection industry (increased orders for pollution control equipment), environmental regulations also create employment in industries that provide intermediate goods to the environmental protection industry. For example, capital expenditures to reduce air pollution involve the purchase of abatement equipment. The equipment manufacturers, in turn, order steel, tanks, vessels, blowers, pumps, and chemicals to manufacture and install the equipment. On the other hand, demand for labor will decrease in sectors that supply inputs for, or demand the outputs of the regulated industry. None of these impacts is accounted for in the current analysis. We also do not estimate employment impacts "induced" by increased output of the environmental protection sector, or decreased output of the regulated sectors.

The estimated impacts of the final rule on employment in affected sources are based on an empirically derived relationship reported in Morgenstern, Pizer and Shih (2002), a peer-reviewed, published study. Estimates of the employment impacts of the capital investments and other non-recurring requirements of the rule are derived from the cost analysis developed for the regulation.[2]

Morgenstern, Pizer and Shih (2002): Overview of Conceptual Approach

The fundamental insight of Morgenstern, Pizer and Shih (2002) is that environmental regulations can be understood as requiring regulated firms to add a new output (environmental quality) to their product mixes. Although legally compelled to satisfy this new demand, regulated firms have to finance this additional production with the proceeds of sales of their other (market) products. Satisfying this new demand requires additional inputs, including labor, and may alter the relative proportions of labor and capital used by regulated firms in their production processes.

Thus, Morgenstern et al., decompose the overall effect of a regulation on employment into the following three subcomponents:

- The "Demand Effect": higher production costs raise market prices, reducing consumption (and production), thereby reducing demand for labor within the regulated industry [3];

[2] Richard D. Morgenstern, William A. Pizer, and Jhih-Shyang Shih, *Journal of Environmental Economics and Management* | May 2002 | Vol. 43, no. 3 | pp. 412-436.

[3] The Morgenstern et al. results rely on industry demand and supply elasticities to determine cost pass-through and reductions in output..

- The "Cost Effect": As production costs increase, plants use more of all inputs, including labor, to maintain a given level of output. For example, in order to reduce pollutant emissions while holding output levels constant, regulated firms may require additional labor;
- The "Factor-Shift Effect": Regulated firms' production technologies may be more or less labor intensive after complying with a regulation (i.e., more/less labor is required per dollar of output).

Decomposing the overall employment impact of environmental regulation into three subcomponents clarifies the conceptual relationship between environmental regulation and employment in regulated sectors, and permitted Morgenstern, et al. to provide an empirical estimate of the net impact. For present purposes, the net effect is of particular interest, and is the focus of our analysis.

Morgenstern, Pizer and Shih (2002): Empirical Results

Morgenstern et al. empirically estimate a model for four highly polluting, regulated industries (pulp and paper, plastics, petroleum refining and steel) to examine the effect of higher abatement costs from regulation on employment. They conclude that increased abatement expenditures generally do not cause a significant change in employment. More specifically, their results show that, on average across the four industries, each additional $1 million spending on pollution abatement results in a (statistically insignificant) net increase of 1.55 (+/- 2.24) jobs.[4] "In plastics and petroleum, [Morgenstern et al] find that increased regulation raises employment by a small but statistically significant amount: 6.9 and 2.2 jobs per million dollars of regulatory expense, respectively. In pulp and paper and steel, the estimates are even smaller and insignificantly different from zero."[5] By applying these estimates to pollution abatement costs, we estimated the net employment effect for major and areas sources to range from -4,100 to +8,500 jobs in the directly affected sectors with a central estimate of +2,200 (Table 4-3).[6, 7]

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[4] These results are similar to Berman and Bui, who find that while sharply increased air quality regulation in Los Angeles to reduce NOx emissions resulted in large abatement costs they did not result in substantially reduced employment. "Environmental regulation and labor demand: evidence from the South Coast Air Basin." *Journal of Public Economics* 79(2): 265-295.

[5] Morgenstern, Pizer and Shih, p. 413.

[6] Since Morgenstern's analysis reports environmental expenditures in $1987, we make an inflation adjustment the engineering cost analysis using GDP implicit price deflator (64.76/108.48) = 0.60)

[7] Net employment effect = 1.55× $2,400 million × 0.60

Table 3-5. Employment Impacts Using Morgenstern, Pizer, Shih (2002) (FTE)

	Demand Effect	Cost Effect	Factor Shift Effect	Net Effect
Change in Full-Time Jobs per Million Dollars of Environmental Expenditure[a]	−3.56	2.42	2.68	1.55
Standard Error	2.03	1.35	0.83	2.24
EPA estimate	−600	400	500	300
	−1,300 to +100	+100 to +700	Less than 100 to +900	−500 to +1,000

[a] Expressed in 1987 dollars. See footnote 7 for inflation adjustment factor used in the analysis.

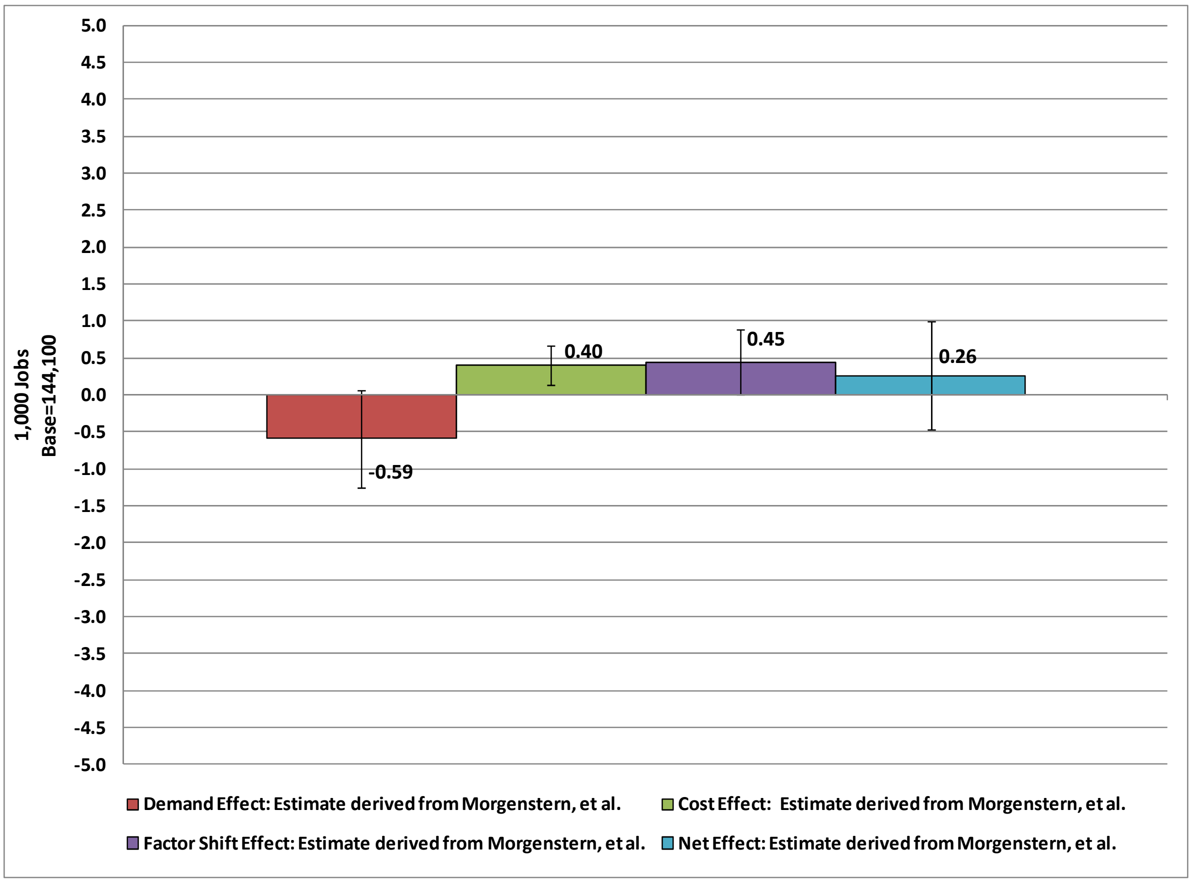


Figure 3-2. Employment Impacts Using Morgenstern, Pizer, Shih (2002) (1,000 FTEs)

Limitations of the Analysis

Although the Morgenstern et al. paper provides information about the potential job effects of environmental protection programs, there are several caveats associated with using those estimates to analyze the final rule. First, the Morgenstern et al. estimates presented in Table 4-3 and used in EPA's analysis represent the weighted average parameter estimates for a set of manufacturing industries (pulp and paper, plastics, petroleum, and steel). This set of industries only partially overlaps with the sectors affected by this rule. Second, relying on Morgenstern et al. implicitly assumes that estimates derived from 1979–1991 data are still applicable. Third, the methodology used in Morgenstern et al. assumes that regulations affect plants in proportion to their total costs. In other words, each additional dollar of regulatory burden affects a plant by an amount equal to that plant's total costs relative to the aggregate industry costs. By transferring the estimates, EPA assumes a similar distribution of regulatory costs by plant size and that the regulatory burden does not disproportionately fall on smaller or larger plants. Further, Morgenstern et al. does not include most indirect effects and all induced effects.

EXHIBIT 11

November 7, 2011

MEMORANDUM

SUBJECT: Regulatory Impact Results for the Reconsideration Proposal for Standards of Performance for New Stationary Sources and Emission Guidelines for Existing Sources: Commercial and Industrial Solid Waste Incineration Units

FROM: Tom Walton
Economist
AEG (C439-02)

TO: Toni Jones
Environmental Engineer
FIG (E143-03)

The EPA analyzed the economic impacts and benefits of this proposed rule using the methodology that was discussed in the final rule RIA and in the preamble to the final rule. *See* FR 76 15704.

The market impact results are very similar to the results in the final rule RIA. The Agency's economic model suggests average national price increases for industrial sectors are less than 0.0008 percent, while average annual domestic production may fall by less than 0.0005 percent. Because of higher domestic prices, imports slightly rise by 0.0006 percent and exports fall by 0.0006 percent. The change in US surplus is now -270 million dollars (2006$). For the final rule RIA, the change in surplus was -283 million dollars (2006$). Table 1 shows the price, production, import, and export changes for this proposed rule, which are very close to the estimated changes for the final rule RIA.

Table 1. Price, Production, Import, and Export Changes Resulting from the CISWI Proposed Reconsideration

Industry Sector	**U.S. Prices**	**U.S. Production**	**Imports**	**U.S. Consumption**	**Exports**
Energy	0.001%	-0.001%	0.003%	-0.001%	0.000%
Nonmanufacturing	0.003%	-0.001%	0.002%	0.000%	-0.002%
Manufacturing					
Food, beverages, and textiles	0.001%	-0.001%	0.001%	0.000%	0.000%
Lumber, paper, and printing	0.024%	-0.010%	0.024%	-0.006%	-0.017%
Chemicals	0.000%	-0.001%	0.000%	-0.001%	0.000%
Plastics and Rubber	0.000%	-0.001%	0.001%	-0.001%	0.000%
Nonmetallic Minerals	0.071%	-0.017%	0.026%	-0.010%	-0.059%
Primary Metals	0.001%	-0.001%	0.001%	-0.001%	-0.001%
Fabricated Metals	0.000%	0.000%	0.000%	0.000%	0.000%
Machinery and Equipment	0.000%	0.000%	0.000%	0.000%	0.000%
Electronic Equipment	0.000%	0.000%	0.000%	0.000%	0.000%
Transportation Equipment	0.000%	0.000%	0.000%	0.000%	0.000%
Other	0.000%	-0.001%	0.001%	0.000%	0.000%
Wholesale and Retail Trade	0.000%	0.000%	0.000%	0.000%	0.000%
Transportation Services	-0.001%	0.000%	0.000%	0.000%	0.000%
Other Services	0.000%	0.000%	0.000%	0.000%	0.000%

The results for sales tests for small businesses are lower for the reconsideration proposal than those calculated for the final rule. The number of small entities affected by the rule dropped from nine to five. For the final rule, four of the nine had cost-to-sales percentages of more than 3 percent. For the reconsideration proposal only two of the five had cost-to-sales percentages of more than 3 percent and the other three had small savings. This is not a significant impact on a substantial number of small entities.

The change in employment estimates between the final rule RIA and the reconsideration proposal is small. The estimated employment changes range between −500 to +1000 employees, with a central estimate of +300 employees for the final rule RIA. For the reconsideration proposal, the estimated employment changes range between −400 to +900 employees, with a central estimate of +200.

The health benefits were calculated using the methodology described in the final CISWI RIA, which is available at http://www.epa.gov/ttnecas1/regdata/RIAs/CISWIRIAfinal110221_psg2.pdf, using the revised emission reductions estimated for the reconsideration proposal. We were unable to estimate the benefits from reducing exposure to HAPs and ozone, ecosystem impairment, and visibility impairment, including reducing 22,000 tons of carbon monoxide, 590 tons of HCl, 3.1 tons of lead, 1.6 tons of cadmium, 290 pounds of mercury, and 94 grams of dioxins/furans. Please refer to the full description in the final CISWI RIA of the unquantified benefits as well as analysis limitations and uncertainties. These monetized benefits are approximately 4% lower than the final CISWI NSPS due to the slight decrease in emission reductions of $PM_{2.5}$, SO_2, and NOx.

Table 2: Summary of Monetized Benefits Estimates for CISWI Reconsideration Proposal in 2015 (2008$)

Pollutant	Emissions Reductions (tons)	Benefit per ton (Pope, 3%)	Benefit per ton (Laden, 3%)	Benefit per ton (Pope, 7%)	Benefit per ton (Laden, 7%)	Total Monetized Benefits (millions 2008$ at 3%)	Total Monetized Benefits (millions 2008$ at 7%)
Direct $PM_{2.5}$	670	$230,000	$560,000	$210,000	$500,000	$150 to $370	$140 to $340
$PM_{2.5}$ Precursors							
SO_2	5,033	$29,000	$72,000	$27,000	$65,000	$150 to $360	$130 to $330
NO_2	5,405	$4,900	$12,000	$4,400	$11,000	$ 26.0 o $ 64.0	$ 24.0 o $ 58.0
					Total	**$ 330 o $ 800**	**$ 300 o $ 720**

*All estimates are for the implementation year (2015), and are rounded to two significant figures so numbers may not sum across columns. These models assume that all fine particles, regardless of their chemical composition, are equally potent in causing premature mortality because the scientific evidence is not yet sufficient to allow differentiation of effect estimates by particle type. The benefit per ton estimates vary because each ton of precursor reduced has a different propensity to become $PM_{2.5}$. The monetized benefits incorporate the conversion from precursor emissions to ambient fine particles. These estimates do not include benefits from reducing HAP emissions or ozone benefits.

Table 3: Summary of Estimated Reductions in Health Incidences from $PM_{2.5}$ for the CISWI Reconsideration Proposal in 2015*

Avoided Premature Mortality	
Pope et al.	37
Laden et al.	94
Avoided Morbidity	
Chronic Bronchitis	25
Acute Myocardial Infarction	59
Hospital Admissions, Respiratory	9
Hospital Admissions, Cardiovascular	19
Emergency Room Visits, Respiratory	35
Acute Bronchitis	59
Work Loss Days	4,900
Asthma Exacerbation	650
MRAD	29,000
Lower Respiratory Symptoms	710
Upper Respiratory Symptoms	530

*All estimates are for the analysis year (2015) and are rounded to whole numbers with two significant figures. These models assume that all fine particles, regardless of their chemical composition, are equally potent in causing premature mortality because the scientific evidence is not yet sufficient to allow differentiation of effect estimates by particle type. These estimates do not include benefits from reducing HAP emissions and ozone exposure, nor energy disbenefits associated with the increased emissions from additional energy usage.

Figure 1: Breakdown of Monetized Benefits by Subcategory

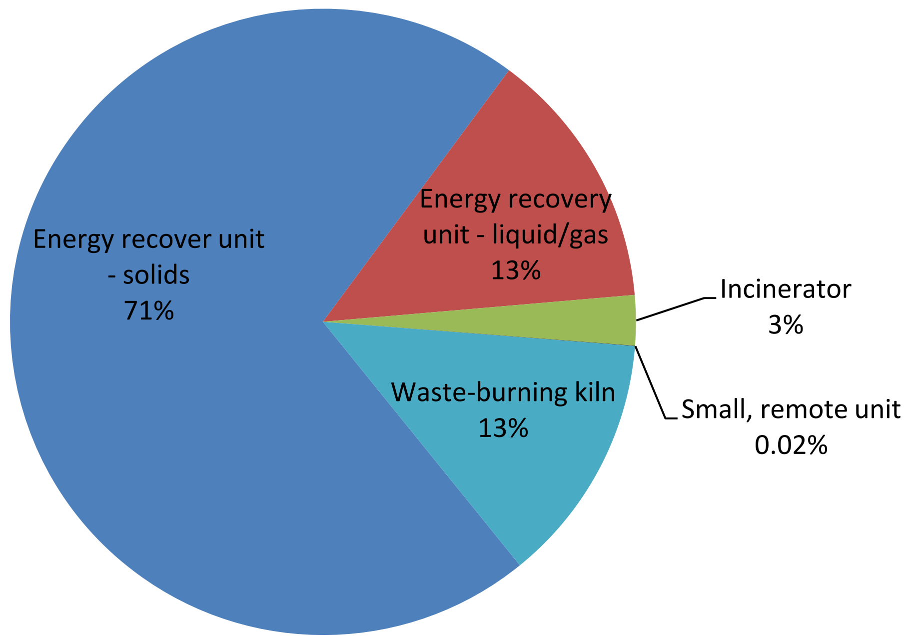


Figure 2: Total Monetized $PM_{2.5}$ Benefits Estimates for the CISWI Reconsideration Proposal in 2015

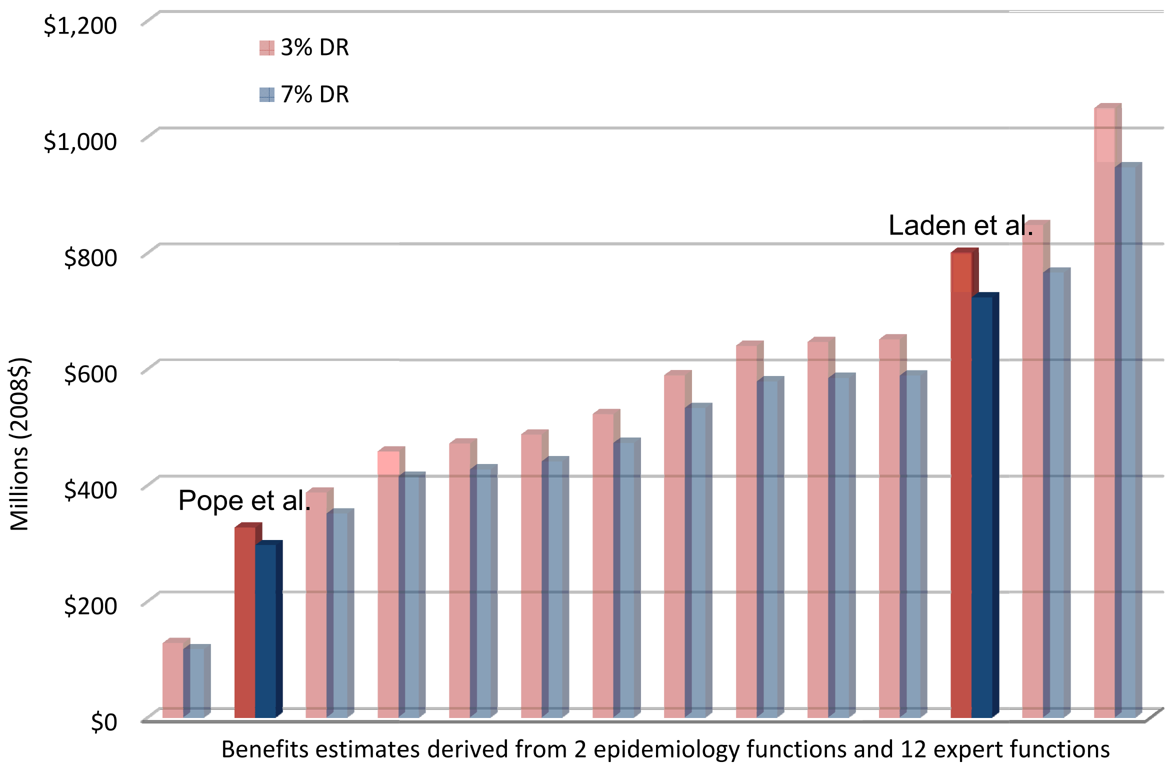


Table 4 shows the estimated costs and benefits for the reconsideration proposal. The estimated net benefits are almost the same as for the final rule RIA, which was $30 million to $470 million at 7 percent and was $60 million to $550 million at 3 percent.

Table 4. Summary of Estimated Social Costs and Benefits

Category	Primary Estimate	Low Estimate	High Estimate	Year Dollar	Discount Rate	Period Covered
Benefits						
Annualized		$300	$720	2008	7%	2015
Monetized ($millions/year)		$330	$800	2008	3%	2015
Costs						
Annualized	$271			2008	7%	2015
Monetized ($millions/year)	$271			2008	3%	2015
Net Benefits						
Annualized		$30	$450	2008	7%	2015
Monetized ($millions/year)		$60	$530	2008	3%	2015

EXHIBIT 12

December 20, 2012

MEMORANDUM

SUBJECT: Regulatory Impact Results for the Reconsideration Final Rule for Standards of Performance for New Stationary Sources and Emission Guidelines for Existing Sources: Commercial and Industrial Solid Waste Incineration Units

FROM: Tom Walton
Economist
AEG (C439-02)

TO: Toni Jones
Environmental Engineer
FIG (E143-03)

The EPA analyzed the economic impacts and benefits of this reconsideration final rule using the methodology that was discussed in the original final rule RIA and in the preamble to the original final rule. *See* FR 76 15704.

Changes Since 2010 Final Rule to Emission Reductions and Engineering Costs

The changes in emission reductions and annual engineering costs in the final CISWI reconsideration are the result of revisions made to the CISWI unit inventory since promulgation of the March 2011 final rule. Since the March 2011 final rule, some units were identified that were not previously in the CISWI inventory database, some units were removed from the inventory, and one unit was moved from one subcategory to another . Making these changes resulted in 1 additional incinerator, 14 additional small remote incinerators, 8 fewer energy recovery units burning solid waste, no change in the number of energy recovery units burning liquid waste, and 11 additional waste-burning kilns. Altogether, the current CISWI inventory comprises 18 more units than the inventory at the time the March 2011 final rule was promulgated. If all units choose to comply with the rule, the resulting incremental cost impact for the revised inventory of CISWI units to comply with the final amended rule is approximately 184 million dollars in capital expenditures and 42 million dollars per year in total annual costs.

The changes in emission reductions and annual engineering costs in the final CISWI reconsideration are mainly the result of revisions made to the emission limits due to receiving new data, subcategory inventory changes, and changes to the emissions monitoring provisions. Incremental annual engineering costs for liquid/gas burning energy recover units decreased by approximately $219,000 because a lower baseline CO emission concentration was determined for one of the units, thus eliminating the need for an oxidation catalyst to meet the new CO limit. Incremental annual engineering costs for energy recover units burning solids decreased by about $70 million because eight units were cut from the inventory and a revised activated carbon injection cost algorithm was used in estimating costs. Incremental annual engineering costs for incinerators increased by about $340,000 because of a more stringent CO limit, which prompted the need for afterburner retrofits on units that can't meet the revised limit. Incremental annual engineering costs for small remote units increased by approximately $3.2 million; although limits became less stringent and fewer controls were required per unit, the additional annual costs required for an additional 14 units to comply ($3.7 million) outweighed the cost reduction from decreased control requirements ($498,000). Incremental annual engineering costs for waste-burning kilns increased by about $109 million because additional wet scrubbers, activated carbon injection, regenerative thermal oxidizers, and fabric filter improvements were required for the original 12 units to meet revised limits, and an additional 11 units were added to the inventory, many of which require similar controls to meet the revised limits.

Table 1 shows the changes in emission reductions of directly emitted $PM_{2.5}$, SO_2, and NOx. Table 2 shows an estimate of the changes in monetized benefits associated with the emission reductions and engineering costs in the final CISWI reconsideration.

Table 1. Changes in Emission Reductions for the Final CISWI Reconsideration[a]

	Direct $PM_{2.5}$ (tons per year)	**SO_2 (tons per year)**	**NOx (tons per year)**
Final CISWI Rule (March 2011)	759	5,259	5,734
Changes due to increase in scope (addition of 18 units)	+98	+970	-8
Changes due to provision changes in this final reconsideration	+60	+33	-327
Net changes since final rule	+158	+1,003	-335
Final CISWI Reconsideration	917	6,262	5,399

[a] We provide only the emission changes associated with these 2 pollutants in this table because the other pollutants (e.g., Cd, CO, HCl, Pb, Hg, D/F) were not monetized in the RIA.

Table 2. Changes in Benefits and Costs for the Final CISWI Reconsideration

	Monetized Benefits in 2015[a]		Annual Engineering Costs[b] (considering fuel savings)
	3% discount rate	**7% discount rate**	
Final CISWI Rule (March 2011)	$360 to $870 million	$320 to $790 million	$218 million
Changes due to increase in scope (addition of 18 units)	+$51 to $120 million	+$46 to $110 million	+$30 million
Changes due to provision changes in this final reconsideration	+$13 to $32 million	+12 to $29 million	+$10 million
Net changes since final rule	+$64 to $160 million	+58 to $140 million	$40 million
Final CISWI Reconsideration	$420 to $1,000 million	$380 to $930 million	$258 million

[a] These benefits do not include benefits associated with reduced exposure to HAP, direct exposure to SO_2, visibility impairment, or ecosystem effects. These benefits reflect the final rule, which were 4% higher than shown in the RIA.

[b] Minimum and maximum fuel savings reflect a range of fuel prices for the final reconsideration. These costs reflect the final rule, which were 22% lower than shown in the RIA.

We estimated the total monetized benefits for the final CISWI RIA (March 2011) to be $340 million to $830 million at 3 percent discount rate and $310 million to $750 million at 7 percent discount rate. However, EPA noted that the RIA did not incorporate the final engineering costs and emission reductions, which would decrease the engineering costs by approximately 22% and increase the monetized benefits by approximately 4%. For this final reconsideration, we estimate the total monetized benefits to be $420 million to $1 billion at 3 percent discount rate and $380 million to $930 million at 7 percent discount rate. All estimates are in 2008$.

Revised Economic Impacts

The market impact results are very similar to the results in the final rule RIA. The Agency's economic model suggests average national price increases for industrial sectors are less than 0.001 percent, while average annual domestic production may fall by less than 0.001 percent. Because of higher domestic prices, imports slightly rise by 0.001 percent and exports fall by 0.001 percent. The change in US surplus is now -258 million dollars (2006$). For the final rule RIA, the change in surplus was -283 million dollars (2006$). Table 3 provides the price, production, import, and export changes for this final reconsideration rule, which are very close to the estimated changes for the final rule RIA.

Table 3. Price, Production, Import, and Export Changes Resulting from the Final CISWI Reconsideration

Industry Sector	U.S. Prices	U.S. Production	Imports	U.S. Consumption	Exports
Energy	0.001%	-0.001%	0.002%	0.000%	0.000%
Nonmanufacturing	0.004%	-0.001%	0.003%	0.000%	-0.003%
Manufacturing					
Food, beverages, and textiles	0.001%	-0.001%	0.001%	0.000%	0.000%
Lumber, paper, and printing	0.020%	-0.009%	0.021%	-0.005%	-0.014%
Chemicals	0.000%	-0.001%	0.000%	-0.001%	0.000%
Plastics and Rubber	0.000%	-0.001%	0.000%	-0.001%	0.000%
Nonmetallic Minerals	0.087%	-0.020%	0.032%	-0.012%	-0.072%
Primary Metals	0.001%	-0.001%	0.001%	-0.001%	-0.001%
Fabricated Metals	0.000%	0.000%	0.000%	0.000%	0.000%
Machinery and Equipment	0.000%	0.000%	0.000%	0.000%	0.000%
Electronic Equipment	0.000%	0.000%	0.000%	0.000%	0.000%
Transportation Equipment	0.000%	0.000%	0.000%	0.000%	0.000%
Other	0.000%	-0.001%	0.001%	0.000%	0.000%
Wholesale and Retail Trade	0.000%	0.000%	0.000%	0.000%	0.000%
Transportation Services	0.000%	-0.001%	0.000%	0.000%	0.000%
Other Services	0.000%	0.000%	0.000%	0.000%	0.000%

The results for sales tests for small businesses are lower for the reconsideration final than those calculated for the final rule. The number of small entities affected by the rule dropped from nine to five. For the final rule, four of the nine had cost-to-sales percentages of more than 3 percent. For the reconsideration final only one of the five had a cost-to-sales percentage of more than 3 percent and the other four had small savings. This is not a significant impact on a substantial number of small entities.

The change in employment estimates between the final rule RIA and the reconsideration final is small. The estimated employment changes range between −500 to +1000 employees, with a central estimate of +300 employees for the final rule RIA. For the reconsideration final, the estimated employment changes range between −400 to +800 employees, with a central estimate of +200.

Revised Benefits

The health benefits were calculated using the methodology described in the final CISWI RIA (U.S. EPA, 2011)[1] using the revised emission reductions estimated for the final reconsideration. We were unable to estimate the benefits from reducing exposure to HAPs and ozone, ecosystem impairment, and visibility impairment, including reducing 20,000 tons of carbon monoxide, 780 tons of HCl, 2.5 tons of lead, 1.8 tons of cadmium, 680 pounds of

[1] U.S. Environmental Protection Agency (U.S. EPA). 2011. *Regulatory Impact Analysis: Standards of Performance for New Stationary Sources and Emission Guidelines for Existing Sources: Commercial and Industrial Solid Waste Incineration Units.* February. Available at http://www.epa.gov/ttnecas1/regdata/RIAs/CISWIRIAfinal110221_psg2.pdf

mercury, and 58 grams of dioxins/furans. Please refer to the full description in the final CISWI RIA of the unquantified benefits as well as analysis limitations and uncertainties. These monetized benefits are approximately 18% higher than the final CISWI NSPS due to the increased emission reductions of $PM_{2.5}$ and SO_2. Since the reconsideration proposal, we have made several updates to the approach we use to estimate mortality and morbidity benefits in the PM NAAQS RIAs (U.S. EPA, 2012a,b)[2,3], including updated epidemiology studies, health endpoints, and population data. Although we have not re-estimated the benefits for this rule to apply this new approach, these updates generally offset each other, and we anticipate that the rounded benefits estimated for this rule are unlikely to be different than those provided below. More information on these updates can be found in the PM NAAQS proposal RIA. We provide the benefits results in Tables 4 and 5 and Figure 2. We also provide the breakdown of monetized benefits by subcategory in Figure 1.

Table 4: Summary of Monetized Benefits Estimates for the Final CISWI Reconsideration in 2015 (2008$)

Pollutant	**Emissions Reductions (tons)**	**Benefit per ton (Pope, 3%)**	**Benefit per ton (Laden, 3%)**	**Benefit per ton (Pope, 7%)**	**Benefit per ton (Laden, 7%)**	**Total Monetized Benefits (millions 2008$ at 3%)**			**Total Monetized Benefits (millions 2008$ at 7%)**		
Direct $PM_{2.5}$	917	$230,000	$560,000	$210,000	$500,000	$210	to	$510	$190	to	$460
$PM_{2.5}$ Precursors											
SO_2	6,262	$29,000	$72,000	$27,000	$65,000	$180	to	$450	$170	to	$410
NO_2	5,399	$4,900	$12,000	$4,400	$11,000	$26	to	$64	$24	to	$58
					Total	**$420**	**to**	**$1,000**	**$380**	**to**	**$930**

*All estimates are for the implementation year (2015), and are rounded to two significant figures so numbers may not sum across columns. These models assume that all fine particles, regardless of their chemical composition, are equally potent in causing premature mortality because the scientific evidence is not yet sufficient to allow differentiation of effect estimates by particle type. The benefit per ton estimates vary because each ton of precursor reduced has a different propensity to become $PM_{2.5}$. The monetized benefits incorporate the conversion from precursor emissions to ambient fine particles. These estimates do not include benefits from reducing HAP emissions or ozone benefits.

[2] U.S. Environmental Protection Agency (U.S. EPA). 2012a. *Regulatory Impact Analysis for the Proposed Revisions to the National Ambient Air Quality Standards for Particulate Matter*. EPA-452/R-12-003. Office of Air Quality Planning and Standards, Health and Environmental Impacts Division. June. Available at http://www.epa.gov/ttnecas1/regdata/RIAs/PMRIACombinedFile_Bookmarked.pdf.

[3] U.S. Environmental Protection Agency (U.S. EPA). 2012b. *Regulatory Impact Analysis for the Final Revisions to the National Ambient Air Quality Standards for Particulate Matter*. EPA-452/R-12-003. Office of Air Quality Planning and Standards, Health and Environmental Impacts Division. December. Available at http://www.epa.gov/pm/2012/finalria.pdf.

Table 5: Summary of Estimated Reductions in Health Incidences from $PM_{2.5}$ for the Final CISWI Reconsideration in 2015*

Avoided Premature Mortality	
Pope et al.	47
Laden et al.	120
Avoided Morbidity	
Chronic Bronchitis	32
Acute Myocardial Infarction	75
Hospital Admissions, Respiratory	11
Hospital Admissions, Cardiovascular	24
Emergency Room Visits, Respiratory	45
Acute Bronchitis	76
Work Loss Days	6,200
Asthma Exacerbation	830
MRAD	37,000
Lower Respiratory Symptoms	910
Upper Respiratory Symptoms	680

*All estimates are for the analysis year (2015) and are rounded to whole numbers with two significant figures. These models assume that all fine particles, regardless of their chemical composition, are equally potent in causing premature mortality because the scientific evidence is not yet sufficient to allow differentiation of effect estimates by particle type. These estimates do not include benefits from reducing HAP emissions and ozone exposure, nor energy disbenefits associated with the increased emissions from additional energy usage.

Figure 1: Breakdown of Monetized Benefits by Subcategory

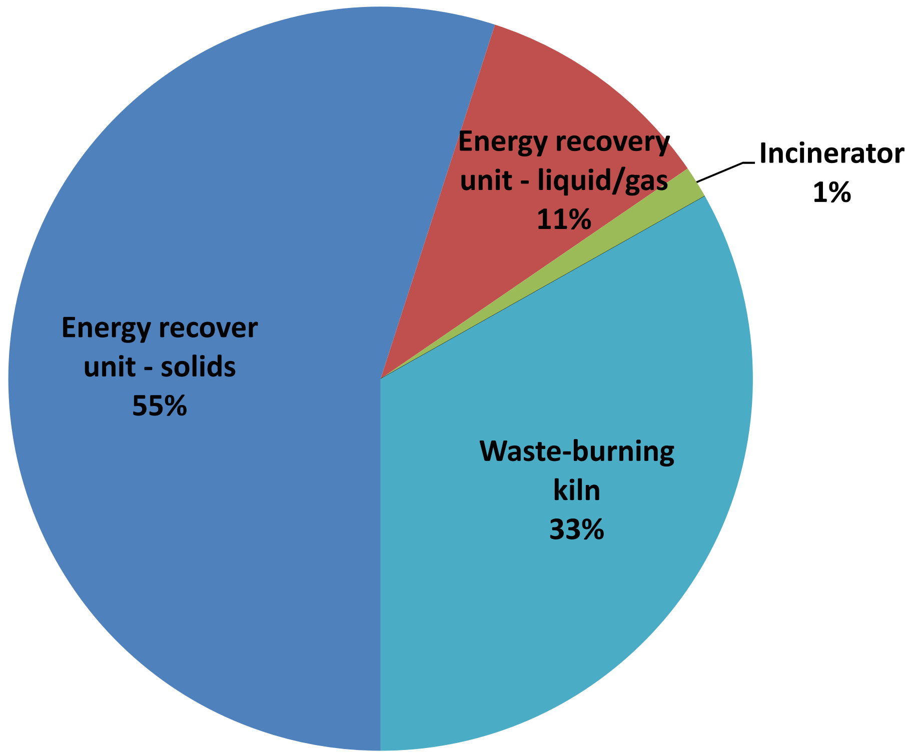
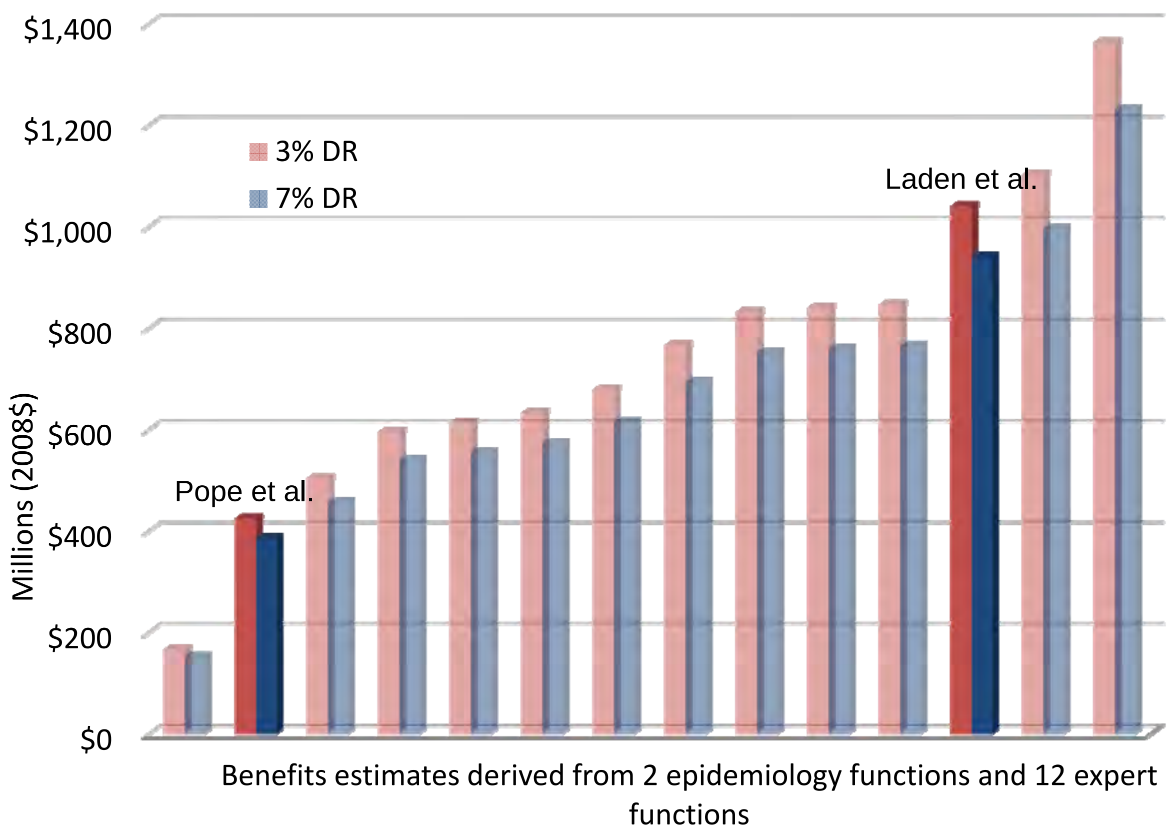


Figure 2: Total Monetized $PM_{2.5}$ Benefits Estimates for the Final CISWI Reconsideration in 2015



Revised Net Benefits

Table 6 shows the estimated costs and benefits for the reconsideration final. The estimated net benefits are higher than the final rule RIA, which was $30 million to $470 million at 7 percent and was $60 million to $550 million at 3 percent.

Table 6. Summary of Estimated Social Costs and Benefits

Category	Primary Estimate	Low Estimate	High Estimate	Year Dollar	Discount Rate	Period Covered
Benefits						
Annualized Monetized ($millions/year)		$380	$930	2008	7%	2015
		$420	$1,000	2008	3%	2015
Costs						
Annualized Monetized ($millions/year)	$258			2008	7%	2015
	$258			2008	3%	2015
Net Benefits						
Annualized Monetized ($millions/year)		$120	$670	2008	7%	2015
		$160	$770	2008	3%	2015

EXHIBIT 13

Regulatory Impact Analysis

Proposed New Source Performance Standards and Amendments to the National Emissions Standards for Hazardous Air Pollutants for the Oil and Natural Gas Industry

U.S. Environmental Protection Agency
Office of Air and Radiation
Office of Air Quality Planning and Standards
Research Triangle Park, NC 27711

July 2011

1 EXECUTIVE SUMMARY

1.1 Background

The U.S. Environmental Protection Agency (EPA) reviewed the New Source Performance Standards (NSPS) for volatile organic compound and sulfur dioxide emissions from Natural Gas Processing Plants. As a result of these NSPS, this proposal amends the Crude Oil and Natural Gas Production source category currently listed under section 111 of the Clean Air Act to include Natural Gas Transmission and Distribution, amends the existing NSPS for volatile organic compounds (VOCs) from Natural Gas Processing Plants, and proposes NSPS for stationary sources in the source categories that are not covered by the existing NSPS. In addition, this proposal addresses the residual risk and technology review conducted for two source categories in the Oil and Natural Gas sector regulated by separate National Emission Standards for Hazardous Air Pollutants (NESHAP). It also proposes standards for emission sources not currently addressed, as well as amendments to improve aspects of these NESHAP related to applicability and implementation. Finally, it addresses provisions in these NESHAP related to emissions during periods of startup, shutdown, and malfunction.

As part of the regulatory process, EPA is required to develop a regulatory impact analysis (RIA) for rules that have costs or benefits that exceed $100 million. EPA estimates the proposed NSPS will have costs that exceed $100 million, so the Agency has prepared an RIA. Because the NESHAP amendments are being proposed in the same rulemaking package (i.e., same Preamble), we have chosen to present the economic impact analysis for the proposed NESHAP amendments within the same document as the NSPS RIA.

This RIA includes an economic impact analysis and an analysis of human health and climate impacts anticipated from the proposed NSPS and NESHAP amendments. We also estimate potential impacts of the proposed NSPS on the national energy economy using the U.S. Energy Information Administration's National Energy Modeling System (NEMS). The engineering compliance costs are annualized using a 7 percent discount rate. This analysis assumes an analysis year of 2015.

Several proposed emission controls for the NSPS capture VOC emissions that otherwise would be vented to the atmosphere. Since methane is co-emitted with VOCs, a large proportion of the averted methane emissions can be directed into natural gas production streams and sold. One emissions control option, reduced emissions well completions, also recovers saleable hydrocarbon condensates which would otherwise be lost to the environment. The revenues derived from additional natural gas and condensate recovery are expected to offset the engineering costs of implementing the NSPS in the proposed option. In the economic impact and energy economy analyses for the NSPS, we present results for three regulatory options that include the additional product recovery and the revenues we expect producers to gain from the additional product recovery.

1.2 NSPS Results

For the proposed NSPS, the key results of the RIA follow and are summarized in Table 1-1:

- **Benefits Analysis:** The proposed NSPS is anticipated to prevent significant new emissions, including 37,000 tons of hazardous air pollutants (HAPs), 540,000 tons of VOCs, and 3.4 million tons of methane. While we expect that these avoided emissions will result in improvements in ambient air quality and reductions in health effects associated with exposure to HAPs, ozone, and particulate matter (PM), we have determined that quantification of those benefits cannot be accomplished for this rule. This is not to imply that there are no benefits of the rules; rather, it is a reflection of the difficulties in modeling the direct and indirect impacts of the reductions in emissions for this industrial sector with the data currently available. In addition to health improvements, there will be improvements in visibility effects, ecosystem effects, as well as additional natural gas recovery. The methane emissions reductions associated with the proposed NSPS are likely to result in significant climate co-benefits. The specific control technologies for the proposed NSPS are anticipated to have minor secondary disbenefits, including an increase of 990,000 tons of carbon dioxide (CO_2), 510 tons of nitrogen oxides NOx, 7.6 tons of PM, 2,800 tons of CO, and 1,000 tons of total hydrocarbons (THC) as well as emission reductions associated with the energy system impacts. The net CO_2-equivalent emission reductions are 62 million metric tons.
- **Engineering Cost Analysis:** EPA estimates the total capital cost of the proposed NSPS will be $740 million. The total annualized engineering costs of the proposed NSPS will be $740 million. When estimated revenues from additional natural gas and condensate recovery are included, the annualized engineering costs of the proposed NSPS are estimated at $-45 million, assuming a wellhead natural gas price of $4/thousand cubic feet (Mcf) and condensate price of $70/barrel. Possible explanations for why there appear to be negative cost control technologies are discussed in the engineering costs analysis section in the RIA. The estimated engineering compliance costs that include the product recovery are sensitive to the assumption about the price of the recovered product. There is also geographic variability in wellhead prices, which can also influence estimated engineering costs. For example, $1/Mcf change in the wellhead price causes a change in estimated engineering compliance costs of about $180 million, given EPA estimates that 180 billion cubic feet of natural gas

will be recovered by implementing the proposed NSPS option. All estimates are in 2008 dollars.

- **Energy System Impacts:** Using the NEMS, when additional natural gas recovery is included, the analysis of energy system impacts for the proposed NSPS shows that domestic natural gas production is likely to increase slightly (about 20 billion cubic feet or 0.1 percent) and average natural gas prices to decrease slightly (about $0.04/Mcf or 0.9 percent at the wellhead for onshore production in the lower 48 states). Domestic crude oil production is not expected to change, while average crude oil prices are estimated to decrease slightly (about $0.02/barrel or less than 0.1 percent at the wellhead for onshore production in the lower 48 states). All prices are in 2008 dollars.
- **Small Entity Analyses:** EPA performed a screening analysis for impacts on small entities by comparing compliance costs to revenues. For the proposed NSPS, we found that there will not be a significant impact on a substantial number of small entities (SISNOSE).
- **Employment Impacts Analysis:** EPA estimated the labor impacts due to the installation, operation, and maintenance of control equipment, as well as labor associated with new reporting and recordkeeping requirements. We estimate up-front and continual, annual labor requirements by estimating hours of labor required for compliance and converting this number to full-time equivalents (FTEs) by dividing by 2,080 (40 hours per week multiplied by 52 weeks). The up-front labor requirement to comply with the proposed NSPS is estimated at 230 full-time-equivalent employees. The annual labor requirement to comply with proposed NSPS is estimated at about 2,400 full-time-equivalent employees. We note that this type of FTE estimate cannot be used to make assumptions about the specific number of people involved or whether new jobs are created for new employees.

Table 1-1 Summary of the Monetized Benefits, Costs, and Net Benefits for the Oil and Natural Gas NSPS Regulatory Options in 2015 (millions of 2008$)[1]

	Option 1: Alternative	Option 2: Proposed[4]	Option 3: Alternative
Total Monetized Benefits[2]	N/A	N/A	N/A
Total Costs[3]	-$19 million	-$45 million	$77 million
Net Benefits	N/A	N/A	N/A
Non-monetized Benefits	17,000 tons of HAPs[5]	37,000 tons of HAPs[5]	37,000 tons of HAPs[5]
	270,000 tons of VOCs	540,000 tons of VOCs	550,000 tons of VOCs
	1.6 million tons of methane[5]	3.4 million tons of methane[5]	3.4 million tons of methane[5]
	Health effects of HAP exposure[5]	Health effects of HAP exposure[5]	Health effects of HAP exposure[5]
	Health effects of $PM_{2.5}$ and ozone exposure	Health effects of $PM_{2.5}$ and ozone exposure	Health effects of $PM_{2.5}$ and ozone exposure
	Visibility impairment	Visibility impairment	Visibility impairment
	Vegetation effects	Vegetation effects	Vegetation effects
	Climate effects[5]	Climate effects[5]	Climate effects[5]

[1] All estimates are for the implementation year (2015) and include estimated revenue from additional natural gas recovery as a result of the NSPS.

[2] While we expect that these avoided emissions will result in improvements in air quality and reductions in health effects associated with HAPs, ozone, and particulate matter (PM) as well as climate effects associated with methane, we have determined that quantification of those benefits and co-benefits cannot be accomplished for this rule in a defensible way. This is not to imply that there are no benefits or co-benefits of the rules; rather, it is a reflection of the difficulties in modeling the direct and indirect impacts of the reductions in emissions for this industrial sector with the data currently available. The specific control technologies for the proposed NSPS are anticipated to have minor secondary disbenefits, including an increase of 990,000 tons of CO_2, 510 tons of NOx, 7.6 tons of PM, 2,800 tons of CO, and 1,000 tons of total hydrocarbons (THC) as well as emission reductions associated with the energy system impacts. The net CO_2-equivalent emission reductions are 62 million metric tons.

[3] The engineering compliance costs are annualized using a 7 percent discount rate.

[4] The negative cost for the NSPS Options 1 and 2 reflects the inclusion of revenues from additional natural gas and hydrocarbon condensate recovery that are estimated as a result of the proposed NSPS. Possible explanations for why there appear to be negative cost control technologies are discussed in the engineering costs analysis section in the RIA.

[5] Reduced exposure to HAPs and climate effects are co-benefits.

1.3 NESHAP Amendments Results

For the proposed NESHAP amendments, the key results of the RIA follow and are summarized in Table 1-2:

- **Benefits Analysis:** The proposed NESHAP amendments are anticipated to reduce a significant amount of existing emissions, including 1,400 tons of HAPs, 9,200 tons of VOCs, and 4,900 tons of methane. Results from the residual risk assessment indicate that for existing natural gas transmission and storage, the maximum individual cancer risk decreases from 90-in-a-million before controls to 20-in-a-million after controls with benzene as the primary cancer risk driver. While we expect that these avoided emissions will result in improvements in ambient air quality and reductions in health effects associated with exposure to HAPs, ozone, and PM, we have determined that quantification of those benefits cannot be accomplished for this rule. This is not to imply that there are no benefits of the rules; rather, it is a reflection of the difficulties in modeling the direct and indirect impacts of the reductions in emissions for this industrial sector with the data currently available. In addition to health improvements, there will be improvements in visibility effects, ecosystem effects, and climate effects as well as additional natural gas recovery. The specific control technologies for the proposed NESHAP is anticipated to have minor secondary disbenefits, including an increase of 5,500 tons of CO_2, 2.9 tons of NOx, 16 tons of CO, and 6.0 tons of total hydrocarbons (THC) as well as emission reductions associated with the energy system impacts. The net CO_2-equivalent emission reductions are 93 thousand metric tons.
- **Engineering Cost Analysis:** EPA estimates the total capital costs of the proposed NESHAP amendments to be $52 million. Total annualized engineering costs of the proposed NESHAP amendments are estimated to be $16 million. All estimates are in 2008 dollars.
- **Energy System Impacts:** We did not estimate the energy economy impacts of the proposed NESHAP amendments as the expected costs of the rule are not likely to have estimable impacts on the national energy economy.
- **Small Entity Analyses:** EPA performed a screening analysis for impacts on small entities by comparing compliance costs to revenues. For the proposed NESHAP amendments, we found that there will not be a significant impact on a substantial number of small entities (SISNOSE).
- **Employment Impacts Analysis:** EPA estimated the labor impacts due to the installation, operation, and maintenance of control equipment, as well as labor associated with new reporting and recordkeeping requirements. We estimate up-front and continual, annual labor requirements by estimating hours of labor required for compliance and converting this number to full-time equivalents (FTEs) by dividing by 2,080 (40 hours per week multiplied by 52 weeks). The up-front labor requirement to comply with the proposed NESHAP Amendments is estimated at 120 full-time-equivalent employees. The annual labor requirement to comply with proposed NESHAP Amendments is estimated at about 102 full-time-equivalent employees. We note that this type of FTE estimate cannot be used to make assumptions about the specific number of people involved or whether new jobs are created for new employees.

- **Break-Even Analysis:** A break-even analysis suggests that HAP emissions would need to be valued at $12,000 per ton for the benefits to exceed the costs if the health benefits, ecosystem and climate co-benefits from the reductions in VOC and methane emissions are assumed to be zero. If we assume the health benefits from HAP emission reductions are zero, the VOC emissions would need to be valued at $1,700 per ton or the methane emissions would need to be valued at $3,300 per ton for the benefits to exceed the costs. Previous assessments have shown that the $PM_{2.5}$ benefits associated with reducing VOC emissions were valued at $280 to $7,000 per ton of VOC emissions reduced in specific urban areas. Previous assessments have shown that the $PM_{2.5}$ benefits associated with reducing VOC emissions were valued at $280 to $7,000 per ton of VOC emissions reduced in specific urban areas, ozone benefits valued at $240 to $1,000 per ton of VOC emissions reduced, and climate co-benefits valued at $110 to $1,400 per short ton of methane reduced. All estimates are in 2008 dollars.

Table 1-2 Summary of the Monetized Benefits, Costs, and Net Benefits for the Proposed Oil and Natural Gas NESHAP in 2015 (millions of 2008$)[1]

	Option 1: Proposed (Floor)
Total Monetized Benefits[2]	N/A
Total Costs[3]	$16 million
Net Benefits	N/A
Non-monetized Benefits	1,400 tons of HAPs
	9,200 tons of VOCs[4]
	4,900 tons of methane[4]
	Health effects of HAP exposure
	Health effects of $PM_{2.5}$ and ozone exposure[4]
	Visibility impairment[4]
	Vegetation effects[4]
	Climate effects[4]

[1] All estimates are for the implementation year (2015).

[2] While we expect that these avoided emissions will result in improvements in air quality and reductions in health effects associated with HAPs, ozone, and PM as well as climate effects associated with methane, we have determined that quantification of those benefits and co-benefits cannot be accomplished for this rule in a defensible way. This is not to imply that there are no benefits or co-benefits of the rules; rather, it is a reflection of the difficulties in modeling the direct and indirect impacts of the reductions in emissions for this industrial sector with the data currently available. The specific control technologies for the proposed NESHAP are anticipated to have minor secondary disbenefits, including an increase of 5,500 tons of CO_2, 2.9 tons of NOx, 16 tons of CO, and 6.0 tons of THC as well as emission reductions associated with the energy system impacts. The net CO_2-equivalent emission reductions are 93 thousand metric tons.

[3] The engineering compliance costs are annualized using a 7 percent discount rate.

[4] Reduced exposure to VOC emissions, PM2.5 and ozone exposure, visibility and vegetation effects, and climate effects are co-benefits.

1.4 Organization of this Report

The remainder of this report details the methodology and the results of the RIA. Section 2 presents the industry profile of the oil and natural gas industry. Section 3 describes the emissions and engineering cost analysis. Section 4 presents the benefits analysis. Section 5 presents statutory and executive order analyses. Section 6 presents a comparison of benefits and costs. Section 7 presents energy system impact, employment impact, and small business impact analyses.

7 ECONOMIC IMPACT ANALYSIS AND DISTRIBUTIONAL ASSESSMENTS

7.1 Introduction

This section includes three sets of analyses for both the NSPS and NESHAP amendments:

- Energy System Impacts
- Employment Impacts
- Small Business Impacts Analysis

7.2 Energy System Impacts Analysis of Proposed NSPS

We use the National Energy Modeling System (NEMS) to estimate the impacts of the proposed NSPS on the U.S. energy system. The impacts we estimate include changes in drilling activity, price and quantity changes in the production and consumption of crude oil and natural gas, and changes in international trade of crude oil and natural gas. We evaluate whether and to what extent the increased production costs imposed by the NSPS might alter the mix of fuels consumed at a national level. With this information we estimate how the changed fuel mix affects national level CO_2-equivalent greenhouse gas emissions from energy sources. We additionally combine these estimates of changes in CO_2-equivalent greenhouse gas emissions from energy sources and emissions co-reductions of methane from the engineering analysis with NEMS analysis to estimate the net change in CO_2-equivalent greenhouse gas emissions from energy-related sources, but this analysis is reserved for the secondary environmental impacts analysis within Section 4.

A brief conceptual discussion about our energy system impacts modeling approach is necessary before going into detail on NEMS, how we implemented the regulatory impacts, and results. Economically, it is possible to view the recovered natural gas as an explicit output or as contributing to an efficiency gain at the producer level. For example, the analysis for the proposed NSPS shows that about 97 percent of the natural gas captured by emissions controls suggested by the rule is captured by performing RECs on new and existing wells that are completed after being hydraulically fractured. The assumed $4/Mcf price for natural gas is the price paid to producers at the wellhead. In the natural gas industry, production is metered at or very near to the wellhead, and producers are paid based upon this metered production. Depending on the situation, the gas captured by RECs is sent through a temporary or permanent meter. Payments for the gas are typically made within 30 days.

To preview the energy systems modeling using NEMS, results show that after economic adjustments to the new regulations are made by producers, the captured natural gas represents both increased output (a slight increment in aggregate production) and increased efficiency (producing slightly more for less). However, because of differing objectives for the regulatory analysis we treat the associated savings differently in the engineering cost analysis (as an explicit output) and in NEMS (as an efficiency gain).

In the engineering cost analysis, it is necessary to estimate the expected costs and revenues from implementing emissions controls at the unit level. Because of this, we estimate the net costs as expected costs minus expected revenues for representative units. On the other hand, NEMS models the profit maximizing behavior of representative project developers at a drilling project level. The net costs of the regulation alter the expected discounted cash flow of drilling and implementing oil and gas projects, and the behavior of the representative drillers adjusts accordingly. While in the regulatory case natural gas drilling has become more efficient because of the gas recovery, project developers still interact with markets for which supply and demand are simultaneously adjusting. Consequently, project development adjusts to a new equilibrium. While we believe the cost savings as measured by revenues from selling recovered gas (engineering costs) and measured by cost savings from averted production through efficiency gains (energy economic modeling) are approximately the same, it is important to note that the engineering cost analysis and the national-level cost estimates do not incorporate economic feedbacks such as supply and demand adjustments.

7.2.1 Description of the Department of Energy National Energy Modeling System

NEMS is a model of U.S. energy economy developed and maintained by the Energy Information Administration of the U.S. Department of Energy. NEMS is used to produce the Annual Energy Outlook, a reference publication that provides detailed forecasts of the energy economy from the current year to 2035. DOE first developed NEMS in the 1980s, and the model has been undergone frequent updates and expansion since. DOE uses the modeling system extensively to produce issue reports, legislative analyses, and respond to Congressional inquiries.

EIA is legally required to make the NEMS system source code available and fully documented for the public. The source code and accompanying documentation is released annually when a new Annual Energy Outlook is produced. Because of the availability of the NEMS model, numerous agencies, national laboratories, research institutes, and academic and private-sector researchers have used NEMS to analyze a variety of issues.

NEMS models the dynamics of energy markets and their interactions with the broader U.S. economy. The system projects the production of energy resources such as oil, natural gas, coal, and renewable fuels, the conversion of resources through processes such as refining and electricity generation, and the quantity and prices for final consumption across sectors and regions. The dynamics of the energy system are governed by assumptions about energy and environmental policies, technological developments, resource supplies, demography, and macroeconomic conditions. An overview of the model and complete documentation of NEMS can be found at <http://www.eia.doe.gov/oiaf/aeo/overview/index.html>.

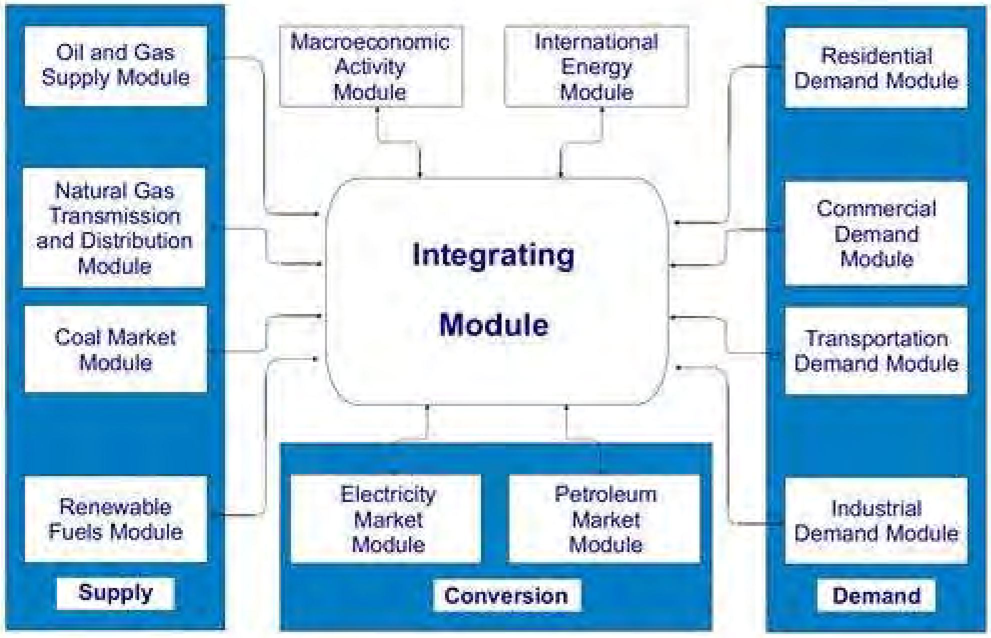


Figure 7-1 Organization of NEMS Modules (source: U.S. Energy Information Administration)

NEMS is a large-scale, deterministic mathematical programming model. NEMS iteratively solves multiple models, linear and non-linear, using nonlinear Gauss-Seidel methods (Gabriel et al. 2001). What this means is that NEMS solves a single module, holding all else constant at provisional solutions, then moves to the next model after establishing an updated provisional solution.

NEMS provides what EIA refers to as "mid-term" projections to the year 2035. However, as this RIA is concerned with estimating regulatory impacts in the first year of full implementation, our analysis focuses upon estimated impacts in the year 2015, with regulatory costs first imposed in 2011. For this RIA, we draw upon the same assumptions and model used in the Annual Energy Outlook 2011.[51] The RIA baseline is consistent with that of the Annual Energy Outlook 2011 which is used extensively in Section 2 in the Industry Profile.

[51] Assumptions for the 2011 Annual Energy Outlook can be found at <http://www.eia.gov/forecasts/aeo/assumptions/index.cfm>.

7.2.2 Inputs to National Energy Modeling System

To model potential impacts associated with the NSPS, we modified oil and gas production costs within the Oil and Gas Supply Module (OGSM) of NEMS and domestic and Canadian natural gas production within the Natural Gas Transmission and Distribution Module (NGTDM). The OGSM projects domestic oil and gas production from onshore, offshore, Alaskan wells, as well as having a smaller-scale treatment of Canadian oil and gas production (U.S. EIA, 2010). The treatment of oil and gas resources is detailed in that oil, shale oil, conventional gas, shale gas, tight sands gas, and coalbed methane (CBM) are explicitly modeled. New exploration and development is pursued in the OGSM if the expected net present value of extracted resources exceeds expected costs, including costs associated with capital, exploration, development, production, and taxes. Detailed technology and reservoir-level production economics govern finding and success rates and costs.

The structure of the OGSM is amenable to analyzing potential impacts of the Oil and Natural Gas NSPS. We are able to target additional expenditures for environmental controls expected to be required by the NSPS on new exploratory and developmental oil and gas production activities, as well as add additional costs to existing projects. We model the impacts of additional environmental costs, as well as the impacts of additional product recovery. We explicitly model the additional natural gas recovered when implementing the NSPS regulatory options. However, we are unable to explicitly model the additional production of condensates expected to be recovered by reduced emissions completions, although we incorporate expected revenues from the condensate recovery in the economic evaluation of new drilling projects.

While the oil production simulated by the OGSM is sent to the refining module (the Petroleum Market Module), simulated natural gas production is sent to a transmission and distribution network captured in the NGTDM. The NGTDM balances gas supplies and prices and "negotiates" supply and consumption to determine a regional equilibrium between supply, demand and prices, including imports and exports via pipeline or LNG. Natural gas transmitted through a simplified arc-node representation of pipeline infrastructure based upon pipeline economics.

7.2.2.1 Compliance Costs for Oil and Gas Exploration and Production

As the NSPS affects new emissions sources, we chose to estimate impacts on new exploration and development projects by adding costs of environmental regulation to the algorithm that evaluates the profitability of new projects. Additional NSPS costs associated with reduced emission completions and future recompletions for new wells are added to drilling, completion, and stimulation costs, as these are, in effect, associated with activities that occur within a single time period, although they may be repeated periodically, as in the case of recompletions. Costs required for reduced emissions recompletions on existing wells are added to stimulation expenses for existing wells exclusively. Other costs are operations and maintenance-type costs and are added to fixed operation and maintenance (O&M) expenses associated with new projects. The one-shot and continuing O&M expenses are estimated and entered on a per well basis, depending on whether the costs would apply to oil wells, natural gas wells, both oil and natural gas wells, or a subset of either. We base the per well cost estimates on the engineering costs including revenues from additional product recovery. This approach is appropriate given the structure of the NEMS algorithm that estimates the net present value of drilling projects.

One concern in basing the regulatory costs inputs into NEMS on the net cost of the compliance activity (estimated annualized cost of compliance minus estimated revenue from product recovery) is that potential barriers to obtaining capital may not be adequately incorporated in the model. However, in general, potential barriers to obtaining additional capital should be reflected in the annualized cost via these barriers increasing the cost of capital. With this in mind, assuming the estimates of capital costs and product recovery are valid, the NEMS results will reflect barriers to obtaining the retired capital. A caveat to this is that the estimated unit-level capital costs of controls which are newly required at a national-level as a result of the proposed regulation—RECs, for example—may not incorporate potential additional transitional costs as the supply of control equipment adjusts to new demand.

Table 7-1 shows the incremental O&M expenses that accrue to new drilling projects as a result of producers having to comply with the relevant NSPS option. We estimate those costs as a function of new wells expected to be drilled in a representative year. To arrive at estimates of the per well costs, we first identify which emissions reductions will apply primarily to crude oil wells, to natural gas wells, or to both crude oil and natural gas wells. Based on the baseline projections of successful completions in 2015, we used 19,097 new natural gas wells and 12,193 new oil wells as the basis of these calculations. We then divide the estimated compliance costs for the given emissions point (from Table 3-3) by the appropriate number of expected new wells in the year of analysis. The result yields an approximation of a per well compliance costs. We assume this approximation is representative of the incremental cost faced by a producer when evaluating a prospective drilling project.

Like the engineering analysis, we assume that hydraulically fractured well completions and recompletions will be required of wells drilled into tight sand, shale gas, and coalbed methane formations. While costs for well recompletions reflect the cost of a single recompletion, the engineering cost analysis assumed that one in ten new wells drilled after the implementation of the promulgation and implementation of the NSPS are completed using hydraulic fracturing will receive a recompletion in any given year using hydraulic fracturing. Meanwhile, within NEMS, wells are assumed to be stimulated every five years. We assume these more frequent stimulations are less intensive than stimulation using hydraulic fracturing but add costs such that the recompletions costs reflect the same assumptions as the engineering analysis. In entering compliance costs into NEMS, we also account for reduced emissions completions, completion combustion, and recompletions performed in absence of the regulation, using the same assumptions as the engineering costs analysis (Table 7-2).

Table 7-1 Summary of Additional Annualized O&M Costs (on a Per New Well Basis) for Environmental Controls Entered into NEMS

Emissions Sources/Points	Emissions Control	Per Well Costs (2008$) Option 1	Option 2 (Proposed)	Option 3	Wells Applied To in NEMS
Equipment Leaks					
Well Pads	Subpart VV	Not in Option	Not in Option	$3,552	Oil and Gas
Gathering and Boosting Stations	Subpart VV	Not in Option	Not in Option	$806	Gas
Processing Plants	Subpart VVa	Not in Option	$56	$56	None
Transmission Compressor Stations	Subpart VV	Not in Option	Not in Option	$320	Gas
Reciprocating Compressors					
Well Pads	Annual Monitoring/ Maintenance	Not in Option	Not in Option	Not in Option	None
Gathering/Boosting Stations	AMM	$17	$17	$17	Gas
Processing Plants	AMM	$12	$12	$12	Gas
Transmission Compressor Stations	AMM	$19	$19	$19	Gas
Underground Storage Facilities	AMM	$1	$1	$1	Gas
Centrifugal Compressors					
Processing Plants	Dry Seals/Route to Process or Control	-$113	-$113	-$113	Gas
Transmission Compressor Stations	Dry Seals/Route to Process or Control	-$62	-$62	-$62	Gas
Pneumatic Controllers -					
Oil and Gas Production	Low Bleed/Route to Process	-$698	-$698	-$698	Oil and Gas
Natural Gas Transmission and Storage	Low Bleed/Route to Process	$0.10	$0.10	$0.10	Gas
Storage Vessels					
High Throughput	95% control	$143	$143	$143	Oil and Gas
Low Throughput	95% control	Not in Option	Not in Option	Not in Option	None

Table 7-2 Summary of Additional Per Completion/Recompletion Costs (2008$) for Environmental Controls Entered into NEMS

Emissions Sources/Points	Emissions Control	Per Completion/Recompletion Costs (2008$) Option 1	Option 2 (proposed)	Option 3	Wells Applied To in NEMS
Well Completions					
Hydraulically Fractured Gas Wells	REC	-$1,275	-$1,275	-$1,275	New Tight Sand/ Shale Gas/CBM
Conventional Gas Wells	Combustion	Not in Option	Not in Option	Not in Option	None
Oil Wells	Combustion	Not in Option	Not in Option	Not in Option	None
Well Recompletions					
Hydraulically Fractured Gas Wells (post-NSPS wells)	REC	-$1,535	-$1,535	-$1,535	Existing Tight Sand/ Shale Gas /Coalbed Methane
Hydraulically Fractured Gas Wells (existing wells)	REC	Not in Option	-$1,535	-$1,535	Existing Tight Sand/ Shale Gas /Coalbed Methane
Conventional Gas Wells	Combustion	Not in Option	Not in Option	Not in Option	None
Oil Wells	Combustion	Not in Option	Not in Option	Not in Option	None

7.2.2.2 Adding Averted Methane Emissions into Natural Gas Production

A significant benefit of controlling VOC emissions from oil and natural gas production is that methane that would otherwise be lost to the atmosphere can be directed into the natural gas production stream. We chose to model methane capture in NEMS as an increase in natural gas industry productivity, ensuring that, within the model, natural gas reservoirs are not decremented by production gains from methane capture. We add estimates of the quantities of methane captured (or otherwise not vented or combusted) to the base quantities that the OGSM model supplies to the NGTDM model. We subdivide the estimates of commercially valuable averted emissions by region and well type in order to more accurately portray the economics of implementing the environmental technology. Adding the averted methane emissions in this manner has the effect of moving the natural gas supply curve to the right an increment consistent with the technically achievable emissions transferred into the production stream as a result of the proposed NSPS.

For all control options, with the exception of recompletions on existing wells, we enter the increased natural gas recovery into NEMS on a per-well basis for new wells, following an estimation procedure similar to that of entering compliance costs into NEMS on a per well basis for new wells. Because each NSPS Option is composed of a different suite of emissions controls, the per-well natural gas recovery value for new wells is different across wells. For Option 1, we estimate that natural gas recovery is 5,739 Mcf per well. For Option 2 and Option 3, we estimate that natural gas recovery is 5,743 Mcf per well. We make a simplifying assumption that natural gas recovery accruing to new wells accrues to new wells in shale gas, tight sands, and CBM fields. We make these assumptions because new wells in these fields are more likely to satisfy criteria such that RECs are required, which contributed that large majority of potential natural gas recovery. Note that these per well natural gas recovery is lower than the per well estimate when RECs are implemented. The estimate is lower because we account for emissions that are combusted, RECs that are implemented absent Federal regulation, as well as the likelihood that natural gas is used during processing and transmission or reinjected.

We treat the potential natural gas recovery associated with recompletions of existing wells (in proposed Option 2 and Option 3) differently in that we estimated the natural gas recovery by natural gas resource type and NSPS Option based on a combination of the engineering analysis and production patterns from the 2011 Annual Energy Outlook. We estimate that additional natural gas product recovered by recompleting existing wells in proposed Option 2 and Option 3 to be 78.7 bcf, with 38.4 bcf accruing to shale gas, 31.4 bcf accruing to tight sands, and 8.9 bcf accruing to CBM, respectively. This quantity is distributed within the NGTDM to reflect regional production by resource type.

7.2.2.3 Fixing Canadian Drilling Costs to Baseline Path

Domestic drilling costs serve as a proxy for Canadian drilling costs in the Canadian oil and natural gas sub-model within the NGTDM. This implies that, without additional modification, additional costs imposed by a U.S. regulation will also impact drilling decisions in Canada. Changes in international oil and gas trade are important in the analysis, as a large majority of natural gas imported into the U.S. originates in Canada. To avoid this problem, we fixed Canadian drilling costs using U.S. drilling costs from the baseline scenario. This solution enables a more accurate analysis of U.S.-Canada energy trade, as increased drilling costs in the U.S. as a result of environmental regulation serve to increase Canada's comparative advantage.

7.2.3 Energy System Impacts

As mentioned earlier, we estimate impacts to drilling activity, reserves, price and quantity changes in the production and consumption of crude oil and natural gas, and changes in international trade of crude oil and natural gas, as well as whether and to what extent the NSPS might alter the mix of fuels consumed at a national level. In each of these estimates, we present estimates for the baseline year of 2015 and results for the three NSPS options. For context, we provide estimates of production activities in 2011.

7.2.3.1 Impacts on Drilling Activities

Because the potential costs of the NSPS options are concentrated in production activities, we first report estimates of impacts on crude oil and natural gas drilling activities and production and price changes at the wellhead. Table 7-3 presents estimates of successful wells drilled in the U.S. in 2015, the analysis year, for the three NSPS options and in the baseline.

Table 7-3 Successful Oil and Gas Wells Drilled, NSPS Options

		Future NSPS Scenario, 2015			
	2011	**Baseline**	**Option 1**	**Option 2 (Proposed)**	**Option 3**
Successful Wells Drilled					
Natural Gas	16,373	19,097	19,191	18,935	18,872
Crude Oil	10,352	11,025	11,025	11,025	11,028
Total	**26,725**	**30,122**	**30,216**	**29,960**	**29,900**
% Change in Successful Wells Drilled from Baseline					
Natural Gas			0.49%	-0.85%	-1.18%
Crude Oil			0.00%	0.00%	0.03%
Total			**0.31%**	**-0.54%**	**-0.74%**

We estimate that the number of successful natural gas wells drilled increases slightly for Option 1, while the number of successful crude oil wells drilled does not change. In Options 2, where costs of the natural gas processing plants equipment leaks standard and REC requirements for existing wells apply, natural gas wells drilling is forecast to decrease less than 1 percent, while crude oil drilling does not change. For Option 3, where the addition of an additional equipment leak standards add to the incremental costs, natural gas well drilling is estimated to decrease about 1.2%. The number of successful crude oil wells drilled under Option 3 increases very slightly. While it may seem counter-intuitive that the number of successful crude wells increased as costs increase, it is important to note that crude oil and natural gas drilling compete with each other for factors of production, such as labor and material. The environmental compliance costs of the NSPS options predominantly affect natural gas drilling. As natural gas drilling declines, for example, as a result of increased compliance costs, crude oil drilling may increase because of the increased availability of labor and material, as well as the likelihood that crude oil can substitute for natural gas to some extent.

Table 7-4 presents the forecast of successful wells by well type, for onshore drilling in the lower 48 states. The results show that conventional well drilling is unaffected by the regulatory options, as reduced emission completion and completion combustion requirements are directed not toward wells in conventional reserves but toward wells that are hydraulically fractured, the wells in so-called unconventional reserves. The impacts on drilling tight sands, shale gas, and coalbed methane vary by option.

Table 7-4 Successful Wells Drilled by Well Type (Onshore, Lower 48 States), NSPS Options

		Future NSPS Scenario, 2015			
	2011	**Baseline**	**Option 1**	**Option 2 (Proposed)**	**Option 3**
Successful Wells Drilled					
Conventional Gas Wells	7,267	7,607	7,607	7,607	7,607
Tight Sands	2,441	2,772	2,791	2,816	2,780
Shale Gas	5,007	7,022	7,074	6,763	6,771
Coalbed Methane	1,593	1,609	1,632	1,662	1,627
Total	**16,308**	**19,010**	**19,104**	**18,849**	**18,785**
% Change in Successful Wells Drilled from Baseline					
Conventional Gas Wells			0.00%	0.00%	0.00%
Tight Sands			0.70%	1.60%	0.29%
Shale Gas			0.74%	-3.68%	-3.57%
Coalbed Methane			1.44%	3.28%	1.09%
Total			**0.50%**	**-0.85%**	**-1.18%**

Well drilling in tight sands is estimated to increase slightly from the baseline under all three options, 0.70 percent, 1.60 percent, and 0.29% for Options 1, 2, and 3, respectively. Wells in CBM reserves are also estimated to increase from the baseline under all three options, or 1.44 percent, 3.28 percent, and 1.09 percent for Options 1, 2, and 3, respectively. However, drilling in shale gas is forecast to decline from the baseline under Options 2 and 3, by 3.68 percent and 3.57 percent, respectively.

7.2.3.2 Impacts on Production, Prices, and Consumption

Table 7-5 shows estimates of the changes in the domestic production of natural gas and crude oil under the NSPS options, as of 2015. Domestic crude oil production is not forecast to change under any of the three regulatory options, again because impacts on crude oil drilling of the NSPS are expected to be negligible.

Table 7-5 Annual Domestic Natural Gas and Crude Oil Production, NSPS Options

		Future NSPS Scenario, 2015			
	2011	**Baseline**	**Option 1**	**Option 2 (Proposed)**	**Option 3**
Domestic Production					
Natural Gas (trillion cubic feet)	21.05	22.43	22.47	22.45	22.44
Crude Oil (million barrels/day)	5.46	5.81	5.81	5.81	5.81
% Change in Domestic Production from Baseline					
Natural Gas			0.18%	0.09%	0.04%
Crude Oil			0.00%	0.00%	0.00%

Natural gas production, on the other hand, increases under all three regulatory options for the NSPS from the baseline. A main driver for these increases is the additional natural gas recovery engendered by the control requirements. Another driver for the increases under Option 1 is the increase in natural gas well drilling. While we showed earlier that natural gas drilling is estimated to decline under Options 2 and 3, the increased natural gas recovery is sufficient to offset the production loss from relatively fewer producing wells.

For the proposed option, the NEMS analysis shown in Table 7-5 estimates a 20 bcf increase in domestic natural gas production. This amount is less than the amount estimated in the engineering analysis to be captured by emissions controls implemented as a result of the proposed NSPS (approximately 180 bcf). This difference is because NEMS models the adjustment of energy markets to the now relatively more efficient natural gas production sector. At the new natural gas supply and demand equilibrium in 2015, the modeling estimates 20 bcf more gas is produced at a relatively lower wellhead price (which will be presented momentarily). However, at the new equilibrium, producers implementing emissions controls still capture and sell approximately 180 bcf of natural gas. For example, as shown in Table 7-4, about 11,200 new unconventional natural gas wells are completed under the proposed NSPS; using assumptions from the engineering cost analysis about RECs required under State regulations and exploratory wells exempted from REC requirements, about 9,000 NSPS-required RECs would be performed on new natural gas well completions, according to the NEMS analysis. This recovered natural gas substitutes for natural gas that would be produced from the ground absent the rule. In effect, then, about 160 bcf of natural gas that would have been extracted and emitted into the atmosphere is left in the formation for future extraction.

As we showed for natural gas drilling, Table 7-6 shows natural gas production from onshore wells in the lower 48 states by type of well, predicted for 2015, the analysis year. Production from conventional natural gas wells and CBM wells are estimated to increase under all NSPS regulatory options. Production from shale gas reserves is estimated to decrease under Options 2 and 3, however, from the baseline projection. Production from tight sands is forecast to decline slightly under Option 1.

Table 7-6 Natural Gas Production by Well Type (Onshore, Lower 48 States), NSPS Options

		Future NSPS Scenario, 2015			
	2011	Baseline	Option 1	Option 2 (Proposed)	Option 3
Natural Gas Production by Well Type (trillion cubic feet)					
Conventional Gas Wells	4.06	3.74	3.75	3.76	3.76
Tight Sands	5.96	5.89	5.87	6.00	6.00
Shale Gas	5.21	7.20	7.26	7.06	7.06
Coalbed Methane	1.72	1.67	1.69	1.72	1.71
Total	**16.95**	**18.51**	**18.57**	**18.54**	**18.53**
% Change in Natural Gas Production by Well Type from Baseline					
Conventional Gas Wells			0.32%	0.42%	0.48%
Tight Sands			-0.43%	1.82%	1.72%
Shale Gas			0.73%	-1.97%	-1.93%
Coalbed Methane			1.07%	2.86%	2.60%
Total			0.31%	0.16%	0.13%

Note: Totals may not sum due to independent rounding.

Overall, of the regulatory options, the proposed Option 2 is estimated to have the highest natural gas production from onshore wells in the lower 48 states, showing a 1.2% increase over the baseline projection.

Table 7-7 presents estimates of national average wellhead natural gas and crude oil prices for onshore production in the lower 48 states, estimated for 2015, the year of analysis. All NSPS options show a decrease in wellhead natural gas and crude oil prices. The decrease in wellhead natural gas price form the baseline is attributable largely to the increased productivity of natural gas wells as a result of capturing a portion of completion emissions (in Options 1, 2, and 3) and in capturing recompletion emissions (in Options 2 and 3).

Table 7-7 Lower 48 Average Natural Gas and Crude Oil Wellhead Price, NSPS Options

		Future NSPS Scenario, 2015			
	2011	**Baseline**	**Option 1**	**Option 2 (Proposed)**	**Option 3**
Lower 48 Average Wellhead Price					
Natural Gas (2008$ per Mcf)	4.07	4.22	4.18	4.18	4.19
Crude Oil (2008$ per barrel)	83.65	94.60	94.59	94.58	94.58
% Change in Lower 48 Average Wellhead Price from Baseline					
Natural Gas			-0.94%	-0.94%	-0.71%
Crude Oil			-0.01%	-0.02%	-0.02%

Table 7-8 presents estimates of the price of natural gas to final consumers in 2008 dollars per million BTU. The production price decreases estimated across NSPS are largely passed on to consumers but distributed unequally across consuming sectors. Electric power sector consumers of natural gas are estimated to receive the largest price decrease while the transportation and residential sectors are forecast to receive the smallest price decreases.

Table 7-8 Delivered Natural Gas Prices by Sector (2008$ per million BTU), 2015, NSPS Options

		Future NSPS Scenario, 2015			
	2011	**Baseline**	**Option 1**	**Option 2 (Proposed)**	**Option 3**
Delivered Prices (2008$ per million BTU)					
Residential	10.52	10.35	10.32	10.32	10.33
Commercial	9.26	8.56	8.52	8.53	8.54
Industrial	4.97	5.08	5.05	5.05	5.06
Electric Power	4.81	4.77	4.73	4.74	4.75
Transportation	12.30	12.24	12.20	12.22	12.22
Average	**6.76**	**6.59**	**6.55**	**6.57**	**6.57**
% Change in Delivered Prices from Baseline					
Residential			**-0.29%**	**-0.29%**	**-0.19%**
Commercial			**-0.47%**	**-0.35%**	**-0.23%**
Industrial			**-0.59%**	**-0.59%**	**-0.39%**
Electric Power			**-0.84%**	**-0.63%**	**-0.42%**
Transportation			**-0.33%**	**-0.16%**	**-0.16%**
Average			**-0.60%**	**-0.41%**	**-0.30%**

Final consumption of natural gas is also estimated to increase in 2015 from the baseline under all NSPS options, as is shown on Table 7-9. Like delivered price, the consumption shifts are distributed differently across sectors.

Table 7-9 Natural Gas Consumption by Sector, NSPS Options

		Future NSPS Scenario, 2015			
	2011	**Baseline**	**Option 1**	**Option 2 (Proposed)**	**Option 3**
Consumption (trillion cubic feet)					
Residential	4.76	4.81	4.81	4.81	4.81
Commercial	3.22	3.38	3.38	3.38	3.38
Industrial	6.95	8.05	8.06	8.06	8.06
Electric Power	7.00	6.98	7.00	6.98	6.97
Transportation	0.03	0.04	0.04	0.04	0.04
Pipeline Fuel	0.64	0.65	0.65	0.66	0.66
Lease and Plant Fuel	1.27	1.20	1.21	1.21	1.21
Total	**23.86**	**25.11**	**25.15**	**25.14**	**25.13**
% Change in Consumption from Baseline					
Residential			0.00%	0.00%	0.00%
Commercial			0.00%	0.00%	0.00%
Industrial			0.12%	0.12%	0.12%
Electric Power			0.29%	0.00%	-0.14%
Transportation			0.00%	0.00%	0.00%
Pipeline Fuel			0.00%	1.54%	1.54%
Lease and Plant Fuel			0.83%	0.83%	0.83%
Total			**0.16%**	**0.12%**	**0.08%**

Note: Totals may not sum due to independent rounding.

7.2.3.3 Impacts on Imports and National Fuel Mix

The NEMS modeling shows that impacts from all NSPS options are not sufficiently large to affect the trade balance of natural gas. As shown in Table 7-10, estimates of crude oil and natural gas imports do not vary from the baseline in 2015 for each regulatory option.

Table 7-10 Net Imports of Natural Gas and Crude Oil, NSPS Options

		Future NSPS Scenario, 2015			
	2011	Baseline	Option 1	Option 2 (Proposed)	Option 3
Net Imports					
Natural Gas (trillion cubic feet)	2.75	2.69	2.69	2.69	2.69
Crude Oil (million barrels/day)	9.13	8.70	8.70	8.70	8.70
% Change in Net Imports					
Natural Gas			0.00%	0.00%	0.00%
Crude Oil			0.00%	0.00%	0.00%

Table 7-11 evaluates estimates of energy consumption by energy type at the national level for 2015, the year of analysis. All three NSPS options are estimated to have small effects at the national level. For Option 1, we estimate an increase in 0.02 quadrillion BTU in 2015, a 0.02 percent increase. The percent contribution of natural gas and biomass is projected to increase, while the percent contribution of liquid fuels and coal is expected to decrease under Option 1. Meanwhile, under the proposed Options 2, total energy consumption is also forecast to rise 0.02 quadrillion BTU, with increase coming from natural gas primarily, with an additional small increase in coal consumption. Under Option 3, total energy consumption is forecast to rise 0.01 quadrillion BTU, or 0.01%, with a slight decrease in liquid fuel consumption from the baseline, but increases in natural gas and coal consumption.

Table 7-11 Total Energy Consumption by Energy Type (Quadrillion BTU), NSPS Options

		Future NSPS Scenario, 2015			
	2011	Baseline	Option 1	Option 2 (Proposed)	Option 3
Consumption (quadrillion BTU)					
Liquid Fuels	37.41	39.10	39.09	39.10	39.09
Natural gas	24.49	25.77	25.82	25.79	25.79
Coal	20.42	19.73	19.71	19.74	19.74
Nuclear Power	8.40	8.77	8.77	8.77	8.77
Hydropower	2.58	2.92	2.92	2.92	2.92
Biomass	2.98	3.27	3.28	3.27	3.27
Other Renewable Energy	1.72	2.14	2.14	2.14	2.14
Other	0.30	0.31	0.31	0.31	0.31
Total	**98.29**	**102.02**	**102.04**	**102.04**	**102.03**
% Change in Consumption from Baseline					
Liquid Fuels			-0.03%	0.00%	-0.03%
Natural Gas			0.19%	0.08%	0.08%
Coal			-0.10%	0.05%	0.05%
Nuclear Power			0.00%	0.00%	0.00%
Hydropower			0.00%	0.00%	0.00%
Biomass			0.31%	0.00%	0.00%
Other Renewable Energy			0.00%	0.00%	0.00%
Other			0.00%	0.00%	0.00%
Total			**0.02%**	**0.02%**	**0.01%**

Note: Totals may not sum due to independent rounding.

With the national profile of energy consumption estimated to change slightly under the regulatory options in 2015, the year of analysis, it is important to examine whether aggregate energy-related CO_2-equivalent greenhouse gas (GHG) emissions also shift. A more detailed discussion of changes in CO_2-equivalent GHG emissions from a baseline is presented within the benefits analysis in Section 4. Here, we present a single NEMS-based table showing estimated changes in energy-related “consumer-side” GHG emissions. We use the terms “consumer-side” emissions to distinguish emissions from the consumption of fuel from emissions specifically associated with the extraction, processing, and transportation of fuels in the oil and natural gas sector under examination in this RIA. We term the emissions associated with extraction, processing, and transportation of fuels “producer-side” emissions.

Table 7-12 Modeled Change in Energy-related "Consumer-Side" CO_2-equivalent GHG Emissions

		Future NSPS Scenario, 2015			
	2011	Baseline	Option 1	Option 2 (Proposed)	Option 3
Energy-related CO_2-equivalent GHG Emissions (million metric tons CO_2-equivalent)					
Petroleum	2,359.59	2,433.60	2,433.12	2,433.49	2,433.45
Natural Gas	1,283.78	1,352.20	1,354.47	1,353.19	1,352.87
Coal	1,946.02	1,882.08	1,879.84	1,883.24	1,883.30
Other	11.99	11.99	11.99	11.99	11.99
Total	**5,601.39**	**5,679.87**	**5,679.42**	**5,681.91**	**5,681.61**
% Change in Energy-related CO_2-equivalent GHG Emissions from Baseline					
Petroleum			-0.02%	0.00%	-0.01%
Natural Gas			0.17%	0.07%	0.05%
Coal			-0.12%	0.06%	0.06%
Other			0.00%	0.00%	0.00%
Total			**-0.01%**	**0.04%**	**0.03%**

Note: Excludes "producer-side" emissions and emissions reductions estimated to result from NSPS alternatives. Totals may not sum due to independent rounding.

As is shown in Table 7-12, NSPS Option 1 is predicted to slightly decrease aggregate consumer-side energy-related CO_2-equivalent GHG emissions, by about 0.01 percent, while the mix of emissions shifts slightly away from coal and petroleum toward natural gas. Proposed Options 2 and 3 are estimated to increase consumer-side aggregate energy-related CO_2-equivalent GHG emissions by about 0.04 and 0.03 percent, respectively, mainly because consumer-side emissions from natural gas and coal combustion increase slightly.

7.3 Employment Impact Analysis

While a standalone analysis of employment impacts is not included in a standard cost-benefit analysis, such an analysis is of particular concern in the current economic climate of sustained high unemployment. Executive Order 13563, states, "Our regulatory system must protect public health, welfare, safety, and our environment while promoting economic growth, innovation, competitiveness, and job creation" (emphasis added). Therefore, we seek to inform the discussion of labor demand and job impacts by providing an estimate of the employment impacts of the proposed regulations using labor requirements for the installation, operation, and maintenance of control requirements, as well as reporting and recordkeeping requirements. Unlike several recent RIAs, however, we do not provide employment impacts estimates based on the study by Morgenstern et al. (2002); we discuss this decision after presenting estimates of the labor requirements associated with reporting and recordkeeping and the installation, operation, and maintenance of control requirements.

7.3.1 Employment Impacts from Pollution Control Requirements

Regulations set in motion new orders for pollution control equipment and services. New categories of employment have been created in the process of implementing regulations to make our air safer to breathe. When a new regulation is promulgated, a response of industry is to order pollution control equipment and services in order to comply with the regulation when it becomes effective. Revenue and employment in the environmental technology industry have grown steadily between 2000 and 2008, reaching an industry total of approximately $300 billion in revenues and 1.7 million employees in 2008.[52] While these revenues and employment figures represent gains for the environmental technologies industry, they are costs to the regulated industries required to install the equipment. Moreover, it is not clear the 1.7 million employees in 2008 represent new employment as opposed to workers being shifted from the production of goods and services to environmental compliance activities.

Once the equipment is installed, regulated firms hire workers to operate and maintain the pollution control equipment – much like they hire workers to produce more output. Morgenstern et al. (2002) examined how regulated industries respond to regulation. The authors found that, on average for the industries they studied, employment increases in regulated firms. Of course, these firms may also reassign existing employees to perform these activities.

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[52] In 2008, the industry totaled approximately $315 billion in revenues and 1.9 million employees including indirect employment effects, pollution abatement equipment production employed approximately 4.2 million workers in 2008. These indirect employment effects are based on a multiplier for indirect employment = 2.24 (1982 value from Nestor and Pasurka - approximate middle of range of multipliers 1977-1991). Environmental Business International (EBI), Inc., San Diego, CA. Environmental Business Journal, monthly (copyright). http://www.ebiusa.com/ EBI data taken from the Department of Commerce International Trade Administration Environmental Industries Fact Sheet from April 2010: http://web.ita.doc.gov/ete/eteinfo.nsf/068f3801d047f26e85256883006ffa54/4878b7e2fc08ac6d85256883006c452c?OpenDocument

Environmental regulations support employment in many basic industries. In addition to the increase in employment in the environmental protection industry (via increased orders for pollution control equipment), environmental regulations also support employment in industries that provide intermediate goods to the environmental protection industry. The equipment manufacturers, in turn, order steel, tanks, vessels, blowers, pumps, and chemicals to manufacture and install the equipment. Bezdek et al. (2008) found that investments in environmental protection industries create jobs and displace jobs, but the net effect on employment is positive.

The focus of this part of the analysis is on labor requirements related to the compliance actions of the affected entities within the affected sector. We do not estimate any potential changes in labor outside of the oil and natural gas sector. This analysis estimates the employment impacts due to the installation, operation, and maintenance of control equipment, as well as employment associated with new reporting and recordkeeping requirements.

It is important to highlight that unlike the typical case where to reduce a bad output (i.e., emissions) a firm often has to reduce production of the good output, many of the emission controls required by the proposed NSPS will simultaneously increase production of the good output and reduce production of bad outputs. That is, these controls jointly produce environmental improvements and increase output in the regulated sector. New labor associated with implementing these controls to comply with the new regulations can also be viewed as additional labor increasing output while reducing undesirable emissions.

No estimates of the labor used to manufacture or assemble pollution control equipment or to supply the materials for manufacture or assembly are included because U.S. EPA does not currently have this information. The employment analysis uses a bottom-up engineering-based methodology to estimate employment impacts. The engineering cost analysis summarized in this RIA includes estimates of the labor requirements associated with implementing the proposed regulations. Each of these labor changes may either be required as part of an initial effort to comply with the new regulation or required as a continuous or annual effort to maintain compliance. We estimate up-front and continual, annual labor requirements by estimating hours of labor required and converting this number to full-time equivalents (FTEs) by dividing by 2,080 (40 hours per week multiplied by 52 weeks). We note that this type of FTE estimate cannot be used to make assumptions about the specific number of people involved or whether new jobs are created for new employees.

In other employment analyses U.S. EPA distinguished between employment changes within the regulated industry and those changes outside the regulated industry (e.g. a contractor from outside the regulated facility is employed to install a control device). For this regulation however, the structure of the industry makes this difficult. The mix of in-house versus contracting services used by firms is very case-specific in the oil and natural gas industry. For example, sometimes the owner of the well, processing plant, or transmission pipelines uses in–house employees extensively in daily operations, while in other cases the owner relies on outside contractors for many of these services. For this reason, we make no distinction in the quantitative estimates between labor changes within and outside of the regulated sector.

The results of this employment estimate are presented in Table 7-13 for the proposed NSPS and in Table 7-14 for the proposed NESHAP amendments. The tables breaks down the installation, operation, and maintenance estimates by type of pollution control evaluated in the RIA and present both the estimated hours required and the conversion of this estimate to FTE. For both the proposed NSPS and NESHAP amendments, reporting and recordkeeping requirements were estimated for the entire rules rather than by anticipated control requirements; the reporting and recordkeeping estimates are consistent with estimates EPA submitted as part of its Information Collection Request (ICR).

The up-front labor requirement is estimated at 230 FTEs for the proposed NSPS and about 120 FTEs for the proposed NESHAP amendments. These up-front FTE labor requirements can be viewed as short-term labor requirements required for affected entities to comply with the new regulation. Ongoing requirements are estimated at about 2,400 FTEs for the proposed NSPS and about 102 FTEs for the proposed NESHAP amendments. These ongoing FTE labor requirements can be viewed as sustained labor requirements required for affected entities to continuously comply with the new regulation

Two main categories contain the majority of the labor requirements for the proposed rules: implementing reduced emissions completions (RECs) and reporting and recordkeeping requirements for the proposed NSPS. Also, note that pneumatic controllers have no up-front or continuing labor requirements. While the controls do require labor for installation, operation, and maintenance, the required labor is less than that of the controllers that would be used absent the regulation. In this instance, we assume the incremental labor requirements are zero.

Implementing RECs are estimated to require about 2,230 FTE, over 90 percent of the total continuing labor requirements for the proposed NSPS.[53] We denote REC-related requirements as continuing, or annual, as the REC requirements will in fact recur annually, albeit at different wells each year. The REC requirements are associated with certain new well completions or existing well recompletions, which while individual completions occur over a short period of time (days to a few weeks), new wells and other existing wells are completed or recompleted annually. Because of these reasons, we assume the REC-related labor requirements are annual.

7.3.2 Employment Impacts Primarily on the Regulated Industry

In previous RIAs, we transferred parameters from a study by Morgenstern et al. (2002) to estimate employment effects of new regulations. (See, for example, the Regulatory Impact Analysis for the recently finalized Industrial Boilers and CISWI rulemakings, promulgated on February 21, 2011). The fundamental insight of Morgenstern, et al. is that environmental regulations can be understood as requiring regulated firms to add a new output (environmental quality) to their product mixes. Although legally compelled to satisfy this new demand, regulated firms have to finance this additional production with the proceeds of sales of their other (market) products. Satisfying this new demand requires additional inputs, including labor, and may alter the relative proportions of labor and capital used by regulated firms in their production processes.

Morgenstern et al. concluded that increased abatement expenditures in these industries generally do not cause a significant change in employment. Using plant-level Census

[53] As shown on earlier in this section, we project that the number of successful natural gas wells drilled in 2015 will decline slightly from the baseline projection. Therefore, there may be small employment losses in drilling-related employment that partly offset gains in employment from compliance-related activities.

information between the years 1979 and 1991, Morgenstern et al. estimate the size of each effect for four polluting and regulated industries (petroleum refining, plastic material, pulp and paper, and steel). On average across the four industries, each additional $1 million (1987$) spending on pollution abatement results in a (statistically insignificant) net increase of 1.55 (+/- 2.24) jobs. As a result, the authors conclude that increases in pollution abatement expenditures do not necessarily cause economically significant employment changes.

For this version of RIA for the proposed NSPS and NESHAP amendments, however, we chose not to quantitatively estimate employment impacts using Morgenstern et al. because of reasons specific to the oil and natural gas industry and proposed rules. We believe the transfer of parameter estimates from the Morgenstern et al. study to the proposed NSPS and NESHAP amendments is beyond the range of the study for two reasons.

Table 7-13 Labor-based Employment Estimates for Reporting and Recordkeeping and Installing, Operating, and Maintaining Control Equipment Requirements, Proposed NSPS Option in 2015

Source/Emissions Point	Emissions Control	Projected No. of Affected Units	Per Unit Up- Front Labor Estimate (hours)	Per Unit Annual Labor Estimate (hours)	Total Up- Front Labor Estimate (hours)	Total Annual Labor Estimate (hours)	Up-Front Full-Time Equivalent	Annual Full-Time Equivalent
Well Completions								
Hydraulically Fractured Gas Wells	Reduced Emissions Completion (REC)	9,313	0	218	0	2,025,869	0.0	974.0
Hydraulically Fractured Gas Wells	Combustion	446	0	22	0	9,626	0.0	4.6
Well Recompletions								
Hydraulically Fractured Gas Wells (pre-NSPS wells)	REC	12,050	0	218	0	2,621,126	0.0	1,260.2
Equipment Leaks								
Processing Plants	NSPS Subpart VVA	29	587	887	17,023	25,723	8.2	12.4
Reciprocating Compressors								
Gathering/Boosting Stations	AMM	210	1	1	210	210	0.1	0.1
Processing Plants	AMM	375	1	1	375	375	0.2	0.2
Transmission Compressor Stations	AMM	199	1	1	199	199	0.1	0.1
Underground Storage Facilities	AMM	9	1	1	9	9	0.0	0.0
Centrifugal Compressors								
Processing Plants	Dry Seals/Route to Process or Control	16	355	0	5,680	0	2.7	0.0
Transmission Compressor Stations	Dry Seals/Route to Process or Control	14	355	0	4,970	0	2.4	0.0
Pneumatic Controllers								
Oil and Gas Production	Low Bleed/Route to Process	13,632	0	0	0	0	0.0	0.0
Natural Gas Trans. and Storage	Low Bleed/Route to Process	67	0	0	0	0	0.0	0.0
Storage Vessels								
High Throughput	95% control	304	271	190	82,279	57,582	39.6	27.7
Reporting and Recordkeeping for Complete NSPS		---	---	---	360,443	201,342	173.3	96.8
TOTAL		**---**	**---**	**---**	**471,187**	**4,942,060**	**226.5**	**2,376.0**

Note: Full-time equivalents (FTE) are estimated by first multiplying the projected number of affected units by the per unit labor requirements and then multiplying by 2,080 (40 hours multiplied by 52 weeks). Totals may not sum due to independent rounding.

Table 7-14 Labor-based Employment Estimates for Reporting and Recordkeeping and Installing, Operating, and Maintaining Control Equipment Requirements, Proposed NESHAP Amendments in 2015

Source/Emissions Point	Emissions Control	Projected No. of Affected Units	Per Unit One-time Labor Estimate (hours)	Per Unit Annual Labor Estimate (hours)	Total One-Time Labor Estimate (hours)	Total Annual Labor Estimate (hours)	One-time Full-Time Equivalent	Annual Full-Time Equivalent
Small Glycol Dehydrators								
Production	Combustion devices, recovery devices, process modifications	115	27	285	3,108	32,821	1.5	15.8
Transmission	Combustion devices, recovery devices, process modifications	19	27	285	513	5,423	0.2	2.6
Storage Vessels								
Production	Combustion devices, recovery devices	674	311	198	209,753	133,231	100.8	64.1
Reporting and Recordkeeping for Complete NESHAP Amendments		---	---	---	36,462	39,923	17.5	19.2
TOTAL		**---**	**--**	**---**	**249,836**	**211,398**	**120.1**	**101.6**

Note: Full-time equivalents (FTE) are estimated by first multiplying the projected number of affected units by the per unit labor requirements and then multiplying by 2,080 (40 hours multiplied by 52 weeks). Totals may not sum due to independent rounding.

First, the possibility that the revenues producers are estimated to receive from additional natural gas recovery as a result of the proposed NSPS might offset the costs of complying with the rule presents challenges to estimating employment effects (see Section 3.2.2.1 of the RIA for a detailed discussion of the natural gas recovery). The Morgenstern et al. paper, for example, is intended to analyze the impact of environmental compliance expenditures on industry employment levels, and it may not be appropriate to draw on their demand and net effects when compliance costs are expected to be negative.

Second, the proposed regulations primarily affect the natural gas production, processing, and transmission segments of the industry. While the natural gas processing segment of the oil and natural gas industry is similar to petroleum refining, which is examined in Morgenstern et al., the production side of the oil and natural gas (drilling and extraction, primarily) and natural gas pipeline transmission are not similar to petroleum refining. Because of the likelihood of negative compliance costs for the proposed NSPS and the segments of the oil and natural gas industry affected by the proposals are not examined by Morgenstern et al., we decided not to use the parameters estimated by Morgenstern et al. to estimate within-industry employment effects for the proposed oil and natural gas NESHAP amendments and NSPS.

That said, the likelihood of additional natural gas recovery is an important component of the market response to the rule, as it is expected that this additional natural gas recovery will reduce the price of natural gas. Because of the estimated fall in prices in the natural gas sector due to the proposed NSPS, prices in other sectors that consume natural gas are likely drop slightly due to the decrease in energy prices. This small production increase and price decrease may have a slight stimulative effect on employment in industries that consume natural gas.

7.4 Small Business Impacts Analysis

The Regulatory Flexibility Act as amended by the Small Business Regulatory Enforcement Fairness Act (SBREFA) generally requires an agency to prepare a regulatory flexibility analysis of any rule subject to notice and comment rulemaking requirements under the Administrative Procedure Act or any other statute, unless the agency certifies that the rule will not have a significant economic impact on a substantial number of small entities. Small entities include small businesses, small governmental jurisdictions, and small not-for-profit enterprises.

After considering the economic impact of the proposed rules on small entities for both the NESHAP and NSPS, the screening analysis indicates that these proposed rules will not have a significant economic impact on a substantial number of small entities (or "SISNOSE"). The supporting analyses for these determinations are presented in this section of the RIA.

As discussed in previous sections of the economic impact analysis, under the proposed NSPS, some affected producers are likely to be able to recover natural gas that would otherwise be vented to the atmosphere, as well as recover saleable condensates that would otherwise be emitted. EPA estimates that the revenues from this additional natural gas product recovery will offset the costs of implementing control options implemented as a result of the Proposed NSPS. Because the total costs of the rule are likely to be more than offset by the revenues producers gain from increased natural gas recovery, we expect there will be no SISNOSE arising from the proposed NSPS. However, not all components of the proposed NSPS are estimated to have cost savings. Therefore, we analyze potential impacts to better understand the potential distribution of impacts across industry segments and firms. We feel taking this approach strengthens the determination that there will be no SISNOSE. Unlike the controls for the proposed NSPS, the controls evaluated under the proposed NESHAP amendments do not recover significant quantities of natural gas products.

7.4.1 Small Business National Overview

The industry sectors covered by the final rule were identified during the development of the engineering cost analysis. The U.S. Census Bureau's Statistics of U.S. Businesses (SUSB) provides national information on the distribution of economic variables by industry and enterprise size. The Census Bureau and the Office of Advocacy of the Small Business Administration (SBA) supported and developed these files for use in a broad range of economic analyses.[54] Statistics include the total number of establishments, and receipts for all entities in an industry; however, many of these entities may not necessarily be covered by the final rule. SUSB also provides statistics by enterprise employment and receipt size (Table 7-15 and Table 7-16).

[54]See http://www.census.gov/csd/susb/ and http://www.sba.gov/advocacy/ for additional details.

The Census Bureau's definitions used in the SUSB are as follows:

- *Establishment*: A single physical location where business is conducted or where services or industrial operations are performed.
- *Firm:* A firm is a business organization consisting of one or more domestic establishments in the same state and industry that were specified under common ownership or control. The firm and the establishment are the same for single-establishment firms. For each multi-establishment firm, establishments in the same industry within a state will be counted as one firm- the firm employment and annual payroll are summed from the associated establishments.
- *Receipts*: Receipts (net of taxes) are defined as the revenue for goods produced, distributed, or services provided, including revenue earned from premiums, commissions and fees, rents, interest, dividends, and royalties. Receipts exclude all revenue collected for local, state, and federal taxes.
- *Enterprise*: An enterprise is a business organization consisting of one or more domestic establishments that were specified under common ownership or control. The enterprise and the establishment are the same for single-establishment firms. Each multi-establishment company forms one enterprise—the enterprise employment and annual payroll are summed from the associated establishments. Enterprise size designations are determined by the sum of employment of all associated establishments.

Because the SBA's business size definitions (SBA, 2008) apply to an establishment's "ultimate parent company," we assumed in this analysis that the "firm" definition above is consistent with the concept of ultimate parent company that is typically used for SBREFA screening analyses, and the terms are used interchangeably.

Table 7-15 Number of Firms, Total Employment, and Estimated Receipts by Firm Size and NAICS, 2007

			Owned by Firms with:					
NAICS	NAICS Description	SBA Size Standard (effective Nov. 5, 2010)	< 20 Employees	20-99 Employees	100-499 Employees	Total < 500 Employees	> 500 Employees	Total Firms
Number of Firms by Firm Size								
211111	Crude Petroleum and Natural Gas Extraction	500	5,759	455	115	6,329	95	6,424
211112	Natural Gas Liquid Extraction	500	77	9	12	98	41	139
213111	Drilling Oil and Gas Wells	500	1,580	333	97	2,010	49	2,059
486210	Pipeline Transportation of Natural Gas	$7.0 million	63	12	9	84	42	126
Total Employment by Firm Size								
211111	Crude Petroleum and Natural Gas Extraction	500	21,170	16,583	17,869	55,622	77,664	133,286
211112	Natural Gas Liquid Extraction	500	372	305	1,198	1,875	6,648	8,523
213111	Drilling Oil and Gas Wells	500	5,972	13,787	16,893	36,652	69,774	106,426
486210	Pipeline Transportation of Natural Gas	$7.0 million	241	382	1,479	2,102	22,581	24,683
Estimated Receipts by Firm Size ($1000)								
211111	Crude Petroleum and Natural Gas Extraction	500	12,488,688	15,025,443	17,451,805	44,965,936	149,141,316	194,107,252
211112	Natural Gas Liquid Extraction	500	209,640	217,982	1,736,706	2,164,328	37,813,413	39,977,741
213111	Drilling Oil and Gas Wells	500	1,101,481	2,460,301	3,735,652	7,297,434	16,550,804	23,848,238
486210	Pipeline Transportation of Natural Gas	$7.0 million	332,177	518,341	1,448,020	2,298,538	18,498,143	20,796,681

Source: U.S. Census Bureau. 2010. "Number of Firms, Number of Establishments, Employment, Annual Payroll, and Estimated Receipts by Enterprise Receipt Size for the United States, All Industries: 2007." <http://www.census.gov/econ/susb/>

Table 7-16 Distribution of Small and Large Firms by Number of Firms, Total Employment, and Estimated Receipts by Firm Size and NAICS, 2007

			Percent of Firms		
NAICS	NAICS Description	Total Firms	Small Businesses	Large Businesses	Total Firms
Number of Firms by Firm Size					
211111	Crude Petroleum and Natural Gas Extraction	6,424	98.5%	1.5%	100.0%
211112	Natural Gas Liquid Extraction	139	70.5%	29.5%	100.0%
213111	Drilling Oil and Gas Wells	2,059	97.6%	2.4%	100.0%
486210	Pipeline Transportation of Natural Gas	126	48.4%	51.6%	100.0%
Total Employment by Firm Size					
211111	Crude Petroleum and Natural Gas Extraction	133,286	41.7%	58.3%	100.0%
211112	Natural Gas Liquid Extraction	8,523	22.0%	78.0%	100.0%
213111	Drilling Oil and Gas Wells	106,426	34.4%	65.6%	100.0%
486210	Pipeline Transportation of Natural Gas	24,683	N/A*	N/A*	N/A*
Estimated Receipts by Firm Size ($1000)					
211111	Crude Petroleum and Natural Gas Extraction	194,107,252	23.2%	76.8%	100.0%
211112	Natural Gas Liquid Extraction	39,977,741	5.4%	94.6%	100.0%
213111	Drilling Oil and Gas Wells	23,848,238	30.6%	69.4%	100.0%
486210	Pipeline Transportation of Natural Gas	20,796,681	N/A*	N/A*	N/A*

Note: Employment and receipts could not be broken down between small and large businesses because of non-disclosure requirements.
Source: SBA

While the SBA and Census Bureau statistics provide informative broad contextual information on the distribution of enterprises by receipts and number of employees, it is also useful to additionally contrast small and large enterprises (where large enterprises are defined as those that are not small, according to SBA criteria) in the oil and natural gas industry. The summary statistics presented in previous tables indicate that there are a large number of relatively small firms and a small number of large firms. Given the majority of expected impacts of the proposed rules arises from well completion-related requirements, which impacts production activities, exclusively, some explanation of this particular market structure is warranted as it pertains to production and small entities. An important question to answer is whether there are particular roles that small entities serve in the production segment of the oil and natural gas industry that may be disproportionately affected by the proposed rules.

The first important broad distinction among firms is whether they are independent or integrated. Independent firms concentrate on exploration and production (E&P) activities, while integrated firms are vertically integrated and often have operations in E&P, processing, refining, transportation, and retail. To our awareness, there are no small integrated firms. Independent firms may own and operate wells or provide E&P-related services to the oil and gas industry. Since we are focused on evaluating potential impacts to small firms owning and operating new and existing hydraulically fractured wells, we should narrow down on this sector.

In our understanding, there is no single industry niche for small entities in the production segment of the industry since small operators have different business strategies and that small entities can own different types of wells. The organization of firms in oil and natural gas industry also varies greatly from firm to firm. Additionally, oil and natural gas resources vary widely geographically and can vary significantly within a single field.

Among many important roles, independent small operators historically pioneered exploration in new areas, as well as developed new technologies. By taking on these relatively large risks, these small entrepreneurs (wildcatters) have been critical sources of industrial innovation and opened up critical new energy supplies for the U.S. (HIS Global Insight). In recent decades, as the oil and gas industry has concentrated via mergers, many of these smaller firms have been absorbed into large firms.

Another critical role, which provides an interesting contrast to small firms pioneering new territory, is that smaller independents maintain and operate a large proportion of the Nation's low producing wells, which are also known as marginal or stripper wells (Duda et al. 2005). While marginal wells represent about 80 percent of the population of producing wells, they produce about 15 percent of domestic production, according to EIA (Table 7-17).

Table 7-17 Distribution of Crude Oil and Natural Gas Wells by Productivity Level, 2009

Type of Wells	Wells (no.)	Wells (%)	Production (MMbbl for oil and Bcf gas)	Production (%)
Crude Oil				
Stripper Wells (<15 boe per year)	310,552	85%	311	19%
Other Wells (>=15 boe per year)	52,907	15%	1,331	81%
Total Crude Oil Wells	**363,459**	**100%**	**1,642**	**100%**
Natural Gas				
Natural Gas Stripper Wells (<15 boe per year)	338,056	73%	2,912	12%
Other Natural Gas Wells (>=15 boe per year)	123,332	27%	21,048	88%
Total Natural Gas Wells	**461,388**	**100%**	**23,959**	**100%**

Source: U.S. Energy Information Administration, **Distribution of Wells by Production Rate Bracket.** <http://www.eia.gov/pub/oil_gas/petrosystem/us_table.html> Accessed 7/10/11.

Note: Natural gas production converted to barrels oil equivalent (boe) uses the conversion of 0.178 barrels of crude oil to 1000 cubic feet natural gas.

Many of these wells were likely drilled and initially operated by major firms (although the data are not available to quantify the percentage of wells initially drilled by small versus large producers). Well productivity levels typically follow a steep decline curve; high production in earlier years but sustained low production for decades. Because of relatively low overhead of maintaining and operating few relatively co-located wells, some small operators with a particular business strategy purchase low producing wells from the majors, who concentrate on new opportunities. As small operators have provided important technical innovation in exploration, small operators have also been sources of innovation in extending the productivity and lifespan of existing wells (Duda et al. 2005).

7.4.2 Small Entity Economic Impact Measures

The proposed Oil and Natural Gas NSPS and NESHAP amendments will affect the owners of the facilities that will incur compliance costs to control their regulated emissions. The owners, either firms or individuals, are the entities that will bear the financial impacts associated with these additional operating costs. The proposed rule has the potential to impact all firms owning affected facilities, both large and small.

The analysis provides EPA with an estimate of the magnitude of impacts the proposed NSPS and NESHAP amendments may have on the ultimate domestic parent companies that own facilities EPA expects might be impacted by the rules. The analysis focuses on small firms because they may have more difficulty complying with a new regulation or affording the costs associated with meeting the new standard. This section presents the data sources used in the screening analysis, the methodology we applied to develop estimates of impacts, the results of the analysis, and conclusions drawn from the results.

The small business impacts analysis for the NSPS and NESHAP amendments relies upon a series of firm-level sales tests (represented as cost-to-revenue ratios) for firms that are likely to be associated with NAICS codes listed in Table 7-15. For both the NSPS and NESHAP amendments, we obtained firm-level employment, revenues, and production levels using various sources, including the American Business Directory, the *Oil and Gas Journal*, corporate websites, and publically-available financial reports. Using these data, we estimated firm-level compliance cost impacts and calculated cost-to-revenue ratios to identify small firms that might be significantly impacts by the rules. The approaches taken for the NSPS and NESHAP amendments differed; more detail on approaches for each set of proposed rules is presented in the following sections.

For the sales test, we divided the estimates of annualized establishment compliance costs by estimates of firm revenue. This is known as the cost-to-revenue ratio, or the “sales test.” The “sales test” is the impact methodology EPA employs in analyzing small entity impacts as opposed to a “profits test,” in which annualized compliance costs are calculated as a share of profits. The sales test is often used because revenues or sales data are commonly available for entities impacted by EPA regulations, and profits data normally made available are often not the true profit earned by firms because of accounting and tax considerations. Revenues as typically published are correct figures and are more reliably reported when compared to profit data. The use of a “sales test” for estimating small business impacts for a rulemaking such as this one is consistent with guidance offered by EPA on compliance with SBREFA[55] and is consistent with guidance published by the U.S. SBA’s Office of Advocacy that suggests that cost as a percentage

[55] The SBREFA compliance guidance to EPA rulewriters regarding the types of small business analysis that should be considered can be found at <http://www.epa.gov/sbrefa/documents/rfaguidance11-00-06.pdf>

of total revenues is a metric for evaluating cost increases on small entities in relation to increases on large entities (U.S. SBA, 2010).[568]

7.4.3 Small Entity Economic Impact Analysis, Proposed NSPS

7.4.3.1 Overview of Sample Data and Methods

The proposed NSPS covers emissions points within various stages of the oil and natural gas production process. We expect that firms within multiple NAICS codes will be affected, namely the NAICS categories presented in Table 7-15. Because of the diversity of the firms potentially affected, we decided to analyze three distinct groups of firms within the oil and natural gas industry, while accounting for overlap across the groups. We analyze firms that are involved in oil and natural gas extraction that are likely to drill and operate wells, while a subset are integrated firms involved in multiple segments of production, as well as retailing products. We also analyze firms that primarily operate natural gas processing plants. A third set of firms we analyzed contains firms that primarily operate natural gas compression and pipeline transmission.

To identify firms involved in the drilling and primary production of oil and natural gas, we relied upon the annual *Oil and Gas Journal* 150 Survey (OGJ 150) as described in the Industry Profile in Section 2. While the OGJ 150 lists public firms, we believe the list is reasonably representative of the larger population of public and private firms operating in this segment of the industry. While the proportion of small firm in the OGJ 150 is smaller than the proportion evaluated by the Census SUSB, the OGJ 150 provides detailed information on the production activities and financial returns of the firms within the list, which are critical ingredients to the small business impacts analysis. We drew upon the OGJ 150 lists published for the years 2008 and 2009 (*Oil and Gas Journal*, September 21, 2009 and *Oil and Gas Journal*, September 6, 2010). The year 2009 saw relatively low levels of drilling activities because of the economic recession, while 2008 saw a relatively high level of drilling activity because of high fuel prices. Combined, we believe these two years of data are representative.

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[56]U.S. SBA, Office of Advocacy. A Guide for Government Agencies, How to Comply with the Regulatory Flexibility Act, Implementing the President's Small Business Agenda and Executive Order 13272, June 2010.

To identify firms that process natural gas, the OGJ also releases a period report entitled "Worldwide Gas Processing Survey", which provides a wide range of information on existing processing facilities. We used the most recent list of U.S. gas processing facilities[57] and other resources, such as the American Business Directory and company websites, to best identify the parent company of the facilities. To identify firms that compress and transport natural gas via pipelines, we examined the periodic OGJ survey on the economics of the U.S. pipeline industry. This report examines the economic status of all major and non-major natural gas pipeline companies.[58] For these firms, we also used the American Business Directory and corporate websites to best identify the ultimate owner of the facilities or companies.

After combining the information for exploration and production firms, natural gas processing firms, and natural gas pipeline transmission firms in order to identify overlaps across the list, the approach yielded a sample of 274 firms that would potentially be affected by the proposed NSPS in 2015 assuming their 2015 production activities were similar to those in 2008 and 2009. We estimate that 129 (47 percent) of these firms are small according to SBA criteria. We estimate 121 firms (44 percent) are not small firms according to SBA criteria. We are unable to classify the remaining 24 firms (9 percent) because of a lack of required information on employee counts or revenue estimates.

Table 7-18 shows the estimated revenues for 250 firms for which we have sufficient data that would be potentially affected by the proposed NSPS based upon their activities in 2008 and 2009. We segmented the sample into four groups, production and integrated firms, processing firms, pipeline firms, and pipelines/processing firms. For the firms in the pipelines/processing group, we were unable to determine the firms' primary line of business, so we opted to group together as a fourth group.

[57] Oil and Gas Journal. "Special Report: Worldwide Gas Processing: New Plants, Data Push Global Gas Processing Capacity Ahead in 2009." June 7, 2010.
[58] Oil and Gas Journal. "Natural Gas Pipelines Continue Growth Despite Lower Earnings; Oil Profits Grow." November 1, 2010.

Table 7-18 Estimated Revenues for Firms in Sample, by Firm Type and Size

		Estimated Revenues (millions, 2008 dollars)				
Firm Type/Size	Number of Firms	Total	Average	Median	Minimum	Maximum
Production and Integrated						
Small	79	18,554.5	234.9	76.3	0.1	1,116.9
Large	49	1,347,463.0	27,499.2	1,788.3	12.9	310,586.0
Subtotal	128	1,366,017.4	10,672.0	344.6	0.1	310,586.0
Pipeline						
Small	11	694.5	63.1	4.6	0.5	367.0
Large	36	166,290.2	4,619.2	212.9	7.1	112,493.0
Subtotal	47	166,984.6	3,552.9	108.0	0.5	112,493.0
Processing						
Small	39	4,972.1	127.5	26.9	1.9	1,459.1
Large	23	177,632.1	8,881.6	2,349.4	10.4	90,000.0
Subtotal	62	182,604.2	3,095.0	41.3	1.9	90,000.0
Pipelines/Processing						
Small	0	N/A	N/A	N/A	N/A	N/A
Large	13	175,128.5	13,471.4	6,649.4	858.6	71,852.0
Subtotal	13	175,128.5	13,471.4	6,649.4	858.6	71,852.0
Total						
Small	**129**	**24,221.1**	**187.8**	**34.9**	**0.1**	**1,459.1**
Large	**121**	**1,866,513.7**	**15,817.9**	**1,672.1**	**7.1**	**310,586.0**
Total	**250**	**1,890,734.8**	**7,654.8**	**163.9**	**0.1**	**310,586.0**

Sources: *Oil and Gas Journal*. "OGJ150." September 21, 2009; *Oil and Gas Journal*. "OGJ150 Financial Results Down in '09; Production, Reserves Up." September 6, 2010. *Oil and Gas Journal*. "Special Report: Worldwide Gas Processing: New Plants, Data Push Global Gas Processing Capacity Ahead in 2009." June 7, 2010, with additional analysis to determine ultimate ownership of plants. *Oil and Gas Journal*. "Natural Gas Pipelines Continue Growth Despite Lower Earnings; Oil Profits Grow." November 1, 2010. American Business Directory was used to determine number of employees.

As shown in Table 7-18, there is a wide variety of revenue levels across firm size, as well as across industry segments. The estimated revenues within the sample are concentrated on integrated firms and firms engaged in production activities (the E&P firms mentioned earlier).

The oil and natural gas industry is capital-intensive. To provide more context on the potential impacts of new regulatory requirements, Table 7-19 presents descriptive statistics for small and large integrated and production firms from the sample of firms (121 of the 128 integrated and production firms listed in the *Oil and Gas Journal*; capital and exploration expenditures for 7 firms were not reported in the *Oil and Gas Journal*).

Table 7-19 Descriptive Statistics of Capital and Exploration Expenditures, Small and Large Firms in Sample, 2008 and 2009 (million 2008 dollars)

		Capital and Exploration Expenditures (millions, 2008 dollars)				
Firm Size	Number	Total	Average	Median	Minimum	Maximum
Small	76	13,478.8	177.4	67.1	0.1	2,401.9
Large	45	126,749.3	2,816.7	918.1	10.3	22,518.7
Total	**121**	**140,228.2**	**1,158.9**	**192.8**	**0.1**	**22,518.7**

Sources: *Oil and Gas Journal*. "OGJ150." September 21, 2009; *Oil and Gas Journal*. "OGJ150 Financial Results Down in '09; Production, Reserves Up." September 6, 2010. American Business Directory was used to determine number of employees.

The average 2008 and 2009 total capital and exploration expenditures for the sample of 121 firms were $140 billion in 2008 dollars). About 10 percent of this total was spent by small firms. Average capital and explorations expenditures for small firms are about 6 percent of large firms; median expenditures of small firms are about 7 percent of large firms' expenditures. For small firms, capital and exploration expenditures are high relative to revenue, which appears to hold true more generally for independent E&P firms compared to integrated major firms. This would seem to indicate the capital-intensive nature of E&P activities. As expected, this would drive up ratios comparing estimated engineering costs to revenues and capital and exploration expenditures.

Table 7-20 breaks down the estimated number of natural gas and crude oil wells drilled by the 121 firms in the sample for which the *Oil and Gas Journal* information reported well-drilling estimates. Note the fractions on the minimum and maximum statistics; the fractions reported are due to our assumptions to estimate oil and natural gas wells drilled from the total wells drilled reported by the *Oil and Gas Journal*. The OGJ150 lists new wells drilled by firm in 2008 and 2009, but the drilling counts are not specific to crude oil or natural gas wells. We apportion the wells drilled to natural gas and crude oil wells using the distribution of well drilling in 2009 (63 percent natural gas and 37 percent oil).

Table 7-20 Descriptive Statistics of Estimated Wells Drilled, Small and Large Firms in Sample, 2008 and 2009 (million 2008 dollars)

			Estimated Average Wells Natural Gas and Crude Oil Wells Drilled (2008 and 2009)				
Well Type	Firm Size	Number of Firms	Total	Average	Median	Minimum	Maximum
Natural Gas							
	Small	76	2,288.3	30.1	6.0	0.2	259.3
	Large	45	9,445.1	209.9	149.1	0.6	868.3
	Subtotal	121	11,733.4	97.0	28.3	0.2	868.3
Crude Oil							
	Small	76	1,317.1	17.3	3.5	0.1	149.2
	Large	45	5,436.3	120.8	85.8	0.4	499.7
	Subtotal	121	6,753.4	55.8	16.3	0.1	499.7
Total							
	Small	**76**	**3,605.4**	**47.4**	**9.5**	**0.0**	**408.5**
	Large	**45**	**14,881.4**	**330.7**	**234.9**	**0.0**	**1,368.0**
	Total	**121**	**18,486.8**	**152.8**	**44.6**	**0.0**	**1,368.0**

Sources: *Oil and Gas Journal*. "OGJ150." September 21, 2009; *Oil and Gas Journal*. "OGJ150 Financial Results Down in '09; Production, Reserves Up." September 6, 2010. American Business Directory was used to determine number of employees.

This table highlights the fact that many firms drill relatively few wells; the median for small firms is 6 natural gas wells compared to 149 for large firms. Later in this section, we examine whether this distribution has implications for the engineering costs estimates, as well as the estimates of expected natural product recovery from controls such as RECs.

Unlike the analysis that follows for the analysis of impacts on small business from the NESHAP amendments, we have no specific data on potentially affected facilities under the NSPS. The NSPS will apply to new and modified sources, for which data are not fully available in advance, particularly in the case of new and modified sources such as well completions and recompletions which are spatially diffuse and potentially large in number.

The engineering cost analysis estimated compliance costs in a top-down fashion, projecting the number of new sources at an annual level and multiplying these estimates by model unit-level costs to estimate national impacts. To estimate per-firm compliance costs in this analysis, we followed a procedure similar to that of entering estimate compliance costs in NEMS on a per well basis. We first use the OGJ150-based list to estimate engineering compliance costs for integrated and production companies that may operate facilities in more than one segment of the oil and natural gas industry. We then estimate the compliance costs per crude oil and natural gas well by totaling all compliance costs estimates in the engineering cost estimates for the proposed NSPS and dividing that cost by the total number of crude oil and natural gas wells forecast as of 2015, the year of analysis. These compliance costs include the expected revenue from natural gas and condensate recovery that result from implementation of some proposed controls.

This estimation procedure yielded an estimate of crude well compliance costs of $162 per drilled well and natural gas well compliance costs of $38,719 without considering estimated revenues from product recovery and -$2,455 per drilled well with estimated revenues from product recovery included. Note that the divergence of estimated per well costs between crude oil and natural gas wells is because the proposed NSPS requirements are primary directed toward natural gas wells. Also note that the per well cost savings estimate for natural gas wells is different than the estimated cost of implementing a REC; this difference is because this estimate is picking up savings from other control options. We then estimate a single-year, firm-level compliance cost for this subset of firms by multiplying the per well cost estimates with the well count estimates.

The OGJ reports plant processing capacity in terms of MMcf/day. In the energy system impacts analysis, the NEMS model estimates a 6.5 percent increase (from 21.05 tcf in 2011 to 22.43 tcf in 2015) in domestic natural gas production from 2011 to 2015, the analysis year. On this, basis, we estimate that natural gas processing capacity for all plants in the OGJ list will increase 1.3 percent per year. This annual increment is equivalent to an increase in national gas processing capacity of 350 bcf per year. We assume that the engineering compliance costs estimates associated with processing are distributed according to the proportion of the increased national processing capacity contributed by each processing plant. These costs are estimated at $6.9 million without estimated revenues from product recovery and $2.3 million with estimated revenues from product recovery, respectively, in 2008 dollars, or about $20/MMcf without revenues and $7/MMcf with revenues.

The OGJ report on pipeline companies has the advantage that it reports expenditures on plant additions. We assume that the firm-level proposed compression and transmission-related NSPS compliance costs are proportional to the expenditures on plant additions and that these additions reflect a representative year or this analysis. We estimate the annual compression and transmission-related NSPS compliance costs at $5.5 million without estimated revenues from product recovery and $3.7 million with estimated revenues from product recovery, respectively, in 2008 dollars.

7.4.3.2 Small Entity Impact Analysis, Proposed NSPS, Results

Summing estimated annualized engineering compliance costs across industry segment and individual firms in our sample, we estimate firms in the OGJ-based sample will face about $480 million in 2008 dollars, about 65 percent of the estimated annualized costs of the Proposed NSPS without including revenues from additional product recovery ($740 million). When including revenues from additional product recovery, the estimated compliance costs for the firms in the sample is about -$23 million, compared to engineering cost estimate of -$45 million.

Table 7-21 presents the distribution of estimated proposed NSPS compliance costs across firm size for the firms within our sample. Evident from this table, about 98 percent of the estimated engineering compliance costs accrue to the integrated and production segment of the industry, again explain by the fact that completion-related requirements contribute the bulk of the estimated engineering compliance costs (as well as estimated emissions reductions). About 17 percent of the total estimated engineering compliance costs (and about 18 percent of the costs accruing the integrated and production segment) are focused on small firms.

Table 7-21 Distribution of Estimated Proposed NSPS Compliance Costs Without Revenues from Additional Natural Gas Product Recovery across Firm Size in Sample of Firms

		Estimated Engineering Compliance Costs Without Estimated Revenues from Natural Gas Product Recovery (2008 dollars)				
Firm Type/Size	Number of Firms	Total	Mean	Median	Minimum	Maximum
Production and Integrated						
Small	79	82,293,903	1,041,695	221,467	3,210	10,054,401
Large	49	387,489,928	7,907,958	5,730,634	15,238	33,677,388
Subtotal	128	469,783,831	3,670,186	969,519	3,210	33,677,388
Pipeline						
Small	11	3,386	308	111	18	1,144
Large	36	1,486,929	41,304	3,821	37	900,696
Subtotal	47	1,490,314	31,709	2,263	18	900,696
Processing						
Small	39	476,165	12,209	1,882	188	276,343
Large	23	859,507	37,370	8,132	38	423,645
Subtotal	62	1,335,672	21,543	2,730	38	423,645
Pipelines/Processing						
Small	0	N/A	N/A	N/A	N/A	N/A
Large	13	5,431,510	417,808	147,925	2,003	2,630,236
Subtotal	13	5,431,510	417,808	147,925	2,003	2,630,236
Total						
Small	**129**	**82,773,454**	**641,655**	**49,386**	**18**	**10,054,401**
Large	**121**	**395,267,874**	**3,266,677**	**57,220**	**37**	**33,677,388**
Total	**250**	**478,041,328**	**1,912,165**	**55,888**	**18**	**33,677,388**

These distributions are similar when the revenues from expected natural gas recovery are included (Table 7-22). About 21 percent of the total savings from the proposed NSPS is expected to accrue to small firms (about 19 percent of the savings to the integrated and production segment accrue to small firms). Note also in Table 7-22 that the pipeline and processing segments (and the pipeline/processing firms) are not expected to experience net cost savings (negative costs) from the proposed NSPS.

Table 7-22 Distribution of Estimated Proposed NSPS Compliance Costs With Revenues from Additional Natural Gas Product Recovery across Firm Size in Sample of Firms

		Estimated Engineering Compliance Costs With Estimated Revenues from Natural Gas Product Recovery (millions, 2008 dollars)				
Firm Type/Size	Number of Firms	Total	Mean	Median	Minimum	Maximum
Production and Integrated						
Small	79	-5,065,551	-64,121	-13,729	-620,880	8,699
Large	49	-22,197,126	-453,003	-318,551	-2,072,384	423,760
Subtotal	128	-27,262,676	-212,990	-43,479	-2,072,384	423,760
Pipeline						
Small	11	2,303	209	76	12	779
Large	36	1,011,572	28,099	2,599	25	612,753
Subtotal	47	1,013,876	21,572	1,539	12	612,753
Processing						
Small	39	160,248	4,109	634	63	93,000
Large	23	289,258	12,576	2,737	13	142,573
Subtotal	62	449,506	7,250	919	13	142,573
Pipelines/Processing						
Small	0	---	---	---	---	---
Large	13	3,060,373	235,413	86,301	716	1,746,730
Subtotal	13	3,060,373	235,413	86,301	716	1,746,730
Total						
Small	**129**	**-4,902,999**	**-38,008**	**-2,520**	**-620,880**	**93,000**
Large	**121**	**-17,835,922**	**-147,404**	**634**	**-2,072,384**	**1,746,730**
Total	**250**	**-22,738,922**	**-90,956**	**22**	**-2,072,384**	**1,746,730**

Table 7-23 Summary of Sales Test Ratios, Without Revenues from Additional Natural Gas Product Recovery for Firms Affected by Proposed NSPS

		Descriptive Statistics for Sales Test Ratio Without Estimated Revenues from Natural Gas Product Recovery (%)			
Firm Type/Size	Number of Firms	Mean	Median	Minimum	Maximum
Production and Integrated					
Small	79	2.18%	0.49%	0.01%	50.83%
Large	49	0.41%	0.28%	<0.01%	2.83%
Subtotal	128	1.50%	0.39%	<0.01%	50.83%
Pipeline					
Small	11	<0.01%	<0.01%	<0.01%	0.01%
Large	36	0.01%	<0.01%	<0.01%	0.06%
Subtotal	47	0.01%	<0.01%	<0.01%	0.06%
Processing					
Small	39	0.05%	0.01%	<0.01%	0.33%
Large	23	0.02%	0.01%	<0.01%	0.15%
Subtotal	62	0.04%	0.01%	<0.01%	0.33%
Pipelines/Processing					
Small	0	---	---	---	---
Large	13	<0.01%	<0.01%	<0.01%	0.01%
Subtotal	13	<0.01%	<0.01%	<0.01%	0.01%
Total					
Small	**129**	**1.34%**	**0.15%**	**<0.01%**	**50.83%**
Large	**121**	**0.17%**	**0.01%**	**<0.01%**	**2.83%**
Total	**250**	**0.78%**	**0.03%**	**<0.01%**	**50.83%**

The mean cost-sales ratio for all businesses when estimated product recovery is excluded from the analysis of the sample data is 0.78 percent, with a median ratio of 0.03 percent, a minimum of less than 0.01 percent, and a maximum of over 50 percent (Table 7-23). For small firms in the sample, the mean and median cost-sales ratios are 1.34 percent and 0.15 percent, respectively, with a minimum of less than 0.01 percent and a maximum of over 50 percent (Table 7-23). Each of these statistics indicates that, when considered in the aggregate, impacts are relatively higher on small firms than large firms when the estimated revenue from additional natural gas product recovery is excluded. However, as the next table shows, the reverse is true when these revenues are included.

Table 7-24 Summary of Sales Test Ratios, With Revenues from Additional Natural Gas Product Recovery for Firms Affected by Proposed NSPS

		Descriptive Statistics for Sales Test Ratio With Estimated Revenues from Natural Gas Product Recovery (%)			
Firm Type/Size	Number of Firms	Mean	Median	Minimum	Maximum
Production and Integrated					
Small	79	-0.13%	-0.03%	-2.96%	<0.00%
Large	49	-0.02%	-0.02%	-0.17%	0.06%
Subtotal	128	-0.09%	-0.02%	-2.96%	0.06%
Pipeline					
Small	11	<0.00%	<0.01%	<0.01%	0.01%
Large	36	0.01%	<0.01%	<0.01%	0.04%
Subtotal	47	0.01%	<0.01%	<0.01%	0.04%
Processing					
Small	39	0.01%	<0.01%	<0.01%	0.05%
Large	23	<0.00%	<0.01%	<0.01%	0.05%
Subtotal	62	0.01%	<0.01%	<0.01%	0.05%
Pipelines/Processing					
Small	0	---	---	---	---
Large	13	<0.01%	<0.01%	<0.01%	0.01%
Subtotal	13	<0.01%	<0.01%	<0.01%	0.01%
Total					
Small	**129**	**-0.08%**	**-0.01%**	**-2.96%**	**0.05%**
Large	**121**	**-0.01%**	**<0.01%**	**-0.17%**	**0.06%**
Total	**250**	**-0.04%**	**<0.01%**	**-2.96%**	**0.06%**

The mean cost-sales ratio for all businesses when estimated product recovery is included is in the sample is -0.04 percent, with a median ratio of less than 0.01 percent, a minimum of -2.96 percent, and a maximum of 0.06 percent (Table 7-24). For small firms in the sample, the mean and median cost-sales ratios are -0.08 percent and -0.01 percent, respectively, with a minimum of -2.96 percent and a maximum of 0.05 percent (Table 7-24). Each of these statistics indicates that, when considered in the aggregate, impacts are small on small business when the estimated revenue from additional natural gas product recovery are included, the reverse of the conclusion found when these revenues are excluded.

Meanwhile, Table 7-25 presents the distribution of estimated cost-sales ratios for the small firms in our sample with and without including estimates of the expected natural gas product recover from implementing controls. When revenues estimates are included, all 129 firms (100 percent) have estimated cost-sales ratios less than 1 percent. While less than 1 percent, the highest cost-sales ratios for small firms in the sample experiencing impacts are largely driven by costs accruing to processing and pipeline firms. That said, the incremental costs imposed on firms that process natural gas or transport natural gas via pipelines are not estimated to create significant impacts on a cost-sales ratio basis at the firm-level.

Table 7-25 Impact Levels of Proposed NSPS on Small Firms as a Percent of Small Firms in Sample, With and Without Revenues from Additional Natural Gas Product Recovery

	Without Estimated Revenues from Natural Gas Product Recovery		With Estimated Revenues from Natural Gas Product Recovery	
Impact Level	Number of Small Firms in Sample Estimated to be Affected	% of Small Firms in Sample Estimated to be Affected	Number of Small Firms in Sample Estimated to be Affected	% of Small Firms in Sample Estimated to be Affected
C/S Ratio less than 1%	109	84.5%	129	100.00%
C/S Ratio 1-3%	11	8.5%	0	0.00%
CS Ratio greater than 3%	9	7.0%	0	0.00%

When the estimated revenues from product recovery are not included in the analysis, 11 firms (about 9 percent) are estimated to have sales test ratios between 1 and 3 percent. Nine firms (about 7 percent) are estimated to have sales test ratios greater than 3 percent. These results noted, the exclusion of product recovery is somewhat artificial. While the mean engineering compliance costs and revenues estimates are valid, drawing on the means ignores the distribution around the mean estimates, which risks masking effects. Because of this risk, the following section offers a qualitative discussion of small entities with regard to obtaining REC services, the validity of the cost and performance of RECs for small firms, as well as offers a discussion about whether older equipment, which may be disproportionately owned and operated be smaller producers, would be affected by the proposed NSPS.

7.4.3.3 Small Entity Impact Analysis, Proposed NSPS, Additional Qualitative Discussion

3.5.3.3.1 Small Entities and Reduced Emissions Completions

Because REC requirements of the proposed NSPS are expected to contribute the large majority of engineering compliance costs, it is important to examine these requirements more closely in the context small entities. Important issues to resolve are the scale of REC costs within a drilling project, how the payment system for recovered natural gas functions, whether small entities pursue particular "niche" strategies that may influence the costs or performance in a way that makes the estimates costs and revenues invalid.

According to the most recent natural gas well cost data from EIA, the average cost of drilling and completing a producing natural gas well in 2007 was about $4.8 million (adjusted to 2008 dollars). This average includes lower cost wells that may be relatively shallow or are not hydraulically fractured. Hydraulically fractured wells in deep formations may cost up to $10 million. RECs contracted from a service provider are estimated to cost $33,200 (in 2008 dollars) or roughly 0.3%-0.7% of the typical cost of a drilling and completing a natural gas well. As this range does not include revenues expected from natural gas and hydrocarbon condensate recovery expected to offset REC implementation costs, REC costs likely represent a small increment of the overall burden of a drilling project.

To implement an REC, a service provider, which may itself be a small entity, is typically contracted to bring a set of equipment to the well pad temporarily to capture the stream that would otherwise be vented to the atmosphere. Typically, service providers are engaged in a long term drilling program in a particular basin covering multiple wells on multiple well pads. For gas captured and sold to the gathering system, Lease Automatic Custody Transfer (LACT) meters are normally read daily automatically, and sales transactions are typically settled at the end of the month. Invoices from service providers are generally delivered in 30-day increments during the well development time period, as well as at the end of the working contract for that well pad. The conclusion from the information, based on the available information, in most cases, the owner/operator incurs the REC cost within the same 30 day period that the owner/operator receives revenue as a result of the REC.

We assume small firms are performing RECs in CO and WY, as in many instances RECs are required under state regulation. In addition to State regulations, some companies are implementing RECs voluntarily such as through participation in the EPA Natural Gas STAR Program and the focus of recent press reports.

As described in more detail below, many small independent E&P companies often do not conduct any of the actual field work. These firms will typically contract the drilling, completion, testing, well design, environmental assessment, and maintenance. Therefore, we believe it is likely that small independent E&P firms will contract for RECs from service providers if required to perform RECs. An important reminder is that performing a REC is a straightforward and inexpensive extension of drilling, completion, and testing activities.

To the extent that very small firms may specialize in operating relatively few low-producing stripper wells, it is important to ask whether low-producing wells are likely candidates for re-fracturing/re-completion and, if so, whether the expected costs and revenues would be valid. These marginal gas wells are likely to be older and in conventional formations, and as such are unlikely to be good candidates for re-fracturing/completion. To the extent the marginal wells may be good candidates for re-fracturing/completion, the REC costs are valid estimates. The average REC cost is valid for RECs performed on any well, regardless of the operator size. The reason for this is that the REC service is contracted out to specialty service providers who charge daily rates for the REC equipment and workers. The cost is not related to any well characteristic.

Large operators may receive a discount for offering larger contracts which help a service provider guarantee that REC equipment will be utilized. However, we should note that the existence of a potential discount for larger contracts is based on a strong assumption; we do not have evidence to support this assumption. Since contracting REC equipment is analogous to contracting for drilling equipment, completion equipment, etc., the premium would likely be in the same range as other equipment contracted by small operators. Since the REC cost is a small portion of the overall well drilling and completion cost, the effect of any bulk discount disparity between large and small operators will be small, if in fact it does exist.

Although small operators may own the majority of marginal and stripper wells, they will make decisions based on economics just as any sized company would. For developing a new well, any sized company will expect a return on their investment meaning the potential for sufficient gas, condensate, and/or oil production to pay back their investment and generate a return that exceeds alternative investment opportunities. Therefore, small or large operators that are performing hydraulic fracture completions will experience the same distribution of REC performance. For refracturing an existing well, the well must be a good candidate to respond to the re-fracture/completion with a production increase that merits the investment in the re-fracture/completion.

Plugging and abandoning wells is complex and costly, so sustaining the productivity of wells is important for maximizing the exploitation of proven domestic resources. However, many marginal gas wells are likely to be older and in conventional formations, and as such are unlikely to be good candidates for re-fracturing/completion, which means they are likely unaffected by the proposed NSPS.

3.5.3.3.2 Age of Equipment and Proposed Regulations

Given a large fraction of domestic oil and natural gas production is produced from older and generally low productivity wells, it is important to examine whether the proposed requirements might present impediments to owners and operators of older equipment. The NSPS is a standard that applies to new or modified sources. Because of this, NSPS requirements target new or modified affected facilities or equipment, such as processing plants and compressors. While the requirements may apply to modifications of existing facilities, it is important to discuss well completion-related requirements aside from other requirements in the NSPS distinctly.

Excluding well completion requirements from the cost estimates, the non-completion NSPS requirements (related to equipment leaks at processing plants, reciprocating and centrifugal compressors, pneumatic controllers, and storage vessels) are estimated to require $27 million in annualized engineering costs. EPA also estimates that the annualized costs of these requirements will be mostly if not fully offset by revenues expected from natural gas recovery. EPA does not expect these requirements to disproportionately affect producers with older equipment. Meanwhile, the REC and emissions combustion requirements in the proposed NSPS relate to well completion activities at new hydraulically fractured natural gas wells and existing wells which are recompleted after being fractured or re-fractured. These requirements constitute the bulk of the expected engineering compliance expenditures (about $710 million in annualized costs) and expected revenues from natural gas product recovery (about $760 million in revenues, annually).

While age of the well and equipment may be an important factor for small and large producers in determining whether it is economical to fracture or re-fracture an existing well, this equipment is unlikely to be subject to the NSPS. To comply with completion-related requirements, producers are likely to rely heavily on portable and temporary completion equipment brought to the wellpad over a short period of time (a few days to a few weeks) to capture and combust emissions that are otherwise vented. The equipment at the wellhead—newly installed in the case of new well completions or already in place and operating in the case of existing wells—is not likely to be subject to the NSPS requirement.

7.4.3.4 Small Entity Impact Analysis, Proposed NSPS, Screening Analysis Conclusion

The number of significantly impacted small businesses is unlikely to be sufficiently large to declare a SISNOSE. Our judgment in this determination is informed by the fact that many affected firms are expected to receive revenues from the additional natural gas and condensate recovery engendered by the implementation of the controls evaluated in this RIA. As much of the additional natural gas recovery is estimated to arise from completion-related activities, we expect the impact on well-related compliance costs to be significantly mitigated. This conclusion is enhanced because the returns to reduced emissions completion activities occur without a significant time lag between implementing the control and obtaining the recovered product unlike many control options where the emissions reductions accumulate over long periods of time; the reduced emission completions and recompletions occur over a short span of time, during which the additional product recovery is also accomplished.

7.4.4 Small Entity Economic Impact Analysis, Proposed NESHAP Amendments

The proposed NESHAP amendments will affect facilities operating three types of equipment: glycol dehydrators at production facilities, glycol dehydrators at transmission and compression facilities, and storage vessels. We identified likely affected facilities in the National Emissions Inventory (NEI) and estimated the number of newly required controls of each type that would be required by the NESHAP amendments for each facility. We then used available data sources to best identify the ultimate owner of the equipment that would likely require new controls and linked facility-level compliance cost estimates to firm-level employment and revenue data. These data were then used to calculate an estimated compliance costs to revenues ratio to identify small businesses that might be significantly impacted by the NESHAP.

While we were able to identify the owners all but 14 facilities likely to be affected, we could not obtain employment and revenue levels for all of these firms. Overall, we expect about 447 facilities to be affected, and these facilities are owned by an estimated 160 firms. We were unable to obtain financial information on 42 (26 percent) of these firms due to inadequate data. In some instances, firms are private, and financial data is not available. In other instance, firms may no longer exist, since NEI data are not updated continuously. From the ownership information and compliance cost estimates from the engineering analysis, we estimated total compliance cost per firm.

Of the 118 firms for which we have financial information, we identified 62 small firms and 56 large firms that would be affected by the NESHAP amendments. Annual compliance costs for small firms are estimated at $3.0 million (18 percent of the total compliance costs), and annual compliance costs for large firms are estimated at $10.7 million (67 percent of the total compliance costs). The facilities for which we were unable to identify the ultimate owners, employment, and revenue levels would have an estimated annual compliance cost of $2.3 million (15 percent of the total). All figures are in 2008 dollars.

The average estimated annualized compliance cost for the 62 small firms identified in the dataset is $48,000, while the mean annual revenue figure for the same firms is over $120 million, or less than 1 percent for a average sales-test ratio for all 62 firms (Table 7-26). The median sale-test ratio for these firms is smaller at 0.14 percent. Large firms are likely to see an average of $190,000 in annual compliance costs, whereas average revenue for these firms exceeds $30 billion since this set of firms includes many of the very large, integrated energy firms. For large firms, the average sales-test ratio is about 0.01 percent, and the median sales-test ratio is less than 0.01 percent (Table 7-26).

Table 7-26 Summary of Sales Test Ratios for Firms Affected by Proposed NESHAP Amendments

Firm Size	No. of Known Affected Firms	% of Total Known Affected Firms	Mean C/S Ratio	Median C/S Ratio	Min. C/S Ratio	Max. C/S Ratio
Small	62	53%	0.62%	0.14%	< 0.01%	6.2%
Large	56	47%	0.01%	< 0.01%	< 0.01%	0.4%
All	118	100%	0.34%	0.02%	< 0.01%	6.2%

Among the small firms, 52 of the 62 (84 percent) are likely to have impacts of less than 1 percent in terms of the ratio of annualized compliance costs to revenues. Meanwhile 10 firms (16 percent) are likely to have impacts greater than 1 percent (Table 7-27). Four of these 10 firms are likely to have impacts greater than 3 percent (Table 7-27) While these 10 firms might receive significant impacts from the proposed NESHAP amendments, they represent a very small slice of the oil and gas industry in its entirety, less than 0.2 percent of the estimated 6,427 small firms in NAICS 211 (Table 7-27).

Table 7-27 Affected Small Firms as a Percent of Small Firms Nationwide, Proposed NESHAP amendments

Firm Size	Number of Small Firms Affected Nationwide	% of Small Firms Affected Nationwide	Affected Firms as a % of National Firms (6,427)
C/S Ratio less than 1%	52	83.9%	0.81%
C/S Ratio 1-3%	6	9.7%	0.09%
CS Ratio greater than 3%	4	6.5%	0.06%

Screening Analysis Conclusion: While there are significant impacts on small business, the analysis shows that a substantial number of small firms are not impacted. Based upon the analysis in this section, we presume there is no SISNOSE arising from the proposed NESHAP amendments.

7.5 References

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EXHIBIT 14

Regulatory Impact Analysis

Final New Source Performance Standards and Amendments to the National Emissions Standards for Hazardous Air Pollutants for the Oil and Natural Gas Industry

U.S. Environmental Protection Agency
Office of Air and Radiation
Office of Air Quality Planning and Standards
Research Triangle Park, NC 27711

April 2012

1 EXECUTIVE SUMMARY

1.1 Background

The U.S. Environmental Protection Agency (EPA) reviewed the New Source Performance Standards (NSPS) for volatile organic compound and sulfur dioxide emissions from Natural Gas Processing Plants. As a result of these NSPS, this rule amends the Crude Oil and Natural Gas Production source category currently listed under section 111 of the Clean Air Act to include Natural Gas Transmission and Distribution, amends the existing NSPS for volatile organic compounds (VOC) from Natural Gas Processing Plants, and finalizes the NSPS for stationary sources in the source categories that are not covered by the existing NSPS. In addition, this rule addresses the residual risk and technology review conducted for two source categories in the Oil and Natural Gas sector regulated by separate National Emission Standards for Hazardous Air Pollutants (NESHAP). It also finalizes standards for emission sources not currently addressed, as well as amendments to improve aspects of these NESHAP related to applicability and implementation. Finally, it addresses provisions in these NESHAP related to emissions during periods of startup, shutdown, and malfunction.

As part of the regulatory process, EPA is required to develop a regulatory impact analysis (RIA) for rules that have costs or benefits that exceed $100 million annually. EPA estimates the final NSPS will have costs that exceed $100 million, so the Agency has prepared an RIA. Because the NESHAP Amendments are being finalized in the same rulemaking package (i.e., same Preamble), we have chosen to present the economic impact analysis for the final NESHAP Amendments within the same document as the NSPS RIA.

This RIA includes an economic impact analysis and an analysis of human health and climate impacts anticipated from the final NSPS and NESHAP Amendments. We also estimate potential impacts of the final rules on the national energy economy using the U.S. Energy Information Administration's National Energy Modeling System (NEMS). The engineering compliance costs are annualized using a 7 percent discount rate. This analysis assumes an analysis year of 2015. The final NSPS contains provisions related to reduced emissions completions, pneumatic controllers, and storage vessels that phase-in emissions control requirements over time. As a result of these provisions, 2015 is the first year that the full requirements of the NSPS are in effect. Because of the phase-in provisions of the NSPS, the RIA does not present an accurate assessment of the period between promulgation and the end of 2014, but is accurate for 2015.

Several emission controls for the NSPS, such as reduced emissions completions (RECs) of hydraulically fractured natural gas wells, capture VOC emissions that otherwise would be vented to the atmosphere. Since methane is co-emitted with VOC, a large proportion of the averted methane emissions can be directed into natural gas production streams and sold. RECs also recover saleable hydrocarbon condensates that would otherwise be lost to the environment. The revenues derived from additional natural gas and condensate recovery are expected to offset the engineering costs of implementing the NSPS. In the economic impact and energy economy analyses for the NSPS, we present results that include the additional product recovery and the revenues we expect producers to gain from the additional product recovery.

The primary baseline used for the impacts analysis of our NSPS for completions of hydraulically fractured natural gas wells takes into account RECs conducted pursuant to state regulations covering these operations and estimates of RECs performed voluntarily. To account for RECs performed in regulated states, EPA subsumed emissions reductions and compliance costs in states where these completion-related emissions are already controlled into the baseline. Additionally, based on public comments and reports to EPA's Natural Gas STAR program, EPA recognizes that some producers conduct well completions using REC techniques voluntarily for economic and/or environmental objectives as a normal part of business. To account for emissions reductions and costs arising from voluntary implementation of pollution controls EPA used information on total emissions reductions reported to the EPA by partners of the EPA Natural Gas STAR. This estimate of this voluntary REC activity in the absence of regulation is also included in the baseline.[1] More detailed discussion on the derivation of the baseline is presented in a technical memorandum in the docket, as well as in Section 3 of this RIA.

[1] Voluntary short-term actions (such as REC) are challenging to capture accurately in a prospective analysis, as such reductions are not guaranteed to continue. However, Natural Gas STAR represents a nearly 20 year voluntary initiative with participation from 124 natural gas companies operating in the U.S., including 28 producers, over a wide historical range of natural gas prices. This unique program and dataset, the significant impact of voluntary REC on the projected cost and emissions reductions (due to significant REC activity), and the fact that RECs can actually increase natural gas recovered from natural gas wells (offering a clear incentive to continue the practice), led the Agency to conclude that it was appropriate to estimate these particular voluntary actions in the baseline for this rule.

Additionally, we provide summary-level estimates of emissions reductions and engineering compliance costs for a case where no voluntary RECs are assumed to occur. This alternative case is presented in order to show impacts if conditions were such that RECs were no longer performed on a voluntary basis, but rather were compelled by the regulation, and serves in part to capture the inherent uncertainty in projecting voluntary activity into the future. As such, this alternative case establishes the full universe of emissions reductions that are guaranteed by this NSPS (those that are *required* to occur under the rule, including those that would likely occur voluntarily). While the primary baseline may better represent actual costs (and emissions reductions) beyond those already expected under business as usual, the alternative case better captures the full amount of emissions reductions where the NSPS acts as a backstop to ensure that emission reduction practices occur (practices covered by this rule).

1.2 Summary of Results

1.2.1 NSPS Results

For the final NSPS, the key results of the RIA follow and are summarized in Table 1-1:

- **Benefits Analysis:** The final NSPS is anticipated to prevent significant new emissions, including 190,000 tons of VOC, as well as from 11,000 tons of hazardous air pollutants (HAP) and 1.0 million tons of methane. While we expect that these avoided emissions will result in improvements in ambient air quality and reductions in health effects associated with exposure to HAP, ozone, and particulate matter (PM), we have determined that quantification of those benefits cannot be accomplished for this rule.[2] This is not to imply that there are no benefits of the rules; rather, it is a reflection of the difficulties in modeling the direct and indirect impacts of the reductions in emissions for this industrial sector with the data currently available. In addition to health improvements, there will be improvements in visibility effects, ecosystem effects, as well as additional natural gas recovery. The methane emissions reductions associated with the final NSPS are likely to result in climate co-benefits. The specific control technologies for the final NSPS are anticipated to have minor secondary disbenefits, including an increase of 1.1 million tons of carbon dioxide (CO_2), 550 tons of nitrogen oxides (NOx), 19 tons of PM, 3,000 tons of CO, and 1,100 tons of total

[2] Previous studies have estimated the monetized benefits-per-ton of reducing VOC emissions associated with the effect that those emissions have on ambient $PM_{2.5}$ levels and the health effects associated with $PM_{2.5}$ exposure (Fann, Fulcher, and Hubbell, 2009). While these ranges of benefit-per-ton estimates provide useful context for the break-even analysis, the geographic distribution of VOC emissions from the oil and gas sector are not consistent with emissions modeled in Fann, Fulcher, and Hubbell (2009). In addition, the benefit-per-ton estimates for VOC emission reductions in that study are derived from total VOC emissions across all sectors. Coupled with the larger uncertainties about the relationship between VOC emissions and $PM_{2.5}$ and the highly localized nature of air quality responses associated with VOC reductions, these factors lead us to conclude that the available VOC benefit-per-ton estimates are not appropriate to calculate monetized benefits of these rules, even as a bounding exercise.

hydrocarbons (THC) as well as emission reductions associated with the energy system impacts. The net CO_2-equivalent ($CO_{2\text{-}e}$) emission reductions are 18 million metric tons. If the EPA's estimate of voluntary action is not included in the NSPS baseline (only REC under state regulations are assumed to occur absent the NSPS), the emissions reductions achieved by the final NSPS in HAP, methane and VOC are estimated at about 19,000 tons, 1.7 million tons and 290,000 tons, respectively.

- **Engineering Cost Analysis:** EPA estimates the total capital cost of the final NSPS will be $25 million, regardless of baseline assumptions. The estimate of total annualized engineering costs of the final NSPS is $170 million. When estimated revenues from additional natural gas and condensate recovery are included, the annualized engineering costs of the final NSPS are estimated to be -$15 million, assuming a wellhead natural gas price of $4/thousand cubic feet (Mcf) and condensate price of $70/barrel. Possible explanations for why there appear to be negative cost control technologies are discussed in the engineering costs analysis section in the RIA. The estimated engineering compliance costs that include the product recovery are sensitive to the assumption about the price of the recovered product. There is also geographic variability in wellhead prices, which can also influence estimated engineering costs. For example, $1/Mcf change in the wellhead price causes a change in estimated engineering compliance costs of about $43 million, given EPA estimates that 43 billion cubic feet of natural gas will be recovered by implementing the NSPS. If voluntary action is not deducted from the baseline, capital costs for the NSPS under the alternative regulatory baseline are estimated at $25 million, and annualized costs without revenues from product recovery for the NSPS are estimated at $330 million. In this scenario, given the assumptions about product prices, estimated revenues from product recovery are $350 million, yielding an estimated cost of savings of about $22 million. All estimates are in 2008 dollars.

- **Small Entity Analyses:** For the final NSPS, EPA performed a screening analysis for impacts on a sample of expected affected small entities by comparing compliance costs to entity revenues. When revenue from additional natural gas product recovered is not included, we estimate that 123 of the 127 small firms analyzed (96.9 percent) are likely to have impacts less than 1 percent in terms of the ratio of annualized compliance costs to revenues. Meanwhile, four firms (3.1 percent) are likely to have impacts greater than 1 percent. Three of these four firms are likely to have impacts greater than 3 percent. However, when revenue from additional natural gas product recovery is included, we estimate that none of the analyzed firms will have an impact greater than 1 percent.

- **Employment Impacts Analysis:** EPA estimated the labor impacts due to the installation, operation, and maintenance of control equipment, as well as labor associated with new reporting and recordkeeping requirements. We estimate up-front and continual, annual labor requirements by estimating hours of labor required for compliance and converting this number to full-time equivalents (FTEs) by dividing by 2,080 (40 hours per week multiplied by 52 weeks). The up-front labor requirement to comply with the final NSPS is estimated at 50 full-time-equivalent employees. The annual labor requirement to comply with final NSPS is estimated at about 570 full-time-equivalent employees. We note that this type of FTE estimate cannot be used to identify the specific number of people involved or whether new jobs are created for new employees, versus displacing jobs from other sectors of the economy.

Table 1-1 Summary of the Monetized Benefits, Costs, and Net Benefits for the Final Oil and Natural Gas NSPS in 2015[1]

	Final[4]
Total Monetized Benefits[2]	N/A
Total Costs[3]	-$15 million
Net Benefits	N/A
Non-monetized Benefits[6]	190,000 tons of VOC
	11,000 tons of HAP[5]
	1.0 million tons of methane[5]
	Health effects of HAP exposure[5]
	Health effects of $PM_{2.5}$ and ozone exposure
	Visibility impairment
	Vegetation effects
	Climate effects[5]

[1] All estimates are for the implementation year (2015) and include estimated revenue from additional natural gas recovery as a result of the NSPS.

[2] While we expect that these avoided emissions will result in improvements in air quality and reductions in health effects associated with HAP, ozone, and particulate matter (PM) as well as climate effects associated with methane, we have determined that quantification of those benefits and co-benefits cannot be accomplished for this rule in a defensible way. This is not to imply that there are no benefits or co-benefits of the rules; rather, it is a reflection of the difficulties in modeling the direct and indirect impacts of the reductions in emissions for this industrial sector with the data currently available.

[3] The engineering compliance costs are annualized using a 7 percent discount rate.

[4] The negative cost for the NSPS reflects the inclusion of revenues from additional natural gas and hydrocarbon condensate recovery that are estimated as a result of the final NSPS. Possible explanations for why there appear to be negative cost control technologies are discussed in the engineering costs analysis section in the RIA.

[5] Reduced exposure to HAP and climate effects are co-benefits.

[6] The specific control technologies for the final NSPS are anticipated to have minor secondary disbenefits, including an increase of 1.1 million tons of carbon dioxide (CO_2), 550 tons of nitrogen oxides (NOx), 19 tons of PM, 3,000 tons of CO, and 1,100 tons of total hydrocarbons (THC) as well as emission reductions associated with the energy system impacts. The net CO_2-equivalent ($CO_{2\text{-}e}$) emission reductions are 18 million metric tons.

1.2.2 NESHAP Amendments Results

For the final NESHAP Amendments, the key results of the RIA follow and are summarized in Table 1-2:

- **Benefits Analysis:** The final NESHAP Amendments are anticipated to reduce a significant amount of existing emissions, including 670 tons of HAP, as well as 1,200 tons of VOC and 420 tons of methane. While we expect that these avoided emissions will result in improvements in ambient air quality and reductions in health effects associated with exposure to HAP, ozone, and PM, we have determined that quantification of those benefits cannot be accomplished for this rule. This is not to imply that there are no benefits of the rules; rather, it is a reflection of the difficulties in modeling the direct and indirect impacts of the reductions in emissions for this industrial sector with the data currently available.[3] In addition to health improvements, there will be improvements in visibility effects, ecosystem effects, and climate effects. The specific control technologies for the NESHAP are anticipated to have minor secondary disbenefits, but EPA was unable to estimate these secondary disbenefits. The net CO_2-equivalent emission reductions are about 8,000 metric tons.
- **Engineering Cost Analysis:** EPA estimates the total capital costs of the final NESHAP Amendments to be $2.8 million. Total annualized engineering costs, which includes annualized capital costs and operating and maintenance costs, of the final NESHAP Amendments are estimated to be $3.5 million. All estimates are in 2008 dollars.
- **Small Entity Analyses:** For the final NESHAP Amendments, EPA estimates that 11 of the 35 firms (31 percent) that own potentially affected facilities are small entities. The EPA performed a screening analysis for impacts on all expected affected small entities by comparing compliance costs to entity revenues. Among the small firms, none of the 11 (zero percent) are likely to have impacts of greater than 1 percent in terms of the ratio of annualized compliance costs to revenues.
- **Employment Impacts Analysis:** EPA estimated the labor impacts due to the installation, operation, and maintenance of control equipment, as well as labor associated with new reporting and recordkeeping requirements. We estimate up-front and continual, annual labor requirements by estimating hours of labor required for compliance and converting this number to full-time equivalents (FTEs) by dividing by 2,080 (40 hours per week multiplied by 52 weeks). The up-front labor requirement to comply with the final NESHAP Amendments is estimated at 4 full-time-equivalent employees. The annual labor requirement to comply with final NESHAP Amendments is estimated at about 30 full-time-equivalent employees. We note that this type of FTE estimate cannot be used to identify the specific

[3] Previous studies have estimated the monetized benefits-per-ton of reducing VOC emissions associated with the effect that those emissions have on ambient $PM_{2.5}$ levels and the health effects associated with $PM_{2.5}$ exposure (Fann, Fulcher, and Hubbell, 2009). While these ranges of benefit-per-ton estimates provide useful context for the break-even analysis, the geographic distribution of VOC emissions from the oil and gas sector are not consistent with emissions modeled in Fann, Fulcher, and Hubbell (2009). In addition, the benefit-per-ton estimates for VOC emission reductions in that study are derived from total VOC emissions across all sectors. Coupled with the larger uncertainties about the relationship between VOC emissions and $PM_{2.5}$ and the highly localized nature of air quality responses associated with VOC reductions, these factors lead us to conclude that the available VOC benefit-per-ton estimates are not appropriate to calculate monetized benefits of these rules, even as a bounding exercise.

number of people involved or whether new jobs are created for new employees, versus displacing jobs from other sectors of the economy.

- **Break-Even Analysis:** A break-even analysis suggests that HAP emissions would need to be valued at $5,200 per ton for the benefits to exceed the costs if the health benefits, ecosystem and climate co-benefits from the reductions in VOC and methane emissions are assumed to be zero. If we assume the health benefits from HAP emission reductions are zero, the VOC emissions would need to be valued at $2,900 per ton or the methane emissions would need to be valued **a**t $8,300 per ton for the benefits to exceed the costs. Previous assessments have shown that the $PM_{2.5}$ benefits associated with reducing VOC emissions were valued at $280 to $7,000 per ton of VOC emissions reduced in specific urban areas, ozone benefits valued at $240 to $1,000 per ton of VOC emissions reduced, and climate co-benefits valued at $110 to $1,400 per short ton of methane reduced. All estimates are in 2008 dollars.

Table 1-2 Summary of the Monetized Benefits, Costs, and Net Benefits for the Final Oil and Natural Gas NESHAP in 2015[1]

	Final
Total Monetized Benefits[2]	N/A
Total Costs[3]	$3.5 million
Net Benefits	N/A
Non-monetized Benefits[5]	670 tons of HAP
	1,200 tons of VOC[4]
	420 tons of methane[4]
	Health effects of HAP exposure
	Health effects of $PM_{2.5}$ and ozone exposure[4]
	Visibility impairment[4]
	Vegetation effects[4]
	Climate effects[4]

[1] All estimates are for the implementation year (2015).

[2] While we expect that these avoided emissions will result in improvements in air quality and reductions in health effects associated with HAP, ozone, and PM as well as climate effects associated with methane, we have determined that quantification of those benefits and co-benefits cannot be accomplished for this rule in a defensible way. This is not to imply that there are no benefits or co-benefits of the rules; rather, it is a reflection of the difficulties in modeling the direct and indirect impacts of the reductions in emissions for this industrial sector with the data currently available.

[3] The engineering compliance costs are annualized using a 7 percent discount rate.

[4] Reduced exposure to VOC emissions, $PM_{2.5}$ and ozone exposure, visibility and vegetation effects, and climate effects are co-benefits.

[5] The specific control technologies for the NESHAP are anticipated to have minor secondary disbenefits, but EPA was unable to estimate these secondary disbenefits. The net CO_2-equivalent emission reductions are 8,000 metric

tons.

1.2.3 Results of Energy System Impacts Analysis of the NSPS and NESHAP Amendments

The analysis of energy system impacts using NEMS for the final NSPS shows that domestic natural gas production is not likely to change in 2015, the year used in the RIA to analyze impacts. Average natural gas prices are also not estimated to change in response to the final rules. Domestic crude oil production is not expected to change, while average crude oil prices are estimated to decrease slightly (about $0.01/barrel or about 0.01 percent at the wellhead for onshore production in the lower 48 states). All prices are in 2008 dollars.

1.2.4 Results for Combined Small Entity Analysis for the NSPS and NESHAP Amendments

After considering the economic impact of the combined NSPS and NESHAP Amendments on small entities, EPA certifies this action will not have a significant economic impact on a substantial number of small entities (SISNOSE). While both the NSPS and NESHAP amendment would individually result in a no SISNOSE finding, EPA performed an additional screening analysis in order to certify the rule in its entirety. This analysis compared compliance costs to entity revenues for the total of all the entities affected by the NESHAP Amendments and the sample of entities analyzed for the NSPS. When revenues from additional natural gas product sales are not included, 132 of the 136 small firms (97 percent) are likely to have impacts of less than 1 percent in terms of the ratio of annualized compliance costs to revenues. Meanwhile, four firms (3 percent) are likely to have impacts greater than 1 percent. Three of these four firms are likely to have impacts greater than 3 percent. When revenues from additional natural gas product sales are included, all 136 small firms (100 percent) in the sample are likely to have impacts of less than 1 percent.

1.3 Summary of NSPS Impacts Changes from the Proposal RIA

This section summarizes major changes from the proposal version of the RIA. These changes were a result of revised assumptions and technical factors, as well as changes in the rule itself from proposal.

- **Revised baseline to include voluntary RECs:** The NSPS analysis used a baseline that accounted for emission controls required by state regulation, but did not include voluntary actions. In the final RIA, to account for emissions reductions and costs arising in the baseline from voluntary implementation of pollution controls, EPA used information on total emissions reductions reported by partners of the EPA Natural Gas STAR. Additionally, we provide summary-level estimates of emissions reductions and engineering compliance costs for a case where no voluntary reduced emission completions (REC) are assumed to occur. This alternative case is presented in order to show impacts if conditions were such that RECs were no longer performed on a voluntary basis, but rather were compelled by the regulation.

- **Changed estimate of number of recompleted natural gas wells:** The NSPS proposal estimated that 12,050 RECs for existing natural gas well recompletions would be required in addition to those already required by state regulations. EPA has reevaluated the assumption based on data submitted to the Agency. Based on this information, EPA has estimated the recompletion frequency to be 1 percent of fractured gas wells per year, rather than 10 percent. More detailed discussion is presented in a technical memorandum on this subject in the docket.[4]
- **Recompletions of existing natural gas wells that are hydraulically refractured:** In the final rule, recompletions of existing natural gas wells that are hydraulically refractured are only subject to the NSPS if emissions from these completions are uncontrolled.
- **New hydraulically fractured natural gas well completions with insufficient pressure to implement REC required to combust completions emissions:** Using the formula estimated to identify hydraulically fractured natural gas well completions that would not have sufficient pressure to perform a REC, approximately 10 percent of well completions would be required to combust emissions rather than implement a REC. More detailed discussion is presented in a technical memorandum on this subject in the docket.[5]
- **Revised natural gas emissions factor for well completions and recompletions of hydraulically fractured wells:** The EPA received several comments regarding the emissions factor selected to calculate whole gas emissions (and the associated VOC emissions) from hydraulically fractured well completions. Comments focused on the data behind the emissions factor, what the emissions factor is intended to represent, and the procedures used to develop the emissions factor from the selected data sets. We reviewed all information received and have decided to retain the data set and the analysis conducted to develop the emissions factor, but rounded from 9,175 Mcf per completion

[4] "Gas Well Refracture Frequency" in U.S. Environmental Protection Agency Oil and Natural Gas Sector: Standards of Performance for Crude Oil and Natural Gas Production, Transmission, and Distribution: Background Supplemental Technical Support Document for the Final New Source Performance Standards. EPA-453/R-11-002. April 2012.

[5] "NSPS Low Pressure Completion Threshold" in U.S. Environmental Protection Agency. Oil and Natural Gas Sector: Standards of Performance for Crude Oil and Natural Gas Production, Transmission, and Distribution: Background Supplemental Technical Support Document for the Final New Source Performance Standards. EPA-453/R-11-002. April 2012.

to 9,000 Mcf per completion. More detailed discussion is presented in a technical memorandum on this subject in the docket.[6]

- **Changed estimate of REC and completion emission combustion capital costs:** The requirements related to completions of hydraulically fractured natural gas wells (combustion and REC) are essentially one-shot events that typically occur over a few days to a couple of weeks and are generally performed by independent contractors. The emissions controls are applied over the course of a well completion, which will typically range over a few days to a couple of weeks. Given that we base our REC costs estimates on the average cost for contracting the REC as a service, we expect contractors' operation and maintenance costs, depreciations, and potential salvage value of the equipment to be reflected in the total contracting costs. Because of these factors, we decided to treat the hydraulically fractured natural gas well completion requirements solely as annualized costs, which differed from our analysis at proposal, which equated capital and annualized costs.
- **Removal of compressors and pneumatic devices in the natural gas transmission segment from NSPS:** In the final rule, proposed requirements relating to reciprocating and centrifugal compressors and pneumatic devices in the transmission segment are removed. Given the large number of sources, and the relatively low level of VOCs emitted from these sources, we have concluded that additional evaluation of these compliance and burden issues is appropriate prior to taking final action on compressors and pneumatic controllers in the transmission and storage segment. Requirements pertaining to storage vessels in the transmission segment remain.
- **Reporting and recordkeeping costs**: EPA identified several ways to streamline reporting and recordkeeping requirements. As a result, the estimated annual cost of reporting and recordkeeping decreased from $19 million per year to $2.6 million per year.

1.4 Summary of NESHAP Amendments Impacts Changes from the Proposal RIA

The cost and emissions reduction estimates for the NESHAP Amendments are reduced from proposal because proposed provisions related to storage vessels were not finalized from proposal, as well as because of changes to the proposed provisions for small gycol dehydrators. The estimated capital costs of the NESHAP Amendments decreased by about $49 million (from $52 to about $3 million), while estimated total annualized compliance costs decreased by about $12.5 million per year (from $16 to $3.5 million per year) . As a result, estimated HAP reductions decreased by about 710 tons per year from proposal (from 1,380 to 670 tons per year).

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[6] "Evaluation of the Emissions factor for Hydraulically Fractured Gas Well Completions" in U.S. Environmental Protection Agency. Oil and Natural Gas Sector: Standards of Performance for Crude Oil and Natural Gas Production, Transmission, and Distribution: Background Supplemental Technical Support Document for the Final New Source Performance Standards. EPA-453/R-11-002. April 2012.

Also, because of changes in emissions limits from proposal, fewer glycol dehydrators are affected, which reduces capital and annualized costs, as well as emissions reductions for these emissions points.

1.5 Organization of this Report

The remainder of this report details the methodology and the results of the RIA. Section 2 presents the industry profile of the oil and natural gas industry. Section 3 describes the emissions and engineering cost analysis. Section 4 presents the benefits analysis. Section 5 presents statutory and executive order analyses. Section 6 presents a comparison of benefits and costs. Section 7 presents energy system impact, employment impact, and small business impact analyses.

7 ECONOMIC IMPACT ANALYSIS AND DISTRIBUTIONAL ASSESSMENTS

7.1 Introduction

This section includes three sets of analyses for both the NSPS and NESHAP Amendments:

- Energy System Impacts
- Employment Impacts
- Small Business Impacts Analysis

7.2 Energy System Impacts Analysis of Final NSPS and NESHAP Amendments

We use the National Energy Modeling System (NEMS) to estimate the impacts of the final NSPS and NESHAP Amendments on the U.S. energy system. The impacts we estimate include changes in drilling activity, price and quantity changes in the production and consumption of crude oil and natural gas, and changes in international trade of crude oil and natural gas. We evaluate whether and to what extent the increased production costs imposed by the final rules might alter the mix of fuels consumed at a national level. With this information we estimate how the changed fuel mix affects national level CO_2-equivalent greenhouse gas emissions from energy sources. We additionally combine these estimates of changes in CO_2-equivalent greenhouse gas emissions from energy sources and emissions co-reductions of methane from the engineering analysis with the NEMS analysis to estimate the net change in CO_2-equivalent greenhouse gas emissions from energy-related sources, but this analysis is reserved for the secondary environmental impacts analysis within Section 4.

A brief conceptual discussion about our energy system impacts modeling approach is necessary before going into detail on NEMS, how we implemented the regulatory impacts, and results. Economically, it is possible to view the recovered natural gas as an explicit output or as contributing to an efficiency gain at the producer level. For example, the analysis for the final rules shows that about 92 percent of the natural gas captured by emissions controls suggested by the rule is captured by performing REC on new and existing wells that are completed after being hydraulically fractured. The assumed $4/Mcf price for natural gas is the price paid to producers at the wellhead. In the natural gas industry, production is metered at or very near to the wellhead, and producers are paid based upon this metered production. Depending on the situation, the gas captured by REC is sent through a temporary or permanent meter. Payments for the gas are typically made within 30 days.

To preview the energy systems modeling using NEMS, results show that after economic adjustments to the new regulations are made by producers, the captured natural gas represents both increased output (a slight increment in aggregate production) and increased efficiency (producing slightly more for less). However, because of differing objectives for the regulatory analysis we treat the associated savings differently in the engineering cost analysis (as an explicit output) and in NEMS (as an efficiency gain).

In the engineering cost analysis, it is necessary to estimate the expected costs and revenues from implementing emissions controls at the unit level. Because of this, we estimate the net costs as expected costs minus expected revenues for representative units. On the other hand, NEMS models the profit maximizing behavior of representative project developers at a drilling project level. The net costs of the regulation alter the expected discounted cash flow of drilling and implementing oil and gas projects, and the behavior of the representative drillers adjusts accordingly. While in the regulatory case natural gas drilling has become more efficient because of the gas recovery, project developers still interact with markets for which supply and demand are simultaneously adjusting. Consequently, project development adjusts to a new equilibrium. While we believe the cost savings as measured by revenues from selling recovered gas (engineering costs) and measured by cost savings from averted production through efficiency gains (energy economic modeling) are approximately the same, it is important to note that the engineering cost analysis and the national-level cost estimates do not incorporate economic feedbacks such as supply and demand adjustments.

7.2.1 Description of the Department of Energy National Energy Modeling System

NEMS is a model of U.S. energy economy developed and maintained by the Energy Information Administration of the U.S. Department of Energy (DOE). NEMS is used to produce the Annual Energy Outlook, a reference publication that provides detailed forecasts of the energy economy from the current year to 2035. DOE first developed NEMS in the 1980s, and the model has undergone frequent updates and expansion since. DOE uses the modeling system extensively to produce issue reports, legislative analyses, and respond to Congressional inquiries.

EIA is legally required to make the NEMS system source code available and fully documented for the public. The source code and accompanying documentation is released annually when a new Annual Energy Outlook is produced. Because of the availability of the NEMS model, numerous agencies, national laboratories, research institutes, and academic and private-sector researchers have used NEMS to analyze a variety of issues.

NEMS models the dynamics of energy markets and their interactions with the broader U.S. economy. The system projects the production of energy resources such as oil, natural gas, coal, and renewable fuels, the conversion of resources through processes such as refining and electricity generation, and the quantity and prices for final consumption across sectors and regions. The dynamics of the energy system are governed by assumptions about energy and environmental policies, technological developments, resource supplies, demography, and macroeconomic conditions. An overview of the model and complete documentation of NEMS can be found at <http://www.eia.doe.gov/oiaf/aeo/overview/index.html>.

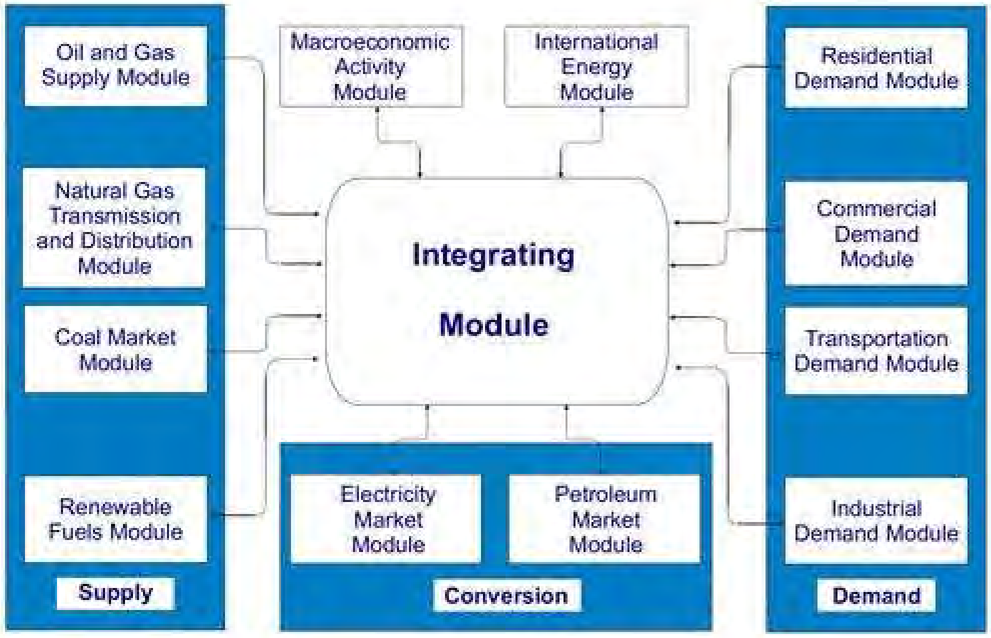

Figure 7-1 Organization of NEMS Modules (source: U.S. Energy Information Administration)

NEMS is a large-scale, deterministic mathematical programming model. NEMS iteratively solves multiple models, linear and non-linear, using nonlinear Gauss-Seidel methods (Gabriel et al. 2001). What this means is that NEMS solves a single module, holding all else constant at provisional solutions, then moves to the next model after establishing an updated provisional solution.

NEMS provides what EIA refers to as “mid-term” projections to the year 2035. However, as this RIA is concerned with estimating regulatory impacts in the first year of full implementation, our analysis focuses upon estimated impacts in the year 2015, with regulatory costs first imposed in 2011. For this RIA, we draw upon the same assumptions and model used in the Annual Energy Outlook 2011.[70] The RIA baseline is consistent with that of the Annual Energy Outlook 2011 which is used extensively in Section 2 in the Industry Profile.

[70] Assumptions for the 2011 Annual Energy Outlook can be found at <http://www.eia.gov/forecasts/aeo/assumptions/index.cfm>.

7.2.2 Inputs to National Energy Modeling System

To model potential impacts associated with the final rules, we modified oil and gas production costs within the Oil and Gas Supply Module (OGSM) of NEMS and domestic and Canadian natural gas production within the Natural Gas Transmission and Distribution Module (NGTDM). The OGSM projects domestic oil and gas production from onshore, offshore, Alaskan wells, as well as having a smaller-scale treatment of Canadian oil and gas production (U.S. EIA, 2010). The treatment of oil and gas resources is detailed in that oil, shale oil, conventional gas, shale gas, tight sands gas, and coalbed methane (CBM) are explicitly modeled. New exploration and development is pursued in the OGSM if the expected net present value of extracted resources exceeds expected costs, including costs associated with capital, exploration, development, production, and taxes. Detailed technology and reservoir-level production economics govern finding and success rates and costs.

The structure of the OGSM is amenable to analyzing potential impacts of the final rules. We are able to target additional expenditures for environmental controls required by the NSPS and NESHAP Amendments on new exploratory and developmental oil and gas production activities, as well as add additional costs to existing projects. We model the impacts of additional environmental costs, as well as the impacts of additional product recovery. We explicitly model the additional natural gas recovered when implementing the final rules. However, we are unable to explicitly model the additional production of condensates expected to be recovered by reduced emissions completions, although we incorporate expected revenues from the condensate recovery in the economic evaluation of new drilling projects.

While the oil production simulated by the OGSM is sent to the refining module (the Petroleum Market Module), simulated natural gas production is sent to a transmission and distribution network captured in the NGTDM. The NGTDM balances gas supplies and prices and "negotiates" supply and consumption to determine a regional equilibrium between supply, demand and prices, including imports and exports via pipeline or LNG. Natural gas is transported through a simplified arc-node representation of pipeline infrastructure based upon pipeline economics.

7.2.2.1 Compliance Costs for Oil and Gas Exploration and Production

As the NSPS affects new emissions sources, we chose to estimate impacts on new exploration and development projects by adding costs of environmental regulation to the algorithm that evaluates the profitability of new projects. Additional NSPS costs associated with reduced emission completions and future recompletions for new wells are added to drilling, completion, and stimulation costs, as these are, in effect, associated with activities that occur within a single time period, although they may be repeated periodically, as in the case of recompletions. Costs required for reduced emissions recompletions on existing wells are added to stimulation expenses for existing wells exclusively. Other costs are operations and maintenance-type costs and are added to fixed operation and maintenance (O&M) expenses associated with new projects. The one-shot and continuing O&M expenses are estimated and entered on a per well basis, depending on whether the costs would apply to oil wells, natural gas wells, both oil and natural gas wells, or a subset of either. We base the per well cost estimates on the engineering costs including revenues from additional product recovery. This approach is appropriate given the structure of the NEMS algorithm that estimates the net present value of drilling projects.

One concern in basing the regulatory costs inputs into NEMS on the net cost of the compliance activity (estimated annualized cost of compliance minus estimated revenue from product recovery) is that potential barriers to obtaining capital may not be adequately incorporated in the model. However, in general, potential barriers to obtaining additional capital should be reflected in the annualized cost via these barriers increasing the cost of capital. With this in mind, assuming the estimates of capital costs and product recovery are valid, the NEMS results will reflect barriers to obtaining the required capital. A caveat to this is that the estimated unit-level capital costs of controls that are newly required at a national-level as a result of the regulation—REC, for example—may not incorporate potential additional transitional costs as the supply of control equipment adjusts to new demand.

Table 7-1 shows the incremental O&M expenses that accrue to new drilling projects as a result of producers having to comply with the NSPS. We estimate those costs as a function of new wells expected to be drilled in a representative year. To arrive at estimates of the per well costs, we first identify which emissions reductions will apply primarily to crude oil wells, to natural gas wells, or to both crude oil and natural gas wells. Based on the baseline projections of successful completions in 2015, we used 19,097 new natural gas wells and 12,193 new oil wells as the basis of these calculations. We then divide the estimated compliance costs for the given emissions point (from Table 3-4) by the appropriate number of expected new wells in the year of analysis. The result yields an approximation of per well compliance costs. We assume this approximation is representative of the incremental cost faced by a producer when evaluating a prospective drilling project.

Like the engineering analysis, we assume that hydraulically fractured well completions and recompletions will be required of wells drilled into tight sand, shale gas, and coalbed methane formations. While costs for well recompletions reflect the cost of a single recompletion, the engineering cost analysis assumed that one in one hundred new wells drilled after the implementation the NSPS are recompleted using hydraulic fracturing in any given year using hydraulic fracturing. Meanwhile, within NEMS, wells are assumed to be stimulated every five years. We assume these more frequent stimulations are less intensive than stimulation using hydraulic fracturing but add costs such that the recompletions costs reflect the same assumptions as the engineering analysis. In entering compliance costs into NEMS, we also account for reduced emissions completions, completion combustion, and recompletions performed in absence of the regulation, using the same assumptions as the engineering costs analysis (Table 7-2).

Table 7-1 Summary of Additional Annualized O&M Costs (on a Per New Well Basis) for Environmental Controls Entered into NEMS

Emissions Sources/Points	Emissions Control	Per Well Costs (2008$)	Wells Applied To in NEMS
Equipment Leaks			
Processing Plants (NSPS)	Subpart VVa	$14	Natural Gas
Reciprocating Compressors			
Gathering and Boosting Stns. (NSPS)	AMM	$10	Natural Gas
Processing Plants (NSPS)	AMM	-$27	Natural Gas
Centrifugal Compressors			
Processing Plants (NSPS)	Route to control	-$35	Natural Gas
Pneumatic Controllers -			
Oil and Gas Production (NSPS)	Emission limits	$11/-$698	Oil/Natural Gas
Processing Plants (NSPS)	Emission limits	7.0	Natural Gas
Storage Vessels			
Emissions at least 6 tons per year (NSPS)	Emission limits	$203/$197	Oil/Natural Gas
Small Glycol Dehydrators			
Production and Transmission Segments (NESHAP)	Emission limits	$60/$60	Oil/Natural Gas
Reporting and Recordkeeping			
NSPS and NESHAP	N/A	$87/$60	Oil/Natural Gas

Table 7-2 Summary of Additional Per Completion/Recompletion Costs (2008$) for Environmental Controls Entered into NEMS

Emissions Sources/Points	Emissions Control	Per Completion Costs (2008$)	Wells Applied To in NEMS
Well Completions			
Hydraulically Fractured New Natural Gas Wells	REC/Combustion	-$271	New Tight Sand/ Shale Gas/CBM
Well Recompletions			
Hydraulically Refractured Existing Natural Gas Wells	REC/Combustion	-$604	Existing Tight Sand/ Shale Gas /Coalbed Methane

7.2.2.2 Adding Averted Methane Emissions into Natural Gas Production

A significant benefit of controlling VOC emissions from oil and natural gas production is that methane that would otherwise be lost to the atmosphere can be directed into the natural gas production stream. We chose to model methane capture in NEMS as an increase in natural gas industry productivity, ensuring that, within the model, natural gas reservoirs are not decremented by production gains from methane capture. We add estimates of the quantities of methane captured (or otherwise not vented or combusted) to the base quantities that the OGSM model supplies to the NGTDM model. We subdivide the estimates of commercially valuable averted emissions by region and well type in order to more accurately portray the economics of implementing the environmental technology. Adding the averted methane emissions in this manner has the effect of moving the natural gas supply curve to the right an increment consistent with the technically achievable emissions transferred into the production stream as a result of the final NSPS.

We enter the increased natural gas recovery into NEMS on a per-well basis for new wells, following an estimation procedure similar to that of entering compliance costs into NEMS on a per-well basis for new wells. For the final NSPS, we estimate that natural gas recovery is 2,473 Mcf per well. We make a simplifying assumption that natural gas recovery accruing to new wells accrues to new wells in shale gas, tight sands, and CBM fields. We make these assumptions because new wells in these fields are more likely to satisfy criteria such that RECs are required, which contributed that large majority of potential natural gas recovery. Note that this per-well natural gas recovery estimate is lower than the per-well estimate when RECs are implemented. The estimate is lower because we account for emissions that are combusted, REC that are implemented absent Federal regulation, as well as the likelihood that natural gas is used during processing and transmission or reinjected.

We treat the potential natural gas recovery associated with recompletions of existing wells differently in that we estimated the natural gas recovery by natural gas resource type based on a combination of the engineering analysis and production patterns from the 2011 Annual Energy Outlook. We estimate that additional natural gas product recovered by recompleting existing wells to be about 3.4 bcf, with 1.6 bcf accruing to shale gas, 1.4 bcf accruing to tight sands, and 0.4 bcf accruing to CBM, respectively. This quantity is distributed within the NGTDM to reflect regional production by resource type.

7.2.2.3 Fixing Canadian Drilling Costs to Baseline Path

Domestic drilling costs serve as a proxy for Canadian drilling costs in the Canadian oil and natural gas sub-model within the NGTDM. This implies that, without additional modification, additional costs imposed by a U.S. regulation will also impact drilling decisions in Canada. Changes in international oil and gas trade are important in the analysis, as a large majority of natural gas imported into the U.S. originates in Canada. To avoid this problem, we fixed Canadian drilling costs using U.S. drilling costs from the baseline scenario. This solution enables a more accurate analysis of U.S.-Canada energy trade, as increased drilling costs in the U.S. as a result of environmental regulation serve to increase Canada's comparative advantage.

7.2.3 Energy System Impacts

As mentioned earlier, we estimate impacts to drilling activity, reserves, price and quantity changes in the production and consumption of crude oil and natural gas, and changes in international trade of crude oil and natural gas, as well as whether and to what extent the final NSPS and NESHAP Amendments might alter the mix of fuels consumed at a national level. In each of these estimates, we present estimates for the baseline year of 2015 and predicted results for 2015 under the final rules. For context, we provide estimates of production activities in 2011.

7.2.3.1 Impacts on Drilling Activities

Because the potential costs of the final rules are concentrated in production activities, we first report estimates of impacts on crude oil and natural gas drilling activities and production and price changes at the wellhead. Table 7-3 presents estimates of successful wells drilled in the U.S. in 2015, the analysis year.

Table 7-3 Successful Oil and Gas Wells Drilled, NSPS

		Future Scenario, 2015	
	2011	**Baseline**	**Under Final NSPS**
Successful Wells Drilled			
Natural Gas	16,373	19,097	19,162
Crude Oil	10,352	11,025	11,025
Total	**26,725**	**30,122**	**30,164**
% Change in Successful Wells Drilled from Baseline			
Natural Gas			0.34%
Crude Oil			0.00%
Total			**0.22%**

We estimate that the number of successful natural gas wells drilled increases slightly for the final NSPS, while the number of successful crude oil wells drilled does not change. The number of successful natural gas wells drilled is estimated to increase about 0.34%. Table 7-4 presents the forecast of successful wells by well type, for onshore drilling in the lower 48 states. The results show that conventional well drilling is unaffected by the NSPS, as reduced emission completion and completion combustion requirements are directed not toward wells in conventional reserves but toward wells that are hydraulically fractured, the wells in so-called unconventional reserves. The number of successful wells drilled increase in tight sands, shale gas, as well as coalbed methane.

Table 7-4 Successful Wells Drilled by Well Type (Onshore, Lower 48 States), NSPS

		Future Scenario, 2015	
	2011	**Baseline**	**Under Final NSPS**
Successful Wells Drilled			
Conventional Gas Wells	7,267	7,607	7,607
Tight Sands	2,441	2,772	2,785
Shale Gas	5,007	7,022	7,066
Coalbed Methane	1,593	1,609	1,618
Total	**16,308**	**19,010**	**19,076**
% Change in Successful Wells Drilled from Baseline			
Conventional Gas Wells			0.00%
Tight Sands			0.47%
Shale Gas			0.63%
Coalbed Methane			0.56%
Total			**0.35%**

Well drilling in tight sands is estimated to increase slightly, about 0.47 percent. Drilling in shale gas is forecast to increase from the baseline by 0.63 percent. Wells in CBM reserves are also estimated to increase from the baseline by 0.56 percent.

7.2.3.2 Impacts on Production, Prices, and Consumption

Table 7-5 shows estimates of the changes in the domestic production of natural gas and crude oil under the final NSPS and NESHAP Amendments, as of 2015. Domestic natural gas and crude oil production are not forecast to change under the final rules, again because impacts of the rules are expected to be negligible.

Table 7-5 Annual Domestic Natural Gas and Crude Oil Production, NSPS

		Future Scenario, 2015	
	2011	**Baseline**	**Under Final NSPS**
Domestic Production			
Natural Gas (trillion cubic feet)	21.05	22.43	22.43
Crude Oil (million barrels/day)	5.46	5.81	5.81
Natural Gas			0.00%
Crude Oil			0.00%

The NEMS analysis estimates no increase in domestic natural gas production. This amount is less than the amount estimated in the engineering analysis to be captured by emissions controls implemented as a result of the NSPS (approximately 43 bcf). This difference is because NEMS models the adjustment of energy markets to the now relatively more efficient natural gas production sector. At the new post-rule equilibrium, producers implementing emissions controls still capture and sell approximately 43 bcf of natural gas. For example, as shown in Table 7-4, about 11,400 new unconventional natural gas wells are completed under the final NSPS; using assumptions from the engineering cost analysis about voluntary RECs performed, RECs required under State regulations and exploratory wells and relatively low pressure wells exempted from REC requirements, about 4,100 NSPS-required RECs would be performed on new natural gas well completions, according to the NEMS analysis, not including the recompletions of existing wells. This recovered natural gas substitutes for natural gas that would be produced from the ground absent the rule. In effect, then, the natural gas that would have been extracted and emitted into the atmosphere is left in the formation for future extraction, according to these results.

As we showed for natural gas drilling, Table 7-6 shows natural gas production from onshore wells in the lower 48 states by type of well, predicted for 2015, the analysis year. With the exception of tight sands, production from all types of wells is estimated to increase under the final rules. However, the decrease in production from tight sands is estimated to offset the slight production increases estimated in conventional, shale, and coalbed methane formations.

Table 7-6 Natural Gas Production by Well Type (Onshore, Lower 48 States), NSPS

		Future Scenario, 2015	
	2011	**Baseline**	**Under Final NSPS**
Natural Gas Production by Well Type (trillion cubic feet)			
Conventional Gas Wells	4.06	3.74	3.75
Tight Sands	5.96	5.89	5.85
Shale Gas	5.21	7.20	7.24
Coalbed Methane	1.72	1.67	1.68
Total	**16.95**	**18.51**	**18.51**
% Change in Natural Gas Production by Well Type from Baseline			
Conventional Gas Wells			0.27%
Tight Sands			-0.68%
Shale Gas			0.56%
Coalbed Methane			0.60%
Total			**0.05%**

Note: Totals may not sum due to independent rounding.

Table 7-7 presents estimates of national average wellhead natural gas and crude oil prices for onshore production in the lower 48 states, estimated for 2015, the year of analysis. Wellhead natural gas price are not forecast to change under the final rules, while crude oil prices are forecast to decrease slightly under the NSPS.

Table 7-7 Lower 48 Average Natural Gas and Crude Oil Wellhead Price, NSPS

		Future Scenario, 2015	
	2011	**Baseline**	**Under Final NSPS**
Lower 48 Average Wellhead Price			
Natural Gas (2008$ per Mcf)	4.07	4.22	4.22
Crude Oil (2008$ per barrel)	83.65	94.60	94.59
% Change in Lower 48 Average Wellhead Price from Baseline			
Natural Gas			0.00%
Crude Oil			-0.01%

Table 7-8 presents estimates of the price of natural gas to final consumers in 2008 dollars per million BTU. Commercial and industrial sector consumers of natural gas are estimated to receive slight price increases, while the national average price to consumers of natural gas is not estimated to change.

Table 7-8 Delivered Natural Gas Prices by Sector (2008$ per million BTU), 2015, NSPS

		Future Scenario, 2015	
	2011	**Baseline**	**Under Final NSPS**
Delivered Prices (2008$ per million BTU)			
Residential	10.52	10.35	10.35
Commercial	9.26	8.56	8.57
Industrial	4.97	5.07	5.08
Electric Power	4.81	4.77	4.77
Transportation	12.30	12.24	12.24
Average	**6.76**	**6.59**	**6.59**
% Change in Delivered Prices from Baseline			
Residential			0.00%
Commercial			0.12%
Industrial			0.20%
Electric Power			0.00%
Transportation			0.00%
Average			**0.00%**

Final consumption of natural gas is not estimated to change in 2015 from the baseline under the final rules, as is shown on Table 7-9. Like delivered price, the consumption shifts are distributed differently across sectors.

Table 7-9 Natural Gas Consumption by Sector, NSPS

		Future Scenario, 2015	
	2011	**Baseline**	**Under Final NSPS**
Consumption (trillion cubic feet)			
Residential	4.76	4.81	4.81
Commercial	3.22	3.38	3.38
Industrial	6.95	8.05	8.06
Electric Power	7.00	6.98	6.97
Transportation	0.03	0.04	0.04
Pipeline Fuel	0.64	0.65	0.65
Lease and Plant Fuel	1.27	1.20	1.20
Total	**23.86**	**25.11**	**25.11**
% Change in Consumption from Baseline			
Residential			0.00%
Commercial			0.00%
Industrial			0.12%
Electric Power			-0.14%
Transportation			0.00%
Pipeline Fuel			0.00%
Lease and Plant Fuel			0.00%
Total			**0.00%**

Note: Totals may not sum due to independent rounding.

7.2.3.3 Impacts on Imports and National Fuel Mix

The NEMS modeling estimates that the impacts from the NSPS and NEHSAP Amendments are not sufficiently large to affect the trade balance of natural gas. As shown in Table 7-10, estimates of crude oil imports do not vary from the baseline in 2015 under the NSPS.

Table 7-10 Net Imports of Natural Gas and Crude Oil, NSPS

		Future Scenario, 2015	
	2011	**Baseline**	**Under Final NSPS**
Net Imports			
Natural Gas (trillion cubic feet)	2.75	2.69	2.69
Crude Oil (million barrels/day)	9.13	8.70	8.70
% Change in Net Imports			
Natural Gas			0.00%
Crude Oil			0.00%

Meanwhile, net imports of natural gas are estimated to decrease about 10 bcf (0.37 percent) under the NSPS, as the increased production substitutes for imported natural gas.

Table 7-11 evaluates estimates of energy consumption by energy type at the national level for 2015, the year of analysis. The NSPS is estimated to have small effects at the national level. We estimate an increase in 0.01 quadrillion BTU in 2015, a 0.01 percent increase. The percent contribution of natural gas, coal, and biomass is projected to increase slightly in 2015.

Table 7-11 Total Energy Consumption by Energy Type (Quadrillion BTU), NSPS

		Future Scenario, 2015	
	2011	**Baseline**	**Under Final NSPS**
Consumption (quadrillion BTU)			
Liquid Fuels	37.41	39.10	39.10
Natural Gas	24.49	25.77	25.78
Coal	20.42	19.73	19.74
Nuclear Power	8.40	8.77	8.77
Hydropower	2.58	2.92	2.92
Biomass	2.98	3.27	3.28
Other Renewable Energy	1.72	2.14	2.14
Other	0.30	0.31	0.31
Total	**98.29**	**102.02**	**102.03**
% Change in Consumption from Baseline			
Liquid Fuels			0.00%
Natural Gas			0.04%
Coal			0.05%
Nuclear Power			0.00%
Hydropower			0.00%
Biomass			0.31%
Other Renewable Energy			0.00%
Other			0.00%
Total			**0.01%**

Note: Totals may not sum due to independent rounding.

With the national profile of energy consumption estimated to change slightly under the NSPS in 2015, the year of analysis, it is important to examine whether aggregate energy-related CO_2-equivalent greenhouse gas (GHG) emissions also shift. A more detailed discussion of changes in CO_2-equivalent GHG emissions from a baseline is presented within the benefits analysis in Section 4. Here, we present a single NEMS-based table showing estimated changes in energy-related "consumer-side" GHG emissions. We use the terms "consumer-side" emissions to distinguish emissions from the consumption of fuel from emissions specifically associated with the extraction, processing, and transportation of fuels in the oil and natural gas sector under examination in this RIA. We term the emissions associated with extraction, processing, and transportation of fuels "producer-side" emissions.

Table 7-12 Modeled Change in Energy-related "Consumer-Side" CO_2-equivalent GHG Emissions

		Future Scenario, 2015	
	2011	**Baseline**	**Under Final NSPS**
Energy-related CO_2-equivalent GHG Emissions (million metric tons CO_2-equivalent)			
Petroleum	2,359.59	2,433.60	2,433.53
Natural Gas	1,283.78	1,352.20	1,352.24
Coal	1,946.02	1,882.08	1,882.76
Other	11.99	11.99	11.99
Total	**5,601.39**	**5,679.87**	**5,680.52**
% Change in Energy-related CO_2-equivalent GHG Emissions from Baseline			
Petroleum			0.00%
Natural Gas			0.00%
Coal			0.04%
Other			0.00%
Total			**0.01%**

Note: Excludes “producer-side” emissions and emissions reductions estimated to result from NSPS. Totals may not sum due to independent rounding.

As is shown in Table 7-12, the final rules are predicted to slightly increase consumer-side aggregate energy-related CO_2-equivalent GHG emissions by about 650,000 metric tons (0.01 percent), mainly because consumer-side emissions from coal combustion increase slightly as a result of the slight consumption increases noted in Table 7-11.

7.3 Employment Impact Analysis

While a standalone analysis of employment impacts is not included in a standard cost-benefit analysis, such an analysis is of particular concern in the current economic climate of sustained high unemployment. Executive Order 13563, states, “Our regulatory system must protect public health, welfare, safety, and our environment while promoting economic growth, innovation, competitiveness, and job creation” (emphasis added). Therefore, we seek to inform the discussion of labor demand and job impacts by providing an estimate of the employment impacts of the regulations using labor requirements for the installation, operation, and maintenance of control requirements, as well as reporting and recordkeeping requirements.

Unlike several recent RIAs, however, we do not provide employment impacts estimates based on the study by Morgenstern et al. (2002); we discuss this decision after presenting estimates of the labor requirements associated with reporting and recordkeeping and the installation, operation, and maintenance of control requirements.

7.3.1 Employment Impacts from Pollution Control Requirements

Regulations set in motion new orders for pollution control equipment and services. New categories of employment have been created in the process of implementing regulations to make our air safer to breathe. When a new regulation is promulgated, a response of industry is to order pollution control equipment and services in order to comply with the regulation when it becomes effective. Revenue and employment in the environmental technology industry have grown steadily between 2000 and 2008, reaching an industry total of approximately $300 billion in revenues and 1.7 million employees in 2008.[71] While these revenues and employment figures represent gains for the environmental technologies industry, they are costs to the regulated industries required to install the equipment. Moreover, it is not clear the 1.7 million employees in 2008 represent new employment as opposed to workers being shifted from the production of goods and services to environmental compliance activities.

Once the equipment is installed, regulated firms hire workers to operate and maintain the pollution control equipment – much like they hire workers to produce more output. Morgenstern et al. (2002) examined how regulated industries respond to regulation. Morgenstern et al. identified three separate components of the employment change in response to a regulation:

- Higher production costs raise market prices, higher prices reduce consumption (and production), reducing demand for labor within the regulated industry ("demand effect");

[71] In 2008, the industry totaled approximately $315 billion in revenues and 1.9 million employees including indirect employment effect; pollution abatement equipment production employed approximately 4.2 million workers in 2008. These indirect employment effects are based on a multiplier for indirect employment = 2.24 (1982 value from Nestor and Pasurka - approximate middle of range of multipliers 1977-1991). Environmental Business International (EBI), Inc., San Diego, CA. Environmental Business Journal, monthly (copyright). http://www.ebiusa.com/ EBI data taken from the Department of Commerce International Trade Administration Environmental Industries Fact Sheet from April 2010: http://web.ita.doc.gov/ete/eteinfo.nsf/068f3801d047f26e85256883006ffa54/4878b7e2fc08ac6d85256883006c452c?OpenDocument

- As costs go up, plants add more capital and labor. For example, pollution abatement activities require additional labor services to produce the same level of output ("cost effect");
- Post-regulation production technologies may be more or less labor intensive (i.e., more/less labor is required per dollar of output) ("factor-shift effect").

The authors found that, on average for the industries they studied, employment increases in regulated firms. Of course, these firms may also reassign existing employees to perform these activities.

Environmental regulations support employment in many basic industries. In addition to the increase in employment in the environmental protection industry (via increased orders for pollution control equipment), environmental regulations also support employment in industries that provide intermediate goods to the environmental protection industry. The equipment manufacturers, in turn, order steel, tanks, vessels, blowers, pumps, and chemicals to manufacture and install the equipment.

The focus of this part of the analysis is on labor requirements related to the compliance actions of the affected entities within the affected sector. We do not estimate any potential changes in labor outside of the oil and natural gas sector. This analysis estimates the employment impacts due to the installation, operation, and maintenance of control equipment, as well as employment associated with new reporting and recordkeeping requirements.

It is important to highlight that unlike the typical case where to reduce a bad output (i.e., emissions) a firm often has to reduce production of the good output, many of the emission controls required by the final NSPS will simultaneously increase production of the good output and reduce production of bad outputs. That is, these controls jointly produce environmental improvements and increase output in the regulated sector. New labor associated with implementing these controls to comply with the new regulations can also be viewed as additional labor increasing output while reducing undesirable emissions. To the extent, however, that these rules may require unprofitable investments for some operators, there is a possibility that these producers decrease output in response and create downward pressure on labor demand, both in the regulated sector and on those sectors using natural gas as an input. This RIA excludes these potential adverse effects on the labor market.

No estimates of the labor used to manufacture or assemble pollution control equipment or to supply the materials for manufacture or assembly are included because U.S. EPA does not currently have this information. The employment analysis uses a bottom-up engineering-based methodology to estimate employment impacts. The engineering cost analysis summarized in this RIA includes estimates of the labor requirements associated with implementing the regulations. Each of these labor changes may either be required as part of an initial effort to comply with the new regulation or required as a continuous or annual effort to maintain compliance. We estimate up-front and continual, annual labor requirements by estimating hours of labor required and converting this number to full-time equivalents (FTEs) by dividing by 2,080 (40 hours per week multiplied by 52 weeks). We note that this type of FTE estimate cannot be used to make assumptions about the specific number of people involved or whether new jobs are created for new employees.

In other employment analyses U.S. EPA distinguished between employment changes within the regulated industry and those changes outside the regulated industry (e.g. a contractor from outside the regulated facility is employed to install a control device). For this regulation however, the structure of the industry makes this difficult. The mix of in-house versus contracting services used by firms is very case-specific in the oil and natural gas industry. For example, sometimes the owner of the well, processing plant, or transmission pipelines uses in–house employees extensively in daily operations, while in other cases the owner relies on outside contractors for many of these services. For this reason, we make no distinction in the quantitative estimates between labor changes within and outside of the regulated sector.

The results of this employment estimate are presented in Table 7-13 for the final NSPS and in Table 7-14 for the final NESHAP Amendments. The tables breaks down the installation, operation, and maintenance estimates by type of pollution control evaluated in the RIA and present both the estimated hours required and the conversion of this estimate to FTE. For both the final NSPS and NESHAP Amendments, reporting and recordkeeping requirements were estimated for the entire rules rather than by anticipated control requirements; the reporting and recordkeeping estimates are consistent with estimates EPA submitted as part of its Information Collection Request (ICR).

The up-front labor requirement is estimated at 50 FTEs for the final NSPS and about 4 FTEs for the final NESHAP Amendments. These up-front FTE labor requirements can be viewed as short-term labor requirements required for affected entities to comply with the new regulation. Ongoing requirements are estimated at about 570 FTEs for the final NSPS and about 30 FTEs for the final NESHAP Amendments. These ongoing FTE labor requirements can be viewed as sustained labor requirements required for affected entities to continuously comply with the new regulation.

Two main categories contain the majority of the labor requirements for the final rules: implementing reduced emissions completions (REC) and reporting and recordkeeping requirements for the final NSPS. Also, note that pneumatic controllers have no up-front or continuing labor requirements. While the controls do require labor for installation, operation, and maintenance, the required labor is less than that of the controllers that would be used absent the regulation. In this instance, we assume the incremental labor requirements are zero.

Implementing RECs are estimated to require about 500 FTE, about 87 percent of the total continuing labor requirements for the final NSPS.[72] We denote REC-related requirements as continuing, or annual, as the REC requirements will in fact recur annually, albeit at different wells each year. The REC requirements are associated with certain new well completions or existing well recompletions. While individual completions occur over a short period of time (days to a few weeks), new wells and other existing wells are completed or recompleted annually. Because of these reasons, we assume the REC-related labor requirements are annual.

[72] As shown on earlier in this section, we project that the number of successful natural gas wells drilled in 2015 will decline slightly from the baseline projection. Therefore, there may be small employment losses in drilling-related employment that partly offset gains in employment from compliance-related activities.

7.3.2 Employment Impacts Primarily on the Regulated Industry

In previous RIAs, we transferred parameters from a study by Morgenstern et al. (2002) to estimate employment effects of new regulations. (See, for example, the Regulatory Impact Analysis for the finalized Mercury and Air Toxics Standards, promulgated on December 16, 2011). The fundamental insight of Morgenstern, et al. is that environmental regulations can be understood as requiring regulated firms to add a new output (environmental quality) to their product mixes. Although legally compelled to satisfy this new demand, regulated firms have to finance this additional production with the proceeds of sales of their other (market) products. Satisfying this new demand requires additional inputs, including labor, and may alter the relative proportions of labor and capital used by regulated firms in their production processes.

Using plant-level Census information between the years 1979 and 1991, Morgenstern et al. estimate the size of each effect for four polluting and regulated industries (petroleum refining, plastic material, pulp and paper, and steel). On average across the four industries, each additional $1 million (1987$) spending on pollution abatement results in a (statistically insignificant) net increase of 1.55 (+/- 2.24) jobs. As a result, the authors conclude that increases in pollution abatement expenditures did not necessarily cause economically significant employment changes in those industries at that time.

For this version of the RIA for the final NSPS and NESHAP Amendments, however, we chose not to quantitatively estimate employment impacts using Morgenstern et al. because of reasons specific to the oil and natural gas industry and the final rules. We believe the transfer of parameter estimates from the Morgenstern et al. study to the final NSPS and NESHAP Amendments is beyond the range of the study for two reasons.

Table 7-13 Labor-based Employment Estimates for Reporting and Recordkeeping and Installing, Operating, and Maintaining Control Equipment Requirements, NSPS, 2015

Source/Emissions Point	Emissions Control	Projected No. of Affected Units	Per Unit One-time Labor Estimate (hours)	Per Unit Annual Labor Estimate (hours)	Total One-Time Labor Estimate (hours)	Total Annual Labor Estimate (hours)	One-time Full-Time Equivalent	Annual Full-Time Equivalent
Well Completions and Recompletions								
New Hydraulically Fractured Gas Wells	REC/Combustion	4,107	0	218	0	893,397	0	430
New Hydraulically Fractured Gas Wells	Combustion	1,377	0	22	0	29,719	0	14
Hydraulically Re-fractured Gas Wells	REC/Combustion	532	0	218	0	115,721	0	56
Hydraulically Re-fractured Gas Wells	Combustion	121	0	22	0	2,611	0	1
Equipment Leaks								
Processing Plants	NSPS Subpart VVA	29	587	887	17,023	25,723	8	12
Reciprocating Compressors								
Gathering and Boosting Stations	Annual Monitoring/ Maintenance (AMM)	210	1	1	210	210	< 1	< 1
Processing Plants	AMM	209	1	1	209	209	< 1	< 1
Centrifugal Compressors								
Processing Plants	Route to Control	13	355	0	4,615	0	2	0
Pneumatic Controllers								
Oil and Gas Production	Low Bleed/Route to Process	13,632	0	0	0	0	0	0
Storage Vessels								
Emissions at least 6 tons per year	95% control	304	271	190	82,279	57,582	40	28
Reporting and Recordkeeping for Complete NSPS		All	N/A	N/A	0	68,882	0.0	33
TOTAL		**N/A**	**N/A**	**N/A**	**104,336**	**1,194,055**	**50**	**574**

Note: Full-time equivalents (FTE) are estimated by first multiplying the projected number of affected units by the per unit labor requirements and then multiplying by 2,080 (40 hours multiplied by 52 weeks). Totals may not sum due to independent rounding.

Table 7-14 Labor-based Employment Estimates for Reporting and Recordkeeping and Installing, Operating, and Maintaining Control Equipment Requirements, Final NESHAP Amendments, 2015

Source/Emissions Point	Emissions Control	Projected No. of Affected Units	Per Unit One-time Labor Estimate (hours)	Per Unit Annual Labor Estimate (hours)	Total One-Time Labor Estimate (hours)	Total Annual Labor Estimate (hours)	One-time Full-Time Equivalent	Annual Full-Time Equivalent
Small Glycol Dehydrators								
Production	Combustion devices, recovery devices, process modifications	74	27	285	2,000	21,120	1	10
Transmission	Combustion devices, recovery devices, process modifications	7	27	285	189	1,998	<1	1
Reporting and Recordkeeping for Complete NESHAP Amendments		N/A	N/A	N/A	6,442	38,923	3	19
TOTAL		**81**	**N/A**	**N/A**	**8,631**	**62,040**	**4**	**30**

Note: Full-time equivalents (FTE) are estimated by first multiplying the projected number of affected units by per unit labor requirements and then multiplying by 2,080 (40 hours multiplied by 52 weeks). Totals may not sum due to independent rounding.

First, the possibility that the revenues producers are estimated to receive from additional natural gas recovery as a result of the final NSPS might offset the costs of complying with the rule presents challenges to estimating employment effects (see Section 3.2.2.1 of the RIA for a detailed discussion of the natural gas recovery). The Morgenstern et al. paper, for example, is intended to analyze the impact of environmental compliance expenditures on industry employment levels, and it may not be appropriate to draw on their demand and net effects when compliance costs are expected to be negative.

Second, the final regulations primarily affect the natural gas production, processing, and transmission segments of the industry. While the natural gas processing segment of the oil and natural gas industry is similar to petroleum refining, which is examined in Morgenstern et al., the production side of the oil and natural gas industry (drilling and extraction, primarily) and natural gas pipeline transmission are not similar to petroleum refining. Because of the likelihood of negative compliance costs for the final NSPS and because the segments of the oil and natural gas industry affected by the rules are not examined by Morgenstern et al., we decided not to use the parameters estimated by Morgenstern et al. to estimate within-industry employment effects for the final oil and natural gas NESHAP Amendments and NSPS.

That said, the likelihood of additional natural gas recovery is an important component of the market response to the rule, as it is expected that this additional natural gas recovery will reduce the price of natural gas. Because of the estimated fall in prices in the natural gas sector due to the final NSPS, prices in other sectors that consume natural gas are likely drop slightly due to the decrease in energy prices. This small production increase and price decrease may have a slight stimulative effect on employment in industries that consume natural gas.

7.4 Small Business Impacts Analysis

The Regulatory Flexibility Act as amended by the Small Business Regulatory Enforcement Fairness Act (SBREFA) generally requires an agency to prepare a regulatory flexibility analysis of any rule subject to notice and comment rulemaking requirements under the Administrative Procedure Act or any other statute, unless the agency certifies that the rule will not have a significant economic impact on a substantial number of small entities. Small entities include small businesses, small governmental jurisdictions, and small not-for-profit enterprises.

After considering the economic impact of the final rules on small entities for both the NESHAP Amendments and NSPS, the analysis indicates that these rules will not have a significant economic impact on a substantial number of small entities (or "SISNOSE"). The supporting analyses for these determinations are presented in this section of the RIA.

As discussed in previous sections of the economic impact analysis, under the final NSPS, some affected producers are likely to be able to recover natural gas that would otherwise be vented to the atmosphere, as well as recover saleable condensates that would otherwise be emitted. EPA estimates that the revenues from this additional natural gas product recovery will offset the costs of implementing control options as a result of the final NSPS. However, not all components of the final NSPS are estimated to have cost savings. Therefore, we analyze potential impacts to better understand the potential distribution of impacts across industry segments and firms. Unlike the controls for the final NSPS, the controls evaluated under the final NESHAP Amendments do not recover significant quantities of natural gas products.

This small entity impacts analysis uses the primary baseline used for the impacts analysis of our NSPS. This primary baseline takes into account RECs conducted pursuant to state regulations covering these operations and estimates of RECs performed voluntarily. To estimate emissions reductions and compliance costs arising from these voluntary RECs, EPA used information reported to EPA by partners of the EPA Natural Gas STAR. More detailed discussion on the derivation of the baseline is presented in a technical memorandum in the docket[73], as well as in Section 3 of this RIA.

7.4.1 Small Business National Overview

The industry sectors covered by the final rule were identified during the development of the engineering cost analysis. The U.S. Census Bureau's Statistics of U.S. Businesses (SUSB) provides national information on the distribution of economic variables by industry and

[73] "Voluntary Reductions from Gas Well Completions with Hydraulic Fracturing" in U.S. Environmental Protection Agency. Oil and Natural Gas Sector: Standards of Performance for Crude Oil and Natural Gas Production, Transmission, and Distribution: Background Supplemental Technical Support Document for the Final New Source Performance Standards. EPA-453/R-11-002. April 2012.

enterprise size. The Census Bureau and the Office of Advocacy of the Small Business Administration (SBA) supported and developed these files for use in a broad range of economic analyses.[74] Statistics include the total number of establishments and receipts for all entities in an industry; however, many of these entities may not necessarily be covered by the final rule. SUSB also provides statistics by enterprise employment and receipt size (Table 7-15 and Table 7-16).

The Census Bureau's definitions used in the SUSB are as follows:

- *Establishmen*t: A single physical location where business is conducted or where services or industrial operations are performed.
- *Firm:* A firm is a business organization consisting of one or more domestic establishments in the same state and industry that were specified under common ownership or control. The firm and the establishment are the same for single-establishment firms. For each multi-establishment firm, establishments in the same industry within a state will be counted as one firm- the firm employment and annual payroll are summed from the associated establishments.
- *Receipts*: Receipts (net of taxes) are defined as the revenue for goods produced, distributed, or services provided, including revenue earned from premiums, commissions and fees, rents, interest, dividends, and royalties. Receipts exclude all revenue collected for local, state, and federal taxes.
- *Enterprise*: An enterprise is a business organization consisting of one or more domestic establishments that were specified under common ownership or control. The enterprise and the establishment are the same for single-establishment firms. Each multi-establishment company forms one enterprise—the enterprise employment and annual payroll are summed from the associated establishments. Enterprise size designations are determined by the sum of employment of all associated establishments.

Because the SBA's business size definitions (SBA, 2008) apply to an establishment's "ultimate parent company," we assumed in this analysis that the "firm" definition above is consistent with the concept of ultimate parent company that is typically used for SBREFA analyses, and the terms are used interchangeably.

[74]See http://www.census.gov/csd/susb/ and http://www.sba.gov/advocacy/ for additional details.

Table 7-15 Number of Firms, Total Employment, and Estimated Receipts by Firm Size and NAICS, 2007

NAICS	NAICS Description	SBA Size Standard (effective Nov. 5, 2010)	Owned by Firms with: < 20 Employees	20-99 Employees	100-499 Employees	Total < 500 Employees	> 500 Employees	Total Firms
Number of Firms by Firm Size								
211111	Crude Petroleum and Natural Gas Extraction	500	5,759	455	115	6,329	95	6,424
211112	Natural Gas Liquid Extraction	500	77	9	12	98	41	139
213111	Drilling Oil and Gas Wells	500	1,580	333	97	2,010	49	2,059
486210	Pipeline Transportation of Natural Gas	$7.0 million	63	12	9	84	42	126
Total Employment by Firm Size								
211111	Crude Petroleum and Natural Gas Extraction	500	21,170	16,583	17,869	55,622	77,664	133,286
211112	Natural Gas Liquid Extraction	500	372	305	1,198	1,875	6,648	8,523
213111	Drilling Oil and Gas Wells	500	5,972	13,787	16,893	36,652	69,774	106,426
486210	Pipeline Transportation of Natural Gas	$7.0 million	241	382	1,479	2,102	22,581	24,683
Estimated Receipts by Firm Size ($1000)								
211111	Crude Petroleum and Natural Gas Extraction	500	12,488,688	15,025,443	17,451,805	44,965,936	149,141,316	194,107,252
211112	Natural Gas Liquid Extraction	500	209,640	217,982	1,736,706	2,164,328	37,813,413	39,977,741
213111	Drilling Oil and Gas Wells	500	1,101,481	2,460,301	3,735,652	7,297,434	16,550,804	23,848,238
486210	Pipeline Transportation of Natural Gas	$7.0 million	332,177	518,341	1,448,020	2,298,538	18,498,143	20,796,681

Source: U.S. Census Bureau. 2010. "Number of Firms, Number of Establishments, Employment, Annual Payroll, and Estimated Receipts by Enterprise Receipt Size for the United States, All Industries: 2007." <http://www.census.gov/econ/susb/>

Table 7-16 Distribution of Small and Large Firms by Number of Firms, Total Employment, and Estimated Receipts by Firm Size and NAICS, 2007

NAICS	NAICS Description	Total Firms	Percent of Firms: Small Businesses	Percent of Firms: Large Businesses	Percent of Firms: Total Firms
Number of Firms by Firm Size					
211111	Crude Petroleum and Natural Gas Extraction	6,424	98.5%	1.5%	100.0%
211112	Natural Gas Liquid Extraction	139	70.5%	29.5%	100.0%
213111	Drilling Oil and Gas Wells	2,059	97.6%	2.4%	100.0%
486210	Pipeline Transportation of Natural Gas	126	48.4%	51.6%	100.0%
Total Employment by Firm Size					
211111	Crude Petroleum and Natural Gas Extraction	133,286	41.7%	58.3%	100.0%
211112	Natural Gas Liquid Extraction	8,523	22.0%	78.0%	100.0%
213111	Drilling Oil and Gas Wells	106,426	34.4%	65.6%	100.0%
486210	Pipeline Transportation of Natural Gas	24,683	N/A*	N/A*	N/A*
Estimated Receipts by Firm Size ($1000)					
211111	Crude Petroleum and Natural Gas Extraction	194,107,252	23.2%	76.8%	100.0%
211112	Natural Gas Liquid Extraction	39,977,741	5.4%	94.6%	100.0%
213111	Drilling Oil and Gas Wells	23,848,238	30.6%	69.4%	100.0%
486210	Pipeline Transportation of Natural Gas	20,796,681	N/A*	N/A*	N/A*

Note: Employment and receipts could not be broken down between small and large businesses because of non-disclosure requirements.

Source: SBA

While the SBA and Census Bureau statistics provide informative broad contextual information on the distribution of enterprises by receipts and number of employees, it is also useful to additionally contrast small and large enterprises (where large enterprises are defined as those that are not small, according to SBA criteria) in the oil and natural gas industry. The summary statistics presented in previous tables indicate that there are a large number of relatively small firms and a small number of large firms. Given the majority of expected impacts of the final rules arises from well completion-related requirements, which impacts production activities, exclusively, some explanation of this particular market structure is warranted as it pertains to production and small entities. An important question to answer is whether there are particular roles that small entities serve in the production segment of the oil and natural gas industry that may be disproportionately affected by the final rules.

The first important broad distinction among firms is whether they are independent or integrated. Independent firms concentrate on exploration and production (E&P) activities, while integrated firms are vertically integrated and often have operations in E&P, processing, refining, transportation, and retail. To our awareness, there are no small integrated firms. Independent firms may own and operate wells or provide E&P-related services to the oil and gas industry. Since we are focused on evaluating potential impacts to small firms owning and operating new and existing hydraulically fractured wells, we should focus on this sector.

In our understanding, there is no single industry niche for small entities in the production segment of the industry since small operators have different business strategies and that small entities can own different types of wells. The organization of firms in the oil and natural gas industry also varies greatly from firm to firm. Additionally, oil and natural gas resources vary widely geographically and can vary significantly within a single field.

Among many important roles, independent small operators historically pioneered exploration in new areas, as well as developed new technologies. By taking on these relatively large risks, these small entrepreneurs (wildcatters) have been critical sources of industrial innovation and opened up critical new energy supplies for the U.S. (IHS Global Insight). In recent decades, as the oil and gas industry has concentrated via mergers, many of these smaller firms have been absorbed into large firms.

Another critical role, which provides an interesting contrast to small firms pioneering new territory, is that smaller independents maintain and operate a large proportion of the Nation's low producing wells, which are also known as marginal or stripper wells (Duda et al. 2005). While marginal wells represent about 80 percent of the population of producing wells, they produce about 15 percent of domestic production, according to EIA (Table 7-17).

Table 7-17 Distribution of Crude Oil and Natural Gas Wells by Productivity Level, 2009

Type of Wells	Wells (no.)	Wells (%)	Production (MMbbl for oil and Bcf gas)	Production (%)
Crude Oil				
Stripper Wells (<15 boe per year)	310,552	85%	311	19%
Other Wells (>=15 boe per year)	52,907	15%	1,331	81%
Total Crude Oil Wells	**363,459**	**100%**	**1,642**	**100%**
Natural Gas				
Natural Gas Stripper Wells (<15 boe per year)	338,056	73%	2,912	12%
Other Natural Gas Wells (>=15 boe per year)	123,332	27%	21,048	88%
Total Natural Gas Wells	**461,388**	**100%**	**23,959**	**100%**

Source: U.S. Energy Information Administration, **Distribution of Wells by Production Rate Bracket.** <http://www.eia.gov/pub/oil_gas/petrosystem/us_table.html> Accessed 7/10/11.

Note: Natural gas production converted to barrels oil equivalent (boe) uses the conversion of 0.178 barrels of crude oil to 1000 cubic feet of natural gas.

Many of these wells were likely drilled and initially operated by major firms (although the data are not available to quantify the percentage of wells initially drilled by small versus large producers). Well productivity levels typically follow a steep decline curve; high production in earlier years but sustained low production for decades. Because of relatively low overhead of maintaining and operating few relatively co-located wells, some small operators with a particular business strategy purchase low producing wells from the majors, who concentrate on new opportunities. As small operators have provided important technical innovation in exploration, small operators have also been sources of innovation in extending the productivity and lifespan of existing wells (Duda et al. 2005).

7.4.2 Small Entity Economic Impact Measures

The final Oil and Natural Gas NSPS and NESHAP Amendments will affect the owners of the facilities that will incur compliance costs to control their regulated emissions. The owners, either firms or individuals, are the entities that will bear the financial impacts associated with these additional operating costs. The final rule has the potential to impact all firms owning affected facilities, both large and small.

The analysis provides EPA with an estimate of the magnitude of impacts the final NSPS and NESHAP Amendments may have on the ultimate domestic parent companies that own facilities EPA expects might be impacted by the rules. The analysis focuses on small firms because they may have more difficulty complying with a new regulation or affording the costs associated with meeting the new standard. This section presents the data sources used in the analysis, the methodology we applied to develop estimates of impacts, the results of the analysis, and conclusions drawn from the results.

The small business impacts analysis for the NSPS and NESHAP Amendments relies upon a series of firm-level sales tests (represented as cost-to-revenue ratios) for firms that are likely to be associated with NAICS codes listed in Table 7-15. For both the NSPS and NESHAP Amendments, we obtained firm-level employment, revenues, and production levels using various sources, including the American Business Directory, the *Oil and Gas Journal*, corporate websites, and publically-available financial reports. Using these data, we estimated firm-level compliance cost impacts and calculated cost-to-revenue ratios to identify small firms that might be significantly impacted by the rules. The approaches taken for the NSPS and NESHAP Amendments differed; more detail on approaches for each set of rules is presented in the following sections.

For the sales test, we divided the estimates of annualized establishment compliance costs by estimates of firm revenue. This is known as the cost-to-revenue ratio, or the "sales test." The "sales test" is the impact methodology EPA employs in analyzing small entity impacts as opposed to a "profits test," in which annualized compliance costs are calculated as a share of profits. The sales test is often used because revenues or sales data are commonly available for entities impacted by EPA regulations, and profits data normally made available are often not the true profit earned by firms because of accounting and tax considerations. Revenues as typically published are correct figures and are more reliably reported when compared to profit data. The use of a "sales test" for estimating small business impacts for a rulemaking such as this one is consistent with guidance offered by EPA on compliance with SBREFA[75] and is consistent with guidance published by the U.S. SBA's Office of Advocacy that suggests that cost as a percentage

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[75] The SBREFA compliance guidance to EPA rulewriters regarding the types of small business analysis that should be considered can be found at <http://www.epa.gov/sbrefa/documents/rfaguidance11-00-06.pdf>

of total revenues is a metric for evaluating cost increases on small entities in relation to increases on large entities (U.S. SBA, 2010).[76]

7.4.3 Small Entity Economic Impact Analysis, Final NSPS

7.4.3.1 Overview of Sample Data and Methods

The final NSPS covers emissions points within various stages of the oil and natural gas production process. We expect that firms within multiple NAICS codes will be affected, namely the NAICS categories presented in Table 7-15. Because of the diversity of the firms potentially affected, we decided to analyze three distinct groups of firms within the oil and natural gas industry, while accounting for overlap across the groups. We analyze firms that are involved in oil and natural gas extraction that are likely to drill and operate wells, while a subset are integrated firms involved in multiple segments of production, as well as retailing products. We also analyze firms that primarily operate natural gas processing plants. A third set of firms we analyzed contains firms that primarily operate natural gas compression and pipeline transmission.

To identify firms involved in the drilling and primary production of oil and natural gas, we relied upon the annual *Oil and Gas Journal* 150 Survey (OGJ 150)[77] as described in the Industry Profile in Section 2. Although the proportion of small firms in the OGJ 150 is smaller than the proportion evaluated by the Census Bureau's SUSB, the OGJ 150 provides detailed information on the production activities and financial returns of the firms within the list, which are critical ingredients to the small business impacts analysis. The Census SUSB provides aggregated totals for all businesses in a particular NAICS code. It is not possible to use these data to identify those firms that actually drill wells or specific financial information for individual firms.

The OGJ 150 includes all public firms incorporated in the U.S. with reserves in the U.S. While the OGJ 150 lists only public firms, we believe the list is reasonably representative of the

[76] U.S. SBA, Office of Advocacy. A Guide for Government Agencies, How to Comply with the Regulatory Flexibility Act, Implementing the President's Small Business Agenda and Executive Order 13272, June 2010.

[77] Oil and Gas Journal. "OGJ150 Financial Results Down in '09; Production, Reserves Up." September 6, 2010 and Oil and Gas Journal. "OGJ150." September 21, 2009.

larger population of public and private firms operating in this segment of the industry. The sample of firms represented by the OGJ 150 accounts for 62% of the gas wells drilled in 2008 and 2009. While the population of firms responsible for the remaining 38% of gas wells may include some small private firms, there are also a number of large private companies and foreign firms not represented in the OGJ 150. Examples of companies that are not included in the OGJ 150, but that are likely responsible for a large number of hydraulically fractured natural gas well completions include BP, Encana, and Royal Dutch Shell.

To further examine the representativeness of the sample, EPA compared the revenues reported for the OGJ 150 to those reported for small firms in the Census Bureau's SUSB. While the average revenues in the OGJ 150 appear significantly larger than those in the Census Bureau's SUSB, this comparison is misleading. First, the OGJ 150 reports pre-tax revenues, which we would expect to be higher in every instance than the post-tax Census Bureau's SUSB receipts.[78] Additionally, due to the size of the sample, the descriptive statistics for the OGJ 150 may be influenced by a few particularly large data points. For example, for firms with 10 to 19 employees, removing one firm from the OGJ 150 sample decreases the average revenue for the group by approximately 38 percent. The result is roughly equal to the Census SUSB average for the same group, even before any adjustment for taxes. We believe that, despite these outliers, the data for the OGJ 150 are generally representative of the population in this industry.

While the Census SUSB data includes a greater proportion of very small firms (0-4 employees) than the OGJ 150 sample, we believe this sample appropriately reflects the industry for a number of reasons. First, the OGJ 150 includes companies of a range of sizes, from 1 to over 1 million employees. While there is generally a relationship between size and revenues, this does not necessarily hold true when examining the impacts on individual firms. In some cases, a firm with relatively few employees may have higher revenues than a much larger firm. Additionally, there is not necessarily a relationship between the size of a firm and the proportion of its costs to revenues. Finally, as discussed above, it is impossible to determine what portion of

[78] Census SUSB receipts (net of taxes) are defined as the revenue for goods produced, distributed, or services provided, including revenue earned from premiums, commissions and fees, rents, interest, dividends, and royalties. Receipts excludes all revenue collected for local, state, and federal taxes. http://www.census.gov//econ/susb/definitions.html

the firms in the Census SUSB would be affected firms under the NSPS provisions related to completions of hydraulically fractured and refractured natural gas wells.

In the analysis that follows, we present median, minimum, and maximum values in addition to the average to provide readers with a more complete understanding of the firms in the sample. We are not able to compare these additional statistics to the Census Bureau's SUSB due to the aggregated nature of those data. When making a SISNOSE determination, we calculate the sales test ratio at the firm level, rather than as an average as is reported by the Census SUSB. By using this methodology, we ensure that the results reflect the impacts to all firms in the sample and are not skewed by unusually large data points.

We drew upon the OGJ 150 lists published for the years 2008 and 2009 (*Oil and Gas Journal*, September 21, 2009 and *Oil and Gas Journal*, September 6, 2010). The year 2009 saw relatively low levels of drilling activities because of the economic recession, while 2008 saw a relatively high level of drilling activity because of high fuel prices. Combined, we believe these two years of data are representative.

To identify firms that process natural gas, the OGJ also releases a period report entitled "Worldwide Gas Processing Survey", which provides a wide range of information on existing processing facilities. We used the most recent list of U.S. gas processing facilities[79] and other resources, such as the American Business Directory and company websites, to best identify the parent company of the facilities. To identify firms that compress and transport natural gas via pipelines, we examined the periodic OGJ survey on the economics of the U.S. pipeline industry. This report examines the economic status of all major and non-major natural gas pipeline companies.[80] For these firms, we also used the American Business Directory and corporate websites to best identify the ultimate owner of the facilities or companies. These firms represent all potentially impacted firms in these segments, not a sample.

[79] Oil and Gas Journal. "Special Report: Worldwide Gas Processing: New Plants, Data Push Global Gas Processing Capacity Ahead in 2009." June 7, 2010.
[80] Oil and Gas Journal. "Natural Gas Pipelines Continue Growth Despite Lower Earnings; Oil Profits Grow." November 1, 2010.

After combining the information for exploration and production firms, natural gas processing firms, and natural gas pipeline transmission firms in order to identify overlaps across the list, the approach yielded a sample of 274 firms that would potentially be affected by the final NSPS in 2015 assuming their 2015 production activities were similar to those in 2008 and 2009. We estimate that 127 (46 percent) of these firms are small according to SBA criteria. We estimate 119 firms (43 percent) are not small firms according to SBA criteria. We are unable to classify the remaining 28 firms (10 percent) because of a lack of required information on employee counts or revenue estimates.

Table 7-18 shows the estimated revenues for 246 firms for which we have sufficient data that would be potentially affected by the final NSPS based upon their activities in 2008 and 2009. We segmented the sample into four groups, production and integrated firms, processing firms, pipeline firms, and pipelines/processing firms. For the firms in the pipelines/processing group, we were unable to determine the firms' primary line of business, so we opted to group together as a fourth group.

Table 7-18 Estimated Revenues for Firms in Sample, by Firm Type and Size

		Estimated Revenues (millions, 2008 dollars)				
Firm Type/Size	Number of Firms	Total	Average	Median	Minimum	Maximum
Production and Integrated						
Small	77	18,451.9	239.6	76.3	0.1	1,116.9
Large	47	1,345,292.0	28623.2	1,788.3	12.9	310,586.0
Subtotal	124	1,363,743.9	10,997.9	344.6	0.1	310,586.0
Pipeline						
Small	11	694.5	63.1	4.6	0.5	367.0
Large	36	166,290.2	4,619.2	212.9	7.1	112,493.0
Subtotal	47	166,984.6	3,552.9	108.0	0.5	112,493.0
Processing						
Small	39	4,972.1	127.5	26.9	1.9	1,459.1
Large	23	177,632.1	8,881.6	2,349.4	10.4	90,000.0
Subtotal	62	182,604.2	3,095.0	41.3	1.9	90,000.0
Pipelines/Processing						
Small	0	N/A	N/A	N/A	N/A	N/A
Large	13	175,128.5	13,471.4	6,649.4	858.6	71,852.0
Subtotal	13	175,128.5	13,471.4	6,649.4	858.6	71,852.0
Total						
Small	**127**	**24,118.5**	**189.9**	**34.9**	**0.1**	**1,459.1**
Large	**119**	**1,864,342.8**	**16,071.9**	**1,672.1**	**7.1**	**310,586.0**
Total	**246**	**1,888,461.3**	**7,771.4**	**164.9**	**0.1**	**310,586.0**

Sources: *Oil and Gas Journal*. “OGJ150.” September 21, 2009; *Oil and Gas Journal*. “OGJ150 Financial Results Down in '09; Production, Reserves Up.” September 6, 2010. *Oil and Gas Journal*. “Special Report: Worldwide Gas Processing: New Plants, Data Push Global Gas Processing Capacity Ahead in 2009.” June 7, 2010, with additional analysis to determine ultimate ownership of plants. *Oil and Gas Journal*. “Natural Gas Pipelines Continue Growth Despite Lower Earnings; Oil Profits Grow.” November 1, 2010. American Business Directory was used to determine number of employees.

As shown in Table 7-18, there is a wide variety of revenue levels across firm size, as well as across industry segments. The estimated revenues within the sample are concentrated on integrated firms and firms engaged in production activities (the E&P firms mentioned earlier).

The oil and natural gas industry is capital-intensive. To provide more context on the potential impacts of new regulatory requirements, Table 7-19 presents descriptive statistics for small and large integrated and production firms from the sample of firms (117 of the 124 integrated and production firms listed in the *Oil and Gas Journal*; capital and exploration expenditures for 7 firms were not reported in the *Oil and Gas Journal*).

Table 7-19 Descriptive Statistics of Capital and Exploration Expenditures, Small and Large Firms in Sample, 2008 and 2009 (million 2008 dollars)

		Capital and Exploration Expenditures (millions, 2008 dollars)				
Firm Size	Number	Total	Average	Median	Minimum	Maximum
Small	74	13,262.9	179.2	60.4	0.1	2,401.9
Large	43	127,505.6	2,965.2	982.7	0.1	22,518.7
Total	**117**	**140,768.5**	**1,203.1**	**192.8**	**0.1**	**22,518.7**

Sources: *Oil and Gas Journal*. "OGJ150." September 21, 2009; *Oil and Gas Journal*. "OGJ150 Financial Results Down in '09; Production, Reserves Up." September 6, 2010. American Business Directory was used to determine number of employees.

The average 2008 and 2009 total capital and exploration expenditures for the sample of 117 firms were approximately $140 billion in 2008 dollars). About 9 percent of this total was spent by small firms. Average capital and explorations expenditures for small firms are about 6 percent of large firms; median expenditures of small firms are about 6 percent of large firms' expenditures. For small firms, capital and exploration expenditures are high relative to revenue, which appears to hold true more generally for independent E&P firms compared to integrated major firms. This would seem to indicate the capital-intensive nature of E&P activities. As expected, this would drive up ratios comparing estimated engineering costs to revenues and capital and exploration expenditures.

Table 7-20 breaks down the estimated number of natural gas and crude oil wells drilled by the 121 firms in the sample for which the *Oil and Gas Journal* information reported well-drilling estimates. Note the fractions on the minimum and maximum statistics; the fractions reported are due to our assumptions to estimate oil and natural gas wells drilled from the total wells drilled reported by the *Oil and Gas Journal*. The OGJ150 lists new wells drilled by firm in 2008 and 2009, but the drilling counts are not specific to crude oil or natural gas wells. We apportion the wells drilled to natural gas and crude oil wells using the distribution of well drilling in 2009 (63 percent natural gas and 37 percent oil).

Table 7-20 Descriptive Statistics of Estimated Wells Drilled, Small and Large Firms in Sample, 2008 and 2009

			Estimated Average Wells Natural Gas and Crude Oil Wells Drilled (2008 and 2009)				
Well Type	Firm Size	Number of Firms	Total	Average	Median	Minimum	Maximum
Natural Gas							
	Small	77	2,049.5	26.6	5.7	0.2	259.3
	Large	44	9,723.1	221.0	153.2	0.6	868.3
	Subtotal	121	11,772.5	97.3	28.3	0.2	868.3
Crude Oil							
	Small	77	1179.6	15.3	3.3	0.1	149.2
	Large	44	5596.3	127.2	88.1	0.4	499.7
	Subtotal	121	6,775.9	56.0	16.3	0.1	499.7
Total							
	Small	**77**	**3,229.1**	**41.9**	**9.0**	**0.3**	**408.5**
	Large	**44**	**15,319.4**	**348.2**	**241.3**	**1.0**	**1,368.0**
	Total	**121**	**18,548.4**	**153.3**	**44.6**	**0.3**	**1,368.0**

Sources: *Oil and Gas Journal*. "OGJ150." September 21, 2009; *Oil and Gas Journal*. "OGJ150 Financial Results Down in '09; Production, Reserves Up." September 6, 2010. American Business Directory was used to determine number of employees.

This table highlights the fact that many firms drill relatively few wells; the median for small firms is approximately 6 natural gas wells compared to 153 for large firms. Later in this section, we examine whether this distribution has implications for the engineering costs estimates, as well as the estimates of expected natural product recovery from controls such as REC.

Unlike the analysis of regulatory impacts on small entities from the NESHAP Amendments, we have no specific data on potentially affected facilities under the NSPS. The NSPS will apply to new and modified sources, for which data are not fully available in advance, particularly in the case of new and modified sources such as well completions and recompletions which are spatially diffuse and potentially large in number.

The engineering cost analysis estimated compliance costs in a top-down fashion, projecting the number of new sources at an annual level and multiplying these estimates by model unit-level costs to estimate national impacts. To estimate per-firm compliance costs in this analysis, we followed a procedure similar to that of entering estimated compliance costs in NEMS on a per-well basis. We first use the OGJ150-based list to estimate engineering compliance costs for integrated and production companies that may operate facilities in more than one segment of the oil and natural gas industry. We then estimate the compliance costs per crude oil and natural gas well by totaling all compliance costs estimates in the engineering cost estimates for the final NSPS and dividing that cost by the total number of crude oil and natural gas wells forecast as of 2015, the year of analysis. These compliance costs include the expected revenue from natural gas and condensate recovery that result from implementation of some controls.

This estimation procedure yielded an estimate of crude oil well compliance costs of $260 per drilled well and natural gas well compliance costs of $8,800 or less than 1 percent of the average costs of drilling a well according to EIA (see Table 2-8) without considering estimated revenues from product recovery and $260 and -$940 per drilled crude oil and natural gas well, respectively, with estimated revenues from product recovery included. Note that the divergence of estimated per well costs between crude oil and natural gas wells is because the final NSPS requirements are primary directed toward natural gas wells. Also note that the per-well cost savings estimate for natural gas wells is different than the estimated cost of implementing a REC; this difference is because this estimate is picking up savings from other control options. We then estimate a single-year, firm-level compliance cost for this subset of firms by multiplying the per well cost estimates by the well count estimates.

The OGJ reports plant processing capacity in terms of MMcf/day. In the energy system impacts analysis, the NEMS model estimates a 6.5 percent increase (from 21.05 tcf in 2011 to 22.43 tcf in 2015) in domestic natural gas production from 2011 to 2015, the analysis year. On this, basis, we estimate that natural gas processing capacity for all plants in the OGJ list will increase 1.3 percent per year. This annual increment is equivalent to an increase in national gas processing capacity of 350 bcf per year. We assume that the engineering compliance costs estimates associated with processing are distributed according to the proportion of the increased national processing capacity contributed by each processing plant. These costs are estimated at $6.9 million without estimated revenues from product recovery and $5.0 million with estimated revenues from product recovery, respectively, in 2008 dollars, or about $20/MMcf without revenues and $14/MMcf with revenues.

The OGJ report on pipeline companies has the advantage that it reports expenditures on plant additions. We assume that the firm-level compression and transmission-related NSPS compliance costs are proportional to the expenditures on plant additions and that these additions reflect a representative year or this analysis. We estimate the annual compression and transmission-related NSPS compliance costs at $6.0 million without estimated revenues from product recovery and $5.9 million with estimated revenues from product recovery, respectively, in 2008 dollars.

7.4.3.2 Small Entity Impact Analysis, Final NSPS, Results

Summing estimated annualized engineering compliance costs across industry segment and individual firms in our sample, we estimate firms in the OGJ-based sample will face about $117 million in 2008 dollars, about 69 percent of the estimated annualized costs of the final NSPS without including revenues from additional product recovery of $116 million. When including revenues from additional product recovery, the estimated compliance costs for the firms in the sample are about $1.1 million.

Table 7-21 presents the distribution of estimated final NSPS compliance costs across firm size for the firms within our sample. Evident from this table, about 92 percent of the estimated engineering compliance costs accrue to the integrated and production segment of the industry, again explained by the fact that completion-related requirements contribute the bulk of the estimated engineering compliance costs (as well as estimated emissions reductions). About 16 percent of the total estimated engineering compliance costs (and about 16 percent of the costs accruing to the integrated and production segment) are concentrated on small firms.

Table 7-21 Distribution of Estimated Final NSPS Compliance Costs Without Revenues from Additional Natural Gas Product Recovery across Firm Size in Sample of Firms

Firm Type/Size	Number of Firms	Estimated Engineering Compliance Costs Without Estimated Revenues from Natural Gas Product Recovery (2008 dollars)				
		Total	Average	Median	Minimum	Maximum
Production and Integrated						
Small	77	17,795,916	231,116	48,134	749	2,299,042
Large	47	90,671,503	1,929,181	1,361,483	10,325	7,710,293
Subtotal	124	108,467,419	874,737	221,017	749	7,710,293
Pipeline						
Small	11	3,738	340	123	20	1,264
Large	36	1,641,771	45,605	4,218	41	994,491
Subtotal	47	1,645,509	35,011	2,498	20	994,491
Processing						
Small	39	482,232	12,365	1,906	191	279,864
Large	23	870,458	37,846	8,236	38	429,043
Subtotal	62	1,352,690	21,818	2,764	38	429,043
Pipelines/Processing						
Small	0	---	---	---	---	---
Large	13	5,828,374	448,336	159,519	2,040	2,892,799
Subtotal	13	5,828,374	448,336	159,519	2,040	2,892,799
Total						
Small	**127**	**18,281,886**	**143,952**	**13,602**	**20**	**2,299,042**
Large	**119**	**99,012,106**	**832,035**	**48,054**	**38**	**7,710,293**
Total	**246**	**117,293,992**	**476,805**	**22,225**	**20**	**7,710,293**

These distributions are similar when the revenues from expected natural gas recovery are included (Table 7-22). A total savings from the final NSPS of about $1.1 million is expected to accrue to small firms (about 23 percent of the savings to the integrated and production segment accrue to small firms), while large firms are expected to have a total cost of $2.3 million. Note also in Table 7-22 that the pipeline and processing segments (and the pipeline/processing firms) are not expected to experience net cost savings (negative costs) from the final NSPS.

Table 7-22 Distribution of Estimated Final NSPS Compliance Costs With Revenues from Additional Natural Gas Product Recovery across Firm Size in Sample of Firms

Firm Type/Size	Number of Firms	Estimated Engineering Compliance Costs With Estimated Revenues from Natural Gas Product Recovery (millions, 2008 dollars)				
		Total	Average	Median	Minimum	Maximum
Production and Integrated						
Small	77	-1,500,434	-19,486	25	-218,672	23,982
Large	47	-5,137,073	-109,299	-108,363	-721,121	924,574
Subtotal	124	-6,637,507	-53,528	-11,873	-721,121	924,574
Pipeline						
Small	11	3,629	330	119	19	1,226
Large	36	1,593,661	44,268	4,095	40	965,348
Subtotal	47	1,597,289	33,985	2,425	19	965,348
Processing						
Small	39	349,635	8,965	1,382	138	202,911
Large	23	631,112	27,440	5,971	28	311,071
Subtotal	62	980,747	15,819	2,004	28	311,071
Pipelines/Processing						
Small	0	---	---	---	---	---
Large	13	5,198,212	399,862	143,446	1,511	2,777,165
Subtotal	13	5,198,212	399,862	143,446	1,511	2,777,165
Total						
Small	**127**	**-1,147,170**	**-9,033**	**207**	**-218,672**	**202,911**
Large	**119**	**2,285,911**	**19,209**	**2,419**	**-721,121**	**2,777,165**
Total	**246**	**1,138,741**	**4,629**	**343**	**-721,121**	**2,777,165**

Table 7-23 Summary of Sales Test Ratios, Without Revenues from Additional Natural Gas Product Recovery for Firms Affected by Final NSPS

		Descriptive Statistics for Sales Test Ratio Without Estimated Revenues from Natural Gas Product Recovery (%)			
Firm Type/Size	Number of Firms	Average	Median	Minimum	Maximum
Production and Integrated					
Small	77	0.49%	0.11%	0.00%	11.86%
Large	47	0.10%	0.07%	0.00%	0.65%
Subtotal	124	0.34%	0.09%	0.00%	11.86%
Pipeline					
Small	11	0.01%	0.00%	0.00%	0.01%
Large	36	0.01%	0.00%	0.00%	0.06%
Subtotal	47	0.01%	0.00%	0.00%	0.06%
Processing					
Small	39	0.02%	0.01%	0.00%	0.16%
Large	23	0.01%	0.00%	0.00%	0.16%
Subtotal	62	0.02%	0.01%	0.00%	0.16%
Pipelines/Processing					
Small	0	---	---	---	---
Large	13	0.00%	0.00%	0.00%	0.01%
Subtotal	13	0.00%	0.00%	0.00%	0.01%
Total					
Small	**127**	**0.30%**	**0.04%**	**0.00%**	**11.86%**
Large	**119**	**0.05%**	**0.01%**	**0.00%**	**0.65%**
Total	**246**	**0.18%**	**0.02%**	**0.00%**	**11.86%**

The mean cost-sales ratio for all businesses when estimated product recovery is excluded from the analysis of the sample data is 0.18 percent, with a median ratio of 0.02 percent, a minimum of less than 0.01 percent, and a maximum of over 11 percent (Table 7-23). For small firms in the sample, the mean and median cost-sales ratios are 0.30 percent and 0.04 percent, respectively, with a minimum of less than 0.01 percent and a maximum of over 11 percent (Table 7-23). Each of these statistics indicates that, when considered in the aggregate, impacts are relatively higher on small firms than on large firms when the estimated revenue from additional natural gas product recovery is excluded. However, as the next table shows, the reverse is true when these revenues are included.

Table 7-24 Summary of Sales Test Ratios, With Revenues from Additional Natural Gas Product Recovery for Firms Affected by Final NSPS

Firm Type/Size	Number of Firms	Descriptive Statistics for Sales Test Ratio With Estimated Revenues from Natural Gas Product Recovery (%) Average	Median	Minimum	Maximum
Production and Integrated					
Small	77	-0.01%	0.00%	-0.85%	0.40%
Large	47	0.00%	0.00%	-0.06%	0.14%
Subtotal	124	-0.01%	0.00%	-0.85%	0.40%
Pipeline					
Small	11	0.01%	0.00%	0.00%	0.01%
Large	36	0.01%	0.00%	0.00%	0.06%
Subtotal	47	0.01%	0.00%	0.00%	0.06%
Processing					
Small	39	0.01%	0.01%	0.00%	0.11%
Large	23	0.01%	0.00%	0.00%	0.11%
Subtotal	62	0.01%	0.00%	0.00%	0.11%
Pipelines/Processing					
Small	0	---	---	---	---
Large	13	0.00%	0.00%	0.00%	0.01%
Subtotal	13	0.00%	0.00%	0.00%	0.01%
Total					
Small	**127**	**0.00%**	**0.00%**	**-0.85%**	**0.40%**
Large	**119**	**0.00%**	**0.00%**	**-0.06%**	**0.14%**
Total	**246**	**0.00%**	**0.00%**	**-0.85%**	**0.40%**

The mean cost-sales ratio for all businesses when estimated product recovery is included is in the sample is less than 0.01 percent, with a median ratio of less than 0.01 percent, a minimum of -0.85 percent, and a maximum of 0.40 percent (Table 7-24). For small firms in the sample, the mean and median cost-sales ratios are less than 0.01 percent and less than 0.01 percent, respectively, with a minimum of -0.85 percent and a maximum of 0.40 percent (Table 7-24). Each of these statistics indicates that, when considered in the aggregate, impacts are small on small business when the estimated revenue from additional natural gas product recovery are included, the reverse of the conclusion found when these revenues are excluded.

Meanwhile, Table 7-25 presents the distribution of estimated cost-sales ratios for the small firms in our sample with and without including estimates of the expected natural gas product recover from implementing controls. When revenues estimates are included, all of the 127 firms (100 percent) have estimated cost-sales ratios less than 1 percent. The highest cost-sales ratios for small firms in the sample experiencing impacts are largely driven by costs accruing to processing and pipeline firms. That said, the incremental costs imposed on firms that process natural gas or transport natural gas via pipelines are not estimated to create significant impacts on a cost-sales ratio basis at the firm-level.

Table 7-25 Impact Levels of Final NSPS on Small Firms as a Percent of Small Firms in Sample, With and Without Revenues from Additional Natural Gas Product Recovery

	Without Estimated Revenues from Natural Gas Product Recovery		With Estimated Revenues from Natural Gas Product Recovery	
Impact Level	Number of Small Firms in Sample Estimated to be Affected	% of Small Firms in Sample Estimated to be Affected	Number of Small Firms in Sample Estimated to be Affected	% of Small Firms in Sample Estimated to be Affected
C/S Ratio less than 1%	123	96.9%	127	100.0%
C/S Ratio 1-3%	1	0.8%	0	0.0%
CS Ratio greater than 3%	3	2.4%	0	0.0%

When the estimated revenues from product recovery are not included in the analysis, one firm (less than 1 percent) is estimated to have sales test ratios between 1 and 3 percent. Three firms (less than 3 percent) are estimated to have sales test ratios greater than 3 percent. These results noted, the exclusion of product recovery is somewhat artificial. While the mean engineering compliance costs and revenues estimates are valid, drawing on the means ignores the distribution around the mean estimates, which risks masking effects. Because of this risk, the following section offers a qualitative discussion of small entities with regard to obtaining REC services, the validity of the cost and performance of REC for small firms, as well as offers a discussion about whether older equipment, which may be disproportionately owned and operated be smaller producers, would be affected by the final NSPS.

7.4.3.3 Small Entity Impact Analysis, Final NSPS, Additional Qualitative Discussion

7.4.3.3.1 Small Entities and Reduced Emissions Completions

Because REC requirements of the final NSPS are expected to contribute the large majority of engineering compliance costs, it is important to examine these requirements more closely in the context small entities. Important issues to resolve are the scale of REC costs within a drilling project, how the payment system for recovered natural gas functions, and whether small entities pursue particular "niche" strategies that may influence the costs or performance in a way that makes the estimates costs and revenues invalid. According to the most recent natural gas well cost data from EIA, the average cost of drilling and completing a producing natural gas well in 2007 was about $4.8 million (adjusted to 2008 dollars). This average includes lower cost wells that may be relatively shallow or are not hydraulically fractured. Hydraulically fractured wells in deep formations may cost up to $10 million. RECs contracted from a service provider are estimated to cost $33,200 (in 2008 dollars) or roughly 0.3%-0.7% of the typical cost of drilling and completing a natural gas well. As this range does not include revenues expected from natural gas and hydrocarbon condensate recovery expected to offset REC implementation costs, REC costs likely represent a small increment of the overall burden of a drilling project.

To implement a REC, a service provider is typically contracted to bring a set of equipment to the well pad temporarily to capture the stream that would otherwise be vented to the atmosphere. Typically, service providers are engaged in a long term drilling program in a particular basin covering multiple wells on multiple well pads. For gas captured and sold to the gathering system, Lease Automatic Custody Transfer (LACT) meters are typically automatically read daily, and sales transactions are typically settled at the end of the month. Invoices from service providers are generally delivered in 30-day increments during the well development time period, as well as at the end of the working contract for that well pad. The conclusion from the information, based on the available information, in most cases, is that the owner/operator incurs the REC cost within the same 30 day period that the owner/operator receives revenue as a result of the REC. To the extent there is a lag between a REC expenditures and receipt of revenue from recovered products, we believe the impact on cash flows would be minimal.

We assume small firms are performing RECs in CO and WY, as in many instances RECs are required under state regulation. In addition to State regulations, some companies are implementing RECs voluntarily such as through participation in the EPA Natural Gas STAR Program and the focus of recent press reports.

As described in more detail below, many small independent E&P companies often do not conduct any of the actual field work. These firms will typically contract the drilling, completion, testing, well design, environmental assessment, and maintenance. Therefore, we believe it is likely that small independent E&P firms will contract for RECs from service providers if required to perform RECs. An important reminder is that performing a REC is a straightforward and inexpensive extension of drilling, completion, and testing activities.

To the extent that very small firms may specialize in operating relatively few low-producing stripper wells, it is important to ask whether low-producing wells are likely candidates for re-fracturing/re-completion and, if so, whether the expected costs and revenues would be valid. These marginal gas wells are likely to be older and in conventional formations, and as such are unlikely to be good candidates for re-fracturing/completion. To the extent the marginal wells may be good candidates for re-fracturing/completion, the REC costs are valid estimates. The average REC cost is valid for RECs performed on any well, regardless of the operator size. The reason for this is that the REC service is contracted out to specialty service providers who charge daily rates for the REC equipment and workers. The cost is not related to any well characteristic.

Large operators may receive a discount for offering larger contracts that help a service provider guarantee that REC equipment will be utilized. However, we should note that the existence of a potential discount for larger contracts is based on a strong assumption; we do not have evidence to support this assumption. Since contracting REC equipment is analogous to contracting for drilling equipment, completion equipment, etc., the premium would likely be in the same range as other equipment contracted by small operators. Since the REC cost is a small portion of the overall well drilling and completion cost, the effect of any bulk discount disparity between large and small operators will be small, if in fact it does exist.

Although small operators may own the majority of marginal and stripper wells, they will make decisions based on economics just as any sized company would. For developing a new well, any sized company will expect a return on their investment, meaning the potential for sufficient gas, condensate, and/or oil production to pay back their investment and generate a return that exceeds alternative investment opportunities. Therefore, small or large operators that are performing hydraulic fracture completions will experience the same distribution of REC performance. For refracturing an existing well, the well must be a good candidate to respond to the re-fracture/completion with a production increase that merits the investment in the re-fracture/completion.

There are situations in which operators, large or small, may face constraints in directing captured gas to the gathering lines or pipelines. In these instances, this rule provides the flexibility to combust completion emissions rather than performing a REC.

Plugging and abandoning wells is complex and costly, so sustaining the productivity of wells is important for maximizing the exploitation of proven domestic resources. However, many marginal gas wells are likely to be older and in conventional formations, and as such are unlikely to be good candidates for re-fracturing/completion, which means they are likely unaffected by the final NSPS.

7.4.3.3.2 Age of Equipment and Final Regulations

Given a large fraction of domestic oil and natural gas production is produced from older and generally low productivity wells, it is important to examine whether the requirements of these rules might present impediments to owners and operators of older equipment. The NSPS is a standard that applies to new or modified sources. Because of this, NSPS requirements target new or modified affected facilities or equipment, such as processing plants and compressors. While the requirements may apply to modifications of existing facilities, it is important to discuss well completion-related requirements aside from other requirements in the NSPS distinctly.

Excluding well completion requirements from the cost estimates, the non-completion NSPS requirements (related to equipment leaks at processing plants, reciprocating and centrifugal compressors, pneumatic controllers, and storage vessels) are estimated to require about $15 million in annualized engineering costs. EPA also estimates that the annualized costs of these requirements will be mostly if not fully, offset by revenues expected from natural gas recovery. EPA does not expect these requirements to disproportionately affect producers with older equipment. Meanwhile, the REC and emissions combustion requirements in the final NSPS relate to well completion activities at new hydraulically fractured natural gas wells and existing wells that are recompleted after being fractured or re-fractured. These requirements constitute the bulk of the expected engineering compliance expenditures (about $320 million in annualized costs) and expected revenues from natural gas product recovery (about $330 million in revenues, annually).

While age of the well and equipment may be an important factor for small and large producers in determining whether it is economical to fracture or re-fracture an existing well, this equipment is unlikely to be subject to the NSPS. To comply with completion-related requirements, producers are likely to rely heavily on portable and temporary completion equipment brought to the wellpad over a short period of time (a few days to a few weeks) to capture and combust emissions that are otherwise vented. The equipment at the wellhead—newly installed in the case of new well completions or already in place and operating in the case of existing wells—is not likely to be subject to the NSPS requirement.

7.4.4 Small Entity Economic Impact Analysis, Final NESHAP Amendments

The Final NESHAP Amendments will affect facilities operating three types of equipment: glycol dehydrators at production facilities, glycol dehydrators at transmission and compression facilities, and storage vessels. We identified likely affected facilities in the National Emissions Inventory (NEI) and estimated the number of newly required controls of each type that would be required by the NESHAP Amendments for each facility. We then used available data sources to best identify the ultimate owner of the equipment that would likely require new controls and linked facility-level compliance cost estimates to firm-level employment and revenue data. These data were then used to calculate an estimated compliance costs to sales ratio to identify small businesses that might be significantly impacted by the NESHAP.

While we were able to identify the owners of all but 9 facilities likely to be affected, we could not obtain employment and revenue levels for all of these firms. Overall, we expect about 81 facilities to be affected, and these facilities are owned by an estimated 42 firms. We were unable to obtain financial information on 7 (16 percent) of these firms due to inadequate data. In some instances, firms are private, and financial data is not available. In other instance, firms may no longer exist, since NEI data are not updated continuously. From the ownership information and compliance cost estimates from the engineering analysis, we estimated total compliance cost per firm.

Of the 35 firms for which we have financial information, we identified 11 small firms (31 percent) and 24 large firms (69 percent) that would be affected by the NESHAP Amendments. Annual compliance costs for small firms are estimated at $390,000 (22 percent of the total compliance costs), and annual compliance costs for large firms are estimated at $1.1 million (66 percent of the total compliance costs). The facilities for which we were unable to identify the ultimate owners, employment, and revenue levels would have an estimated annual compliance cost of $200,000 (11percent of the total). All figures are in 2008 dollars.

The average estimated annualized compliance cost for the 11 small firms identified in the dataset is $35,000, while the mean annual revenue figure for the same firms is over $116 million, or less than 0.01 percent on average for all 10 firms (Table 7-26). The median sale-test ratio for these firms is smaller at 0.09 percent. Large firms are likely to see an average of $48,000 in annual compliance costs, whereas average revenue for these firms exceeds $29 billion since this set of firms includes many of the very large, integrated energy firms. For large firms, the average sales-test ratio is less than 0.01 percent, and the median sales-test ratio is also less than 0.01 percent (Table 7-26).

Table 7-26 Summary of Sales Test Ratios for Firms Affected by Final NESHAP Amendments

Firm Size	No. of Known Affected Firms	% of Total Known Affected Firms	Mean C/S Ratio	Median C/S Ratio	Min. C/S Ratio	Max. C/S Ratio
Small	11	31%	0.24%	0.09%	< 0.01%	0.93%
Large	24	69%	< 0.01%	< 0.01%	< 0.01%	0.01%
All	35	100%	0.08%	< 0.01%	< 0.01%	0.93%

Among the small firms, all are likely to have impacts of less than 1 percent in terms of the ratio of annualized compliance costs to revenues (Table 7-27). These firms represent a very small slice of the oil and gas industry in its entirety, less than 0.02 percent of the estimated 6,427 small firms in NAICS 211 (Table 7-27).

Table 7-27 Affected Small Firms as a Percent of Small Firms Nationwide, Final NESHAP Amendments

Firm Size	Number of Small Firms Affected Nationwide	% of Small Firms Affected Nationwide	Affected Firms as a % of National Firms (6,427)
C/S Ratio less than 1%	11	100.0%	0.17%
C/S Ratio 1-3%	0	0.0%	0.0%
CS Ratio greater than 3%	0	0.0%	0.0%

7.4.5 Conclusions for NSPS and NESHAP Amendments

While both the NSPS and NESHAP amendment would individually result in a no SISNOSE finding, the EPA performed an additional analysis in order to certify the rule in its entirety. This analysis compared compliance costs to entity revenues for the total of all the entities affected by the NESHAP Amendments and the sample of entities analyzed for the NSPS. When revenues from additional natural gas product sales are not included, 132 of the 136 small firms (97 percent) are likely to have impacts of less than 1 percent in terms of the ratio of annualized compliance costs to revenues (Table 7-28).

Meanwhile, four firms (3 percent) are likely to have impacts greater than 1 percent. Three of these four firms are likely to have impacts greater than 3 percent. When revenues from additional natural gas product sales are included, all 136 small firms (100 percent) are likely to have impacts of less than 1 percent.

Table 7-28 Affected Small Firms as a Percent of Small Firms Nationwide, Final NSPS and NESHAP Amendments

	Without Estimated Revenues from Natural Gas Product Recovery		With Estimated Revenues from Natural Gas Product Recovery	
Impact Level	Number of Small Firms in Sample Estimated to be Affected	% of Small Firms in Sample Estimated to be Affected	Number of Small Firms in Sample Estimated to be Affected	% of Small Firms in Sample Estimated to be Affected
C/S Ratio less than 1%	132	97.1%	136	100.0%
C/S Ratio 1-3%	1	0.7%	0	0.0%
CS Ratio greater than 3%	3	2.2%	0	0.0%

The number of significantly impacted small businesses is unlikely to be sufficiently large to declare a SISNOSE. Our judgment in this determination is informed by the fact that many affected firms are expected to receive revenues from the additional natural gas and condensate recovery engendered by the implementation of the controls evaluated in this RIA. As much of the additional natural gas recovery is estimated to arise from completion-related activities, we expect the impact on well-related compliance costs to be significantly mitigated. This conclusion is enhanced because the returns to reduced emissions completion activities occur without a significant time lag between implementing the control and obtaining the recovered product unlike many control options where the emissions reductions accumulate over long periods of time; the reduced emission completions and recompletions occur over a short span of time, during which the additional product recovery is also accomplished.

7.5 References

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EXHIBIT 15

Regulatory Impact Analysis (RIA)
for the final Transport Rule
Docket ID No. EPA-HQ-OAR-2009-0491

Regulatory Impact Analysis for the Federal Implementation Plans to Reduce Interstate Transport of Fine Particulate Matter and Ozone in 27 States; Correction of SIP Approvals for 22 States

U.S. EPA
Office of Air and Radiation

June 2011

CHAPTER 1

EXECUTIVE SUMMARY

This Regulatory Impact Analysis (RIA) presents the health and welfare benefits, costs, and other impacts of the Transport Rule focusing primarily on 2014.

1.1 Key Findings

The final Transport Rule will lower sulfur dioxide (SO_2) and nitrogen oxide (NO_x) emissions from the electric power industry in 28 eastern states starting in 2012[1]. In 2014, this final rule will have annual benefits (in 2007$) between $120 to $280 billion using a 3% discount rate and $110 and $250 billion using a 7% discount rate. At these respective discount rates, the annual social costs are $0.8 billion and the annual quantified net benefits are $120 to $280 billion or $110 to $270 billion. The benefits outweigh social costs from 150 up to 350 to 1, or from 110 up to 335 to 1. The benefits result primarily from 13,000 to 34,000 fewer $PM_{2.5}$ and ozone-related premature mortalities. There are some costs and important benefits that EPA could not monetize. Upon considering these limitations and uncertainties, it remains clear that the benefits of the Transport Rule are substantial and far outweigh the costs. The annualized private compliance costs to the power industry in 2014 are $0.8 billion. Employment impacts associated with the final rule are estimated to be small. The benefits of the Transport Rule in 2012 are greater than in 2014 due, in part, to the final rule expediting emissions reductions that otherwise would have occurred in 2014.

The benefits and costs in 2014 of the selected remedy (air quality-assured trading) in the final rule are in Table 1-1. This selected remedy covers the electric power industry and allows interstate emissions trading of sulfur dioxide (SO_2) and nitrogen oxides (NO_x) in the covered states as listed in section 2.2 of this RIA.

1 As finalized, the rule requires emission reductions in 27 states. EPA issued a supplemental proposal to request comment on requiring ozone-season NOx reductions in additional states; including the states addressed in the supplemental proposal, the total number of states covered by the Transport Rule would be 28.

Table 1-1. Summary of EPA's Estimates of Benefits, Costs, and Net Benefits of the Selected Remedy in the Transport Rule in 2014[a] (billions of 2007$)

Description	Estimate (3% Discount Rate)	Estimate (7% Discount Rate)
Social costs[b]	$0.81	$0.81
Social benefits[c,d]	$120 to $280 + B	$110 to $250 + B
Health-related benefits:	$110 to $270 + B	$100 to $250 + B
Visibility benefits[e]	$4.1	$4.1
Net benefits (benefits-costs)	$120 to $280	$110 to $250

[a] All estimates are rounded to two significant digits and represent annualized benefits and costs anticipated for the year 2014. For notational purposes, unquantified benefits are indicated with a "B" to represent the sum of additional monetary benefits and disbenefits. Data limitations prevented us from quantifying these endpoints, and as such, these benefits are inherently more uncertain than those benefits that we were able to quantify. A listing of health and welfare effects is provided in Table 1-5. Estimates here are subject to uncertainties discussed further in the body of the document.

[b] Social costs are estimated using the MultiMarket model, the model employed by EPA in this RIA to estimate economic impacts of the industries outside the electric power sector. This model does not estimate indirect impacts associated with a regulation such as this one. Details on the social cost estimates can be found in Chapter 8 and Appendix B of this RIA.

[c] The reduction in premature mortalities account for over 90% of total monetized benefits. Benefit estimates are national except for visibility that covers Class I areas. Valuation assumes discounting over the SAB-recommended 20-year segmented lag structure described in Chapter 5. Results reflect 3 percent and 7 percent discount rates consistent with EPA and OMB guidelines for preparing economic analyses (U.S. EPA, 2010; OMB, 2003). The estimate of social benefits also includes CO_2 related benefits calculated using the social cost of carbon, discussed further in Chapter 5.

[d] Potential benefit categories that have not been quantified and monetized are listed in Table 1-5.

[e] Over 99% of visibility-related benefits occur within Class-1 areas located in the Eastern U.S.

1.1.1 Health Benefits

The final Transport Rule is expected to yield significant health benefits by reducing emissions of two key contributors to fine particle and ozone formation. Sulfur dioxide contributes to the formation of fine particle pollution ($PM_{2.5}$), and nitrogen oxide contributes to the formation of both $PM_{2.5}$ and ground-level ozone.

Our analyses suggest this would yield benefits in 2014 of $120 to $280 billion (based on a 3 percent discount rate) and $110 to $250 billion (based on a 7 percent discount rate). The estimated benefits of this rule are substantial, particularly when viewed within the context of the total public health burden of $PM_{2.5}$ and ozone air pollution. A recent EPA analysis estimated that 2005 levels of $PM_{2.5}$ and ozone were responsible for between 130,000 and 320,000 PM2.5-related and 4,700 ozone-related premature deaths, or about 6.1% of total deaths (based on the lower end of the avoided mortality range) from all causes in the continental U.S. (Fann et al. 2011). This same analysis attributed almost 200,000 non-fatal heart attacks, 90,000 hospital admissions due to respiratory or cardiovascular illness and 2.5 million cases of aggravated asthma among children--among many other impacts. We estimate the Transport Rule to reduce the number of $PM_{2.5}$-related premature deaths in 2014 by between 13,000 and 34,000, 15,000 non-fatal heart attacks, 8,700 fewer hospital admissions and 400,000 fewer cases of aggravated asthma. By 2014, in combination with other federal and state air quality actions, the Transport Rule will address a substantial fraction of the total public health burden of $PM_{2.5}$ and ozone air pollution. However, the benefits and costs reported in this RIA reflect only the incremental costs and benefits of the Transport Rule.

We also estimate substantial additional health improvements for children from reductions in upper and lower respiratory illnesses, acute bronchitis, and asthma attacks. See Table 1-2 for a list of the annual reduction in health effects expected in 2014 and Table 1-3 for the estimated value of those reductions. In these tables we summarize the benefits according to whether they accrue within or beyond the Transport region (Eastern part of the US covered by the final rule). While not analyzed here, we expect the benefits in 2012 (the first compliance year for this final rule) to be significantly larger than those modeled for 2014 because of the much greater incremental SO_2 reductions in 2012 compared to 2014 from the base case. This occurs because the final rule expedites the adoption of SO_2 emissions controls that are planned in the base case to occur after 2012 and be underway by 2014.

Table 1-2: Estimated Reduction in Incidence of Adverse Health Effects of the Selected remedy (95% confidence intervals)[A]

Health Effect	*Within transport region*	*Beyond transport region*	*Total*
PM-Related endpoints			
Premature Mortality			
Pope et al. (2002) (age >30)	13,000 (5,200—21,000)	33 (5—60)	13,000 (5,200—21,000)
Laden et al. (2006) (age >25)	34,000 (18,000—49,000)	84 (31—140)	34,000 (18,000—49,000)
Infant (< 1 year)	59 (-47—160)	0.15 (-0.2—0.5)	59 (-47—160)
Chronic Bronchitis	8,700 (1,600—16,000)	23 (-5—50)	8,700 (1,600—16,000)
Non-fatal heart attacks (age > 18)	15,000 (5,600—24,000)	40 (7—72)	15,000 (5,600—24,000)
Hospital admissions—respiratory (all ages)	2,700 (1,300—4,000)	5 (2—9)	2,700 (1,300—4,000)
Hospital admissions—cardiovascular (age > 18)	5,700 (4,200—6,600)	15 (10—19)	5,800 (4,200—6,600)
Emergency room visits for asthma (age < 18)	9,800 (5,800—14,000)	21 (7—36)	9,800 (5,800—14,000)
Acute bronchitis (age 8-12)	19,000 (-630—37,000)	50 (-29—130)	19,000 (-660—37,000)
Lower respiratory symptoms (age 7-14)	240,000 (120,000—360,000)	630 (130—1,100)	240,000 (120,000—360,000)
Upper respiratory symptoms (asthmatics age 9-18)	180,000 (57,000—310,000)	480 (-25—980)	180,000 (57,000—310,000)
Asthma exacerbation (asthmatics 6-18)	400,000 (45,000—1,100,000)	1,100 (-250—2,900)	400,000 (45,000—1,100,000)
Lost work days (ages 18-65)	1,700,000 (1,500,000—1,900,000)	4,300 (3,500—5,200)	1,700,000 (1,500,000—1,900,000)
Minor restricted-activity days (ages 18-65)	10,000,000 (8,400,000—11,000,000)	26,000 (20,000—32,000)	10,000,000 (8,400,000—12,000,000)

Ozone-related endpoints				
Premature mortality				
Multi-city and NMMAPS	Bell et al. (2004) (all ages)	27 (11—42)	0.1 (0.01—0.3)	27 (11—42)
	Schwartz et al. (2005) (all ages)	41 (17—64)	0.2 (0.1—0.4)	41 (17—65)
	Huang et al. (2005) (all ages)	37 (17—57)	0.2 (0.1—0.4)	37 (17—57)
Meta-analyses	Ito et al. (2005) (all ages)	120 (78—160)	0.6 (0.3—0.9)	120 (79—160)
	Bell et al. (2005) (all ages)	87 (48—130)	0.5 (0.2—0.8)	87 (48—130)
	Levy et al. (2005) (all ages)	120 (89—150)	0.7 (0.4—0.9)	120 (90—160)
Hospital admissions—respiratory causes (ages > 65)		160 (21—280)	1.2 (0.1—2.3)	160 (21—290)
Hospital admissions—respiratory causes (ages <2)		83 (43—120)	0.5 (0.2—0.8)	84 (43—120)
Emergency room visits for asthma (all ages)		86 (-2—260)	0.4 (-0.2—1.4)	86 (-2—260)
Minor restricted-activity days (ages 18-65)		160,000 (80,000—240,000)	910 (240—1,600)	160,000 (80,000—240,000)
School absence days		51,000 (22,000—73,000)	290 (59—490)	51,000 (22,000—74,000)

[A] Estimates rounded to two significant figures; column values will not sum to total value.
[B] The negative estimates for certain endpoints are the result of the weak statistical power of the study used to calculate these health impacts and do not suggest that increases in air pollution exposure result in decreased health impacts.

Table 1-3: Estimated Economic Value of Health and Welfare Benefits (95% confidence intervals, billions of 2007$)[A,B]

Health Effect	*Pollutant*	*Within transport region*	*Beyond transport region[C]*	*Total*
Premature Mortality (Pope et al. 2002 PM mortality and Bell et al. 2004 ozone mortality estimates)				
3% discount rate	$PM_{2.5}$ & O_3	$100 ($8.3—$320)	$0.3 ($0.01—$0.9)	$100 ($8.3—$320)
7% discount rate	$PM_{2.5}$ & O_3	$94 ($7.5—$280)	$0.2 ($0.01—$0.8)	$94 ($7.5—$290)
Premature Mortality (Laden et al. 2006 PM mortality and Levy et al. 2005 ozone mortality estimates)				
3% discount rate	$PM_{2.5}$ & O_3	$270 ($23—$770)	$0.7 ($0.05—$2)	$270 ($23—$770)
7% discount rate	$PM_{2.5}$ & O_3	$240 ($21—$700)	$0.6 ($0.05—$1.8)	$240 ($21—$700)
Chronic Bronchitis	$PM_{2.5}$	$4.2 ($0.2—$19)	$0.01 ($-0.003--$0.06)	$4.2 ($0.2—$19)
Non-fatal heart attacks				
3% discount rate	$PM_{2.5}$	$1.7 ($0.3—$4.2)	$0.004 ($0.003—$0.01)	$1.7 ($0.3—$4.2)
7% discount rate	$PM_{2.5}$	$1.3 ($0.3—$3.1)	$0.004 ($0.002—$0.001)	$1.3 ($0.3—$3.1)
Hospital admissions—respiratory	$PM_{2.5}$ & O_3	$0.04 ($0.02—$0.06)	---	$0.04 ($0.02—$0.06)
Hospital admissions—cardiovascular	$PM_{2.5}$	$0.09 ($0.01—$0.2)	---	$0.09 ($0.01—$0.2)
Emergency room visits for asthma	$PM_{2.5}$ & O_3	$0.003 ($0.002—$0.006)	---	$0.003 ($0.002—$0.006)
Acute bronchitis	$PM_{2.5}$	$0.008 (<$-0.01—$0.02)[D]	---	$0.008 (<$-0.01—$0.02)[c]
Lower respiratory symptoms	$PM_{2.5}$	$0.004 ($0.002—$0.009)	---	$0.004 ($0.002—$0.009)
Upper respiratory symptoms	$PM_{2.5}$	$0.005 (<$0.01—$0.014)	---	$0.005 (<$0.01—$0.014)
Asthma exacerbation	$PM_{2.5}$	$0.02 ($0.002—$0.08)	---	$0.02 ($0.002—$0.08)
Lost work days	$PM_{2.5}$	$0.2 ($0.17—$0.24)	---	$0.2 ($0.17—$0.24)
School loss days	O_3	$0.01 ($0.004—$0.013)	---	$0.01 ($0.004—$0.013)
Minor restricted-activity	$PM_{2.5}$ & O_3	$0.7	---	$0.7

days		($0.3—$1)		($0.3—$1)
Recreational visibility, Class I areas	$PM_{2.5}$			$4.1
Social cost of carbon (3% discount rate, 2014 value)	CO_2			$0.6

Monetized total Benefits (Pope et al. 2002 $PM_{2.5}$ mortality and Bell et al. 2004 ozone mortality estimates)				
3% discount rate	$PM_{2.5}$, O_3	**$110 ($8.8—$340)**	**$0.28 ($0.01—$0.9)**	**$120 ($14—$350)**
7% discount rate	$PM_{2.5}$, O_3	**$100 ($8—$310)**	**$0.03 ($0.01—$0.85)**	**$110 ($13—$320)**
Monetized total Benefits (Laden et al. 2006 $PM_{2.5}$ mortality and Levy et al. 2005 ozone mortality estimates)				
3% discount rate	$PM_{2.5}$, O_3	**$270 ($24—$800)**	**$0.7 ($0.05—$2.1)**	**$280 ($29—$810)**
7% discount rate	$PM_{2.5}$, O_3	**$250 ($22—$720)**	**$0.6 ($0.04—$1.9)**	**$250 ($26—$730)**

[A] Estimates rounded to two significant figures.
[B] States included in transport region may be found in chapter 2.
[C] Monetary value of endpoints marked with dashes are < $100,000. [D] The negative estimates for certain endpoints are the result of the weak statistical power of the study used to calculate these health impacts and do not suggest that increases in air pollution exposure result in decreased health impacts.

1.1.2 Welfare Benefits

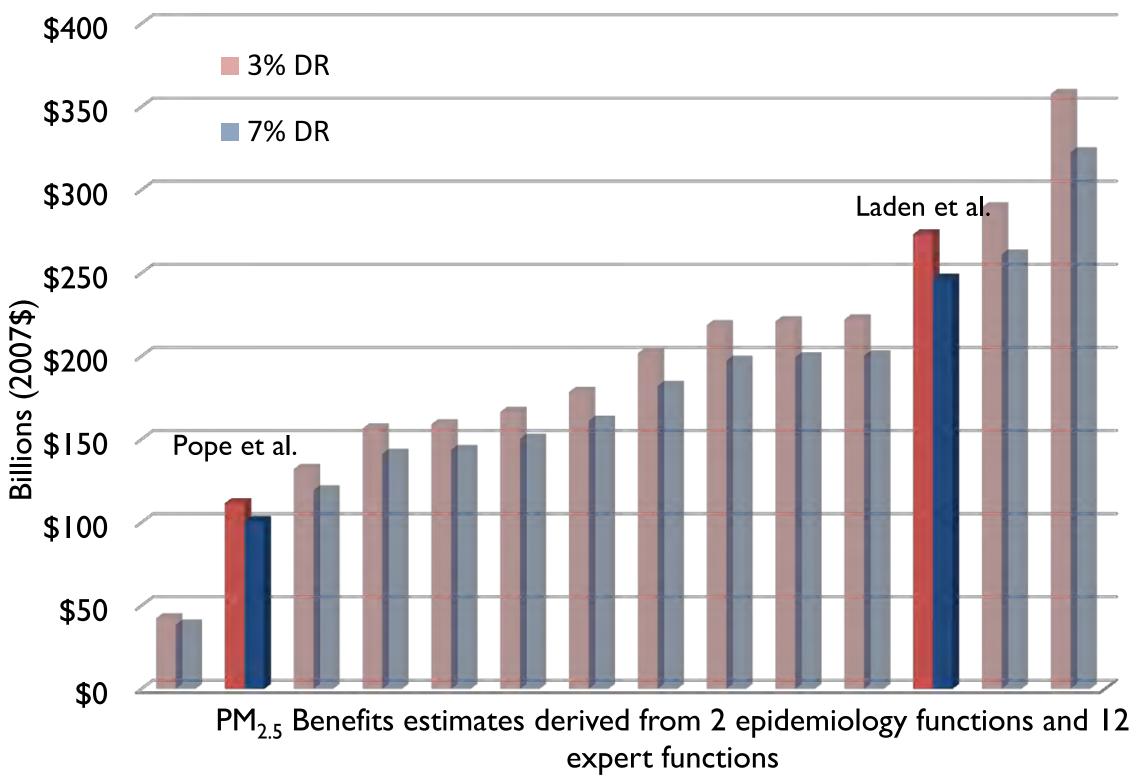
The term *welfare benefits* covers both environmental and societal benefits of reducing pollution, such as reductions in damage to ecosystems, improved visibility and improvements in recreational and commercial fishing, agricultural yields, and forest productivity. Although we are unable to monetize all welfare benefits, EPA estimates the final Transport Rule will yield welfare benefits of $4.1 billion in 2014 (2007$) for visibility improvements in southeastern Class I (national park) areas for a total of $4.1 billion in benefits across southeastern, southwestern and California Class I areas. These benefits are included in the full suite of benefits categories that are accounted for in the monetized benefits for this final rule.

Figure 1-1 summarizes an array of $PM_{2.5}$-related monetized benefits estimates based on alternative epidemiology and expert-derived PM-mortality estimate as well as the sum of ozone-related benefits using the Bell et al. (2004) mortality estimate.

Figure 1-2 summarizes the estimated net benefits for the selected remedy by displaying all possible combinations of PM and ozone-related monetized benefits and costs. The graphic includes one estimate of ozone-related mortality and fourteen different $PM_{2.5}$ related mortality and a single 3% or 7% discounted cost estimate.[2] Each of the 14 bars in each graph represents a separate point estimate of net benefits under a certain combination of cost and benefit estimation methods. Because it is not a distribution, it is not possible to infer the likelihood of any single net benefit estimate.

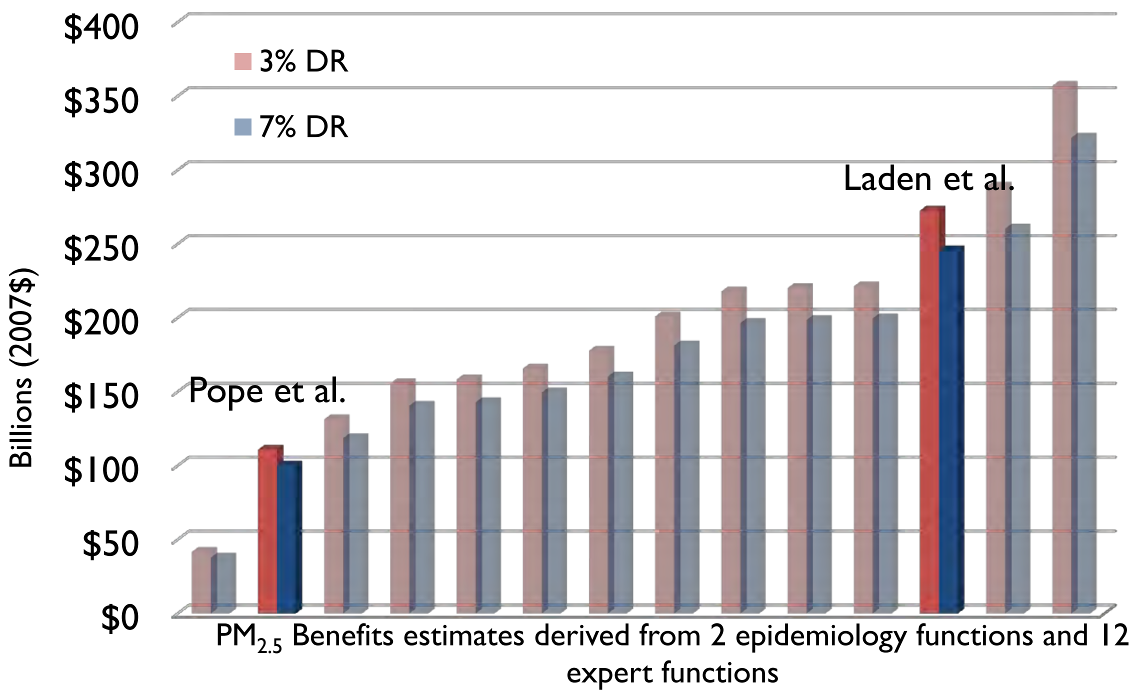
[2] Versions of this figure found in previous EPA RIA's have included the full suite of ozone mortality estimates. Because total benefits are relatively insensitive to the specification of ozone mortality estimate, for simplicity of presentation we have not included this full suite.

Figure 1-1 Estimated Monetized Value of Estimated $PM_{2.5}$- Related Premature Mortalities Avoided According to Epidemiology or Expert-derived Derived PM Mortality Risk Estimate[A]



[A] Column total equals sum of $PM_{2.5}$-related mortality and morbidity benefits and ozone-related morbidity and mortality benefits using the Bell et al. (2004) mortality estimate.

Figure 1-2: Net Benefits of the Transport Rule According to $PM_{2.5}$ Epidemiology or Expert-derived Mortality Risk Estimate[A]



[A] Column total equals sum of $PM_{2.5}$-related mortality and morbidity benefits and ozone-related morbidity and mortality benefits using the Bell et al. (2004) mortality estimate.

1.1.3 Assessment of More and Less Stringent Scenarios

1.1.3.1 Alternatives that Are More or Less Stringent

In accordance with Circular A-4 and EPA's for Guidelines for Preparing Economic Analyses, EPA also analyzed the costs and benefits of two options that differed in their stringency from the selected remedy option – one less stringent, the other more stringent. Both options have the same 2012 requirements and varied in the requirements for SO_2

emissions reductions in 2014. Both options only applied to the Group 1 states; requirements for SO_2 reductions remain the same in Group 2 states in 2014 under each option. Annual and ozone season NOx emissions requirements remain unchanged under these emission caps.

Unlike the selected remedy, which requires greater SO_2 reductions, reductions of up to $2,300/ton in marginal cost in 16 states (Group 1) beginning in 2014 from 2012 emissions levels, the less stringent option only requires SO_2 reductions in 2014 of up to $1,600/ton in marginal cost in Group 1 states. The more stringent option requires SO_2 reductions in 2014 of up to $10,000/ton in marginal cost in Group 1 states.

Table 1-4 provides a summary of the benefits, costs, and net benefits for the two alternatives considered to the selected remedy along with those for the selected remedy.

Table 1-4. Summary of Annual Benefits, Costs, and Net Benefits of Versions of the Selected Remedy Option in 2014[a] (billions of 2007 dollars)

Description	*Preferred Remedy*	*Less Stringent Scenario*	*More Stringent Scenario*
Social costs[b]			
3 % discount rate	$0.81	$0.43	$3.6
7 % discount rate	$0.81	$0.43	$3.6
Health-related benefits[c,d]			
3 % discount rate	$110 to $270 + B	$98 to $240 + B	$130 to $320 + B
7 % discount rate	$100 to $250 + B	$89 to $220 + B	$120 to $290 + B
Net benefits (benefits-costs)[e]			
3 % discount rate	$110 to $270	$98 to $240 + B	$130 to $320 + B
7 % discount rate	$100 to $250	$88 to $220 + B	$120 to $290 + B

[a] When presenting benefits and net benefits, EPA traditionally rounds all estimates to two significant figures. In this case we have rounded to three significant digits to facilitate comparison of the benefits and costs among the preferred remedy and the less and more stringent scenarios.

[b] The social costs are estimated using the MultiMarket model, the model employed by EPA in this RIA to estimate economic impacts of industries outside the electric power sector. This model does not estimate indirect impacts associated with a regulation such as this one. More information on the social costs can be found in Chapter 8 and Appendix B of this RIA.

[c] Due to methodological limitations, the health benefits of the two A-4 alternative remedies include $PM_{2.5}$ –related benefits but omit visibility, ozone, and CO_2-related benefits. We present the $PM_{2.5}$ –related benefits of the selected remedy, omitting these other important benefits, so that readers may compare directly the benefits of the selected and alternate remedies. Total benefits are primarily of the value of PM-related avoided premature mortalities. The reduction in these premature mortalities in each year account for over 90 percent of total $PM_{2.5}$ –related monetized benefits. Benefits in this table are nationwide and are associated with NO_x and SO_2 reductions. Visibility and ozone-related benefits not calculated for the more and less stringent scenarios because these impacts were estimated using $PM_{2.5}$-related benefit per ton estimates.

[d] Not all possible benefits or disbenefits are monetized in this analysis. These are listed in Table 1-5.

[e] Valuation assumes discounting over the SAB-recommended 20-year segmented lag structure. Results reflect the use of 3 % and 7 % discount rates consistent with EPA and OMB guidelines.

1.2 Not All Benefits Quantified

EPA was unable to quantify or monetize all of the health and environmental benefits associated with the Transport Rule. EPA believes these unquantified benefits are substantial, including the value of increased agricultural crop and commercial forest yields, visibility improvements, reductions in nitrogen and acid deposition and the resulting changes in ecosystem functions, and health and welfare benefits associated with reduced mercury emissions. Table 1-5 provides a list of these benefits.

Table 1-5: Human Health and Welfare Effects of Pollutants Affected by the Transport Rule

Pollutant/ Effect	*Quantified and monetized in base estimate*	*Unquantified*
PM: health[a]	Premature mortality based on cohort study estimates[b] Premature mortality based on expert elicitation estimates Hospital admissions: respiratory and cardiovascular Emergency room visits for asthma Nonfatal heart attacks (myocardial infarctions) Lower and upper respiratory illness Minor restricted activity days **Work loss days** Asthma exacerbations (among asthmatic populations Respiratory symptoms (among asthmatic populations) Infant mortality	Low birth weight Pulmonary function Chronic respiratory diseases other than chronic bronchitis Non-asthma respiratory emergency room visits UVb exposure (+/-)[c]
PM: welfare	Visibility in Class I areas	Household soiling Visibility in residential and non-class I areas UVb exposure (+/-)[c] Global climate impacts[c]
Ozone: health	Premature mortality based on short-term study estimates Hospital admissions: respiratory Emergency room visits for asthma Minor restricted activity days School loss days	Chronic respiratory damage Premature aging of the lungs Non-asthma respiratory emergency room visits UVb exposure (+/-)[c]
Ozone: welfare	Decreased outdoor worker productivity	Yields for: --Commercial forests --Fruits and vegetables, and --Other commercial and noncommercial crops Damage to urban ornamental plants Recreational demand from damaged forest

	aesthetics Ecosystem functions UVb exposure (+/-)[c]
NO_2: health	Respiratory hospital admissions Respiratory emergency department visits Asthma exacerbation Acute respiratory symptoms Premature mortality Pulmonary function
NO_2: welfare	Commercial fishing and forestry from acidic deposition Commercial fishing, agriculture and forestry from nutrient deposition Recreation in terrestrial and estuarine ecosystems from nutrient deposition Other ecosystem services and existence values for currently healthy ecosystems Coastal eutrophication from nitrogen deposition
SO_2: health	Respiratory hospital admissions Asthma emergency room visits Asthma exacerbation Acute respiratory symptoms Premature mortality Pulmonary function
SO_2: welfare	Commercial fishing and forestry from acidic deposition Recreation in terrestrial and aquatic ecosystems from acid deposition Increased mercury methylation
Mercury: health	Incidence of neurological disorders Incidence of learning disabilities Incidences in developmental delays Potential cardiovascular effects including: --Altered blood pressure regulation --Increased heart rate variability --Incidences of heart attack Potential reproductive effects
Mercury: environment	Impact on birds and mammals (e.g. reproductive effects)
Mercury: welfare	Impacts to commercial., subsistence and recreational fishing

[a] In addition to primary economic endpoints, there are a number of biological responses that have been associated with PM health effects including morphological changes and altered host defense mechanisms. The public health impact of these biological responses may be partly represented by our quantified endpoints.
[b] Cohort estimates are designed to examine the effects of long term exposures to ambient pollution, but relative risk estimates may also incorporate some effects due to shorter term exposures (see Kunzli et al., 2001 for a discussion of this issue). While some of the effects of short term exposure are likely to be captured by the cohort estimates, there may be additional premature mortality from short term PM exposure not captured in the cohort estimates included in the primary analysis.
[c] May result in benefits or disbenefits.

1.3 Costs and Economic Impacts

For the affected region, the projected annual incremental private costs of the selected remedy option (air quality-assured trading) to the power industry are $1.4 billion in 2012 and $0.8 billion in 2014 (in 2007 dollars). Costs are lower in 2014 than in 2012 as the rule becomes more stringent because there are larger amounts of State and Federally enforceable controls that happen between 2012 and 2014 in the baseline. These costs represent the total cost to the electricity-generating industry of reducing NO_x and SO_2 emissions to meet the emissions caps set out in the rule. Estimates are in 2007 dollars. These costs of the rule are estimated using the Integrated Planning Model (IPM). It should be noted that the rule modeled for this analysis differs from the final rule in that it includes reductions that would be required by the supplemental proposal for six states (Iowa, Kansas, Michigan, Missouri, Oklahoma, and Wisconsin). These reductions are included in the cost and impacts estimates described in this RIA, and therefore are accounted for in the benefits estimates.

In estimating the net benefits of regulation presented above, the appropriate cost measure is ―social costs‖. Social costs represent the changes in social welfare from the rule measured as the change in total surplus (consumer and producer) in the macroeconomic analysis of this rule.

There are several national changes in energy prices that result from the Transport Rule. Retail electricity prices are projected to increase nationally by an average of 1.3 % in 2012 and 0.8 % in 2014 with the final Transport Rule. The average delivered coal price decreases by about 1.4 percent in 2012 and 0.5 percent in 2014 relative to the base case as a result of decreased coal demand and shifts in the type of coal demanded. EPA also projects that delivered natural gas prices for the electric power sector will increase by about 0.3% over the 2012-2030 timeframe and that natural gas use for electricity generation will increase by approximately 200 billion cubic feet (BCF) by 2014, or roughly 4%. This impact is well within the range of price variability that is regularly experienced in natural gas markets. Finally, under the Transport Rule, EPA projects coal production for use by the power sector will increase above 2009 levels by 40 million tons in 2012 and 54 million tons in 2014 (compared to roughly one billion tons of total coal produced for the power sector in 2009). This increase in production is 16% less in 2012 and 27% less in 2014 than the increase projected in the base case. The Transport Rule is not projected to impact production of coal for uses outside the power sector (e.g., export, industrial sources), which represent approximately 6% of total coal production in 2009. More detail and background for these results can be found in Chapter 7 of the RIA.

There are several other types of energy impacts from the Transport Rule. A relatively small amount of coal-fired capacity, about 4.8 GW (1 percent of all coal-fired capacity and 0.5% of total generating capacity), is projected to be uneconomic to maintain and EPA forecast that 1 GW of that capacity was likely to be unprofitable to operate in the 2020 in the base case. In practice units projected to be uneconomic to maintain may be ―mothballed," retired, or kept in service to ensure transmission reliability in certain parts of the grid. For the most part, these units are small and infrequently used generating units that are dispersed throughout the Transport Rule region.

In addition to addressing the costs, benefits, and economic impacts of the Transport Rule, EPA has estimated a portion of the employment impacts of this rulemaking. We have estimated three types of impacts. One provides an estimate of the employment impacts on the regulated industry over time. The second covers the short-term employment impacts associated with the construction of needed pollution control equipment until the compliance date of the regulation. The third is to estimate short-term employment impacts extending outside of the power sector, as described in Appendix D. We expect that the rule‘s impact on employment will be small.

In Table 1-6, we show the employment impacts of the Transport Rule as estimated by the environmental protection sector approach and by the Morgenstern approach. The estimated employment changes due to changes in fuel use are reported in Chapter 8.

Table 1-6. Estimated Employment Impact Table

	Annual (reoccurring)	**One time (construction during compliance period)**
Environmental Protection Sector approach*	Not Applicable	2,230
Net Effect on Electric Utility Sector Employment from Morgenstern et al. approach***	700** -1, 000 to +3,000****	Not Applicable

*These one-time impacts on employment are estimated in terms of job-years.

**This estimate is not statistically different from zero.

**These annual or reoccurring employment impacts are estimated in terms of production workers as defined by the US Census Bureau's Annual Survey of Manufacturers (ASM).

**** 95% confidence interval

Overall, the impacts of the final rule are modest, particularly in light of the large projected benefits mentioned earlier.

1.4 Small Entity and Unfunded Mandates Impacts

After preparing an analysis of small entity impacts, EPA has certified that this final rule will have no SISNOSE (significant economic impacts on a substantial number of small entities). First, of the small entities projected to have costs greater than 1 percent of revenues (24 out of 108 affected), around 70 percent of them operate in cost of service regions and would generally be able to pass any increased costs along to rate-payers. In EPA's modeling, most of the cost impacts for these small entities and their associated units are driven by lower electricity generation relative to the base case. Specifically, two units reduce their generation by significant amounts, driving the bulk of the costs for all small entities. Excluding these two units, another driver of small entity impacts for sub-divisions and private small entities is higher fuel costs, which the affected units would be expected to use irrespective of whether they had to comply with this rule. Further, increased fuel costs are often passed through to rate-payers as common practice in many areas of the U.S. due to fuel adder arrangements instituted by state public utility commissions. Finally, EPA's decision to exclude units smaller than 25 Megawatt capacity (MW) has already significantly reduced the burden on small entities by reducing the number of affected small entity-owned units by about 390.

EPA examined the potential economic impacts on state and municipality-owned entities associated with this rulemaking based on assumptions of how the affected states will implement control measures to meet their emissions. These impacts have been calculated to provide additional understanding of the nature of potential impacts and additional information.

According to EPA's analysis, of the 98 government entities considered in this analysis and the 365 government entities in the Transport Rule region that are included in EPA's modeling, 26 may experience compliance costs in excess of 1 percent of revenues in 2014, based on our assumptions of how the affected states implement control measures to meet their emissions budgets as set forth in this rulemaking.

Government entities projected to experience compliance costs in excess of 1 percent of revenues may have some potential for significant impact resulting from implementation of the Transport Rule. However, it is EPA's position that because these government entities can pass on their costs of compliance to rate-payers, they will not be significantly affected. Furthermore, the decision to include only units greater than 25 MW in size exempts 354 government entities that would otherwise be potentially affected by the Transport Rule.

1.5 Limitations and Uncertainties

Every analysis examining the potential benefits and costs of a change in environmental protection requirements is limited to some extent by data gaps, limitations in model capabilities (such as geographic coverage), and variability or uncertainties in the underlying scientific and economic studies used to configure the benefit and cost models. Despite the uncertainties, we believe this benefit-cost analysis provides a reasonable indication of the expected economic benefits and costs of the final Transport Rule.

For this analysis, such uncertainties include possible errors in measurement and projection for variables such as population growth and baseline incidence rates; uncertainties associated with estimates of future-year emissions inventories and air quality; variability in the estimated relationships between changes in pollutant concentrations and the resulting changes in health and welfare effects; and uncertainties in exposure estimation.

EPA's cost estimates assume that all states in the final Transport Rule region participate in the programs that reduce SO_2 and NO_x emissions from the power industry, rather than complying with state-level requirements through other regulatory means.

Below is a summary of the key uncertainties of the analysis:

Costs

- Analysis does not capture employment shifts as workers are retrained at the same company or re-employed elsewhere in the economy.

- We do not include the costs of certain relatively small permitting costs associated with Title V that new program entrants face.
- Technological innovation is not incorporated into these cost estimates.
- Economic impacts do not take into response of electric power consumers to changes in electricity prices. While this response is likely to be of small magnitude, it may have some impact on the final estimate of private compliance costs.

Benefits

- Most of the estimated PM-related benefits in this rule accrue to populations exposed to higher levels of $PM_{2.5}$. Of these estimated PM-related mortalities avoided, about 69% occur among populations initially exposed to annual mean $PM_{2.5}$ level of 10 $\mu g/m^3$ and about 96% occur among those initially exposed to annual mean $PM_{2.5}$ level of 7.5 $\mu g/m^3$; these are the lowest air quality levels considered in the Laden et al. (2006) and Pope et al. (2002) studies, respectively. This fact is important, because as we estimate PM-related mortality among populations exposed to levels of $PM_{2.5}$ that are successively lower, our confidence in the results diminishes. However, our analysis shows that the great majority of the impacts occur at higher exposures.

- There are uncertainties related to the health impact functions used in the analysis. These include: within study variability; across study variation; the application of concentration-response (C-R) functions nationwide; extrapolation of impact functions across population; and various uncertainties in the C-R function, including causality and thresholds. Therefore, benefits may be under- or over-estimates.

- Analysis is for 2014, and projecting key variables introduces uncertainty. Inherent in any analysis of future regulatory programs are uncertainties in projecting atmospheric conditions and source level emissions, as well as population, health baselines, incomes, technology, and other factors.

- This analysis omits certain unquantified effects due to lack of data, time and resources. These unquantified endpoints include other health and ecosystem effects. EPA will continue to evaluate new methods and models and select those most appropriate for estimating the benefits of reductions in air pollution. Enhanced collaboration between air quality modelers, epidemiologists, toxicologists, ecologists, and economists should result in a more tightly integrated analytical framework for measuring benefits of air pollution policies.

- $PM_{2.5}$ mortality benefits represent a substantial proportion of total monetized benefits (over 90%), and these estimates have following key assumptions and uncertainties.

    1. The $PM_{2.5}$ -related benefits of the alternative scenarios were derived through a benefit per-ton approach, which does not fully reflect local variability in population density, meteorology, exposure, baseline health incidence rates, or other local factors that might lead to an over-estimate or under-estimate of the actual benefits of controlling SO_2.

    2. We assume that all fine particles, regardless of their chemical composition, are equally potent in causing premature mortality. This is an important assumption, because $PM_{2.5}$ produced via transported precursors emitted from EGUs may differ significantly from direct $PM_{2.5}$ released from diesel engines and other industrial sources, but no clear scientific grounds exist for supporting differential effects estimates by particle type.

    3. We assume that the health impact function for fine particles is linear within the range of ambient concentrations under consideration. Thus, the estimates include health benefits from reducing fine particles in areas with varied concentrations of $PM_{2.5,}$ including both regions that are in attainment with fine particle standard and those that do not meet the standard down to the lowest modeled concentrations.

    4. To characterize the uncertainty in the relationship between $PM_{2.5}$ and premature mortality, we include a set of twelve estimates based on results of the expert elicitation study in addition to our core estimates. Even these multiple characterizations omit the uncertainty in air quality estimates, baseline incidence rates, populations exposed and transferability of the effect estimate to diverse locations. As a result, the reported confidence intervals and range of estimates give an incomplete picture about the overall uncertainty in the $PM_{2.5}$ estimates. This information should be interpreted within the context of the larger uncertainty surrounding the entire analysis.

These projected impacts of this final rule do not reflect minor technical corrections to SO_2 budgets in three states (KY, MI, and NY). These projections also assumed preliminary variability limits that were smaller than the variability limits finalized in this rule. EPA conducted sensitivity analysis confirming that these differences do not meaningfully alter any of the Agency's findings or conclusions based on the projected cost, benefit, and air quality impacts presented for the final Transport Rule. The results of this sensitivity analysis are presented in Appendix F in the final Transport Rule RIA.

1.6 References

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CHAPTER 8
MACROECONOMIC AND EMPLOYMENT IMPACTS

8.1 Partial Equilibrium Analysis (Multiple Markets)

In this chapter, we provide estimates of the economic impacts to industry sectors outside the electric power industry and social costs associated with the selected remedy. Economic impacts presented in this chapter are changes in price and outputs for affected products from a large number of industry sectors (100). Social costs are estimates of the costs to society associated with the control and administrative costs presented in Chapter 7. Such costs are estimated from changes in consumer and producer surplus, as discussed in more detail below.

Our partial equilibrium analysis uses a market model that simulates how stakeholders (consumers and industries) might respond to the additional regulatory program costs. In this section, we provide an overview of the economic model and the results for a short-run economic impact analysis (in this case, for 2014). While the Multimarket Model has not been peer-reviewed, EPA plans to peer-review the model in the near future. More details on the economic model, the results, and data used by the model can be found in Appendix B.

8.1.1 Overview

Although several tools are available to estimate social costs, current EPA guidelines suggest that multimarket models ―. are best used when potential impacts on related markets might be considerable" and modeling using a computable general equilibrium model is not available or practical (EPA, 2010, p. 9-21). Other guides for environmental economists offer similar advice (Berck and Hoffmann, 2002; Just, Hueth, and Schmitz, 2004). Multimarket models focus on ―short-run" time horizons and measure a policy‘s near-term or transition costs as stated in the EPA Economic Resource Document (EPA, 1999). These models have greater levels of aggregation than detailed partial equilibrium models of compliance for individual sectors, like IPM, but represent more sectors of the economy.

A linked partial equilibrium model is useful for evaluating relative economic impacts across related markets and providing a measure of consumer and producer surplus losses. It may not be sufficient for fully estimating social costs, just as a single market model may not be appropriate for fully estimating social costs. Generally speaking, the smaller the effect of a regulation on partial-equilibrium measures of social welfare such as consumer and producer surplus, the more accurately those estimates reflect the true social cost.[61] However, a transition or short-term evaluation using a partial equilibrium model does not explicitly account for resources to be reallocated across sectors according to relative price changes (although the multi-market model does account for certain resource constraints and the employment of intermediate inputs). Furthermore, these models (if static) may not capture how resource use and consumption shifts over time in response to the regulation, which may be accounted for with a dynamic computable general equilibrium model. Therefore, we use care in referring to the estimate of total change in surplus coming out of the Multimarket model as a social cost. For regulations with a relatively modest impact on the economy, however, such as this final rule, the change in surplus estimated by this model may provide a reasonable approximation of the social cost.

Our multimarket model contains the following features:

Industry sectors and benchmark data set[62]

-100 industry sectors

-multiple benchmark years

Economic behavior

-industries respond to regulatory costs by changing production rates

-market prices rise and fall to reflect higher energy and other non-energy material -costs and changes in demand

-customers respond to price increases and consumption falls

[61] A general equilibrium framework (e.g., such as that employed in the EMPAX model used by US EPA) is necessary for determining social costs in a theoretically complete way, but general equilibrium models have their own drawbacks and their application may not be practical or sufficiently informative to warrant their use.

[62] A benchmark data set is included in the model to define the prepolicy equilibrium in the year of analysis (i.e., 2015 in this rule) for the 100 sectors included. Thus, the dataset provides a benchmark for estimating economic impacts and social costs in the year of analysis.

Model scope

-100 sectors are linked with each other based on their use of energy and other non-energy materials. For example, the construction industry is linked with the petroleum, cement, and steel industries and is influenced by price changes that occur in each sector. The links allow EPA to account for indirect effects the regulation has on related markets.

-production adjustments influence employment levels

-international trade (imports/exports) responds to domestic price changes

Model time horizon (―short run”) for a single period (2015)[63]

-fixed production resources (e.g., capital) lead to an upward-sloping industry supply function

-firms cannot alter certain input mixes; there is no substitution among intermediate production inputs

-there is no explicit labor market (a real wage and labor supply is not determined within the model)

-investment and government expenditures are fixed.

Although the model is intended to examine transition or short-term effects of this rulemaking, the results may be muted due to the use of annualized capital cost as an input to the model rather than the total capital cost.

Labor and Capital Markets and Pre-existing Distortions in Other Markets

Unlike CGE models, our multimarket model does not include a national labor or capital market. As a result, we do not estimate real wage changes, changes in labor /leisure choices, or savings and investment decisions within the model.

[63] For this analysis, we use 2015 as our analysis year and as a proxy for 2014. This allows us to maintain consistency with the results of the analysis using IPM (found in Chapter 7) that serve as inputs to this economic impact analysis.

Therefore we do not consider whether policies interact with existing distortions, particularly tax distortions in a ways that increase or decrease estimates of the social cost. Since savings and investment decisions are not modeled, social costs associated with capital stock changes are also not considered.

Although the model is intended to examine transition or short-term effects of this rulemaking, the estimate of the short-term effects may be understated due to the way the model accounts for changes in capital demand. The cost of new capital associated with the rule is accounted for by imposing an increase in the annualized capital cost rather than the total capital cost in the year of analysis. Additionally, using an economic impact model that constrains the physical capital stock to be fixed will not fully depict the social costs of an adjustment to a post-policy equilibrium as discussed in the EPA Economics Guidelines.

The own-price elasticities used by the Multimarket Model are drawn from secondary sources, as fully described in Appendix B. While the Multimarket Model is a short-run model that examines transitional costs that arise as a result of a new regulation, the estimation methods used by the secondary sources generally assume that people and firms have more flexibility to adjust consumption and production decisions than they would have in a short-run model. Consequently, use of these elasticities within the Multimarket Model may in some cases lead to estimates of larger market output changes than would actually occur in the short-run, all other things being equal.

On the other hand, while the scale of environmental regulation often is not sufficient to influence government spending and investment demand, the Leontief structure for intermediate goods and its assumption of fixed investment and government spending may make the Multimarket Model less responsive to regulatory shocks. Given the competing sources of bias, the ultimate direction of the bias with regards to economic impacts and social costs is difficult to ascertain *a priori*.

8.1.2 Economic Impact Analysis Results

Market-Level Results

Market-level impacts include price and quantity adjustments including the changes in international trade (Table 8-1).For the final Transport Rule, , the Agency's economic model suggests the average national price increase for energy is 0.16%. Higher energy costs result in subsequent manufacturing sector price increases nationwide of 0.01% or less. Imports also slightly rise because of higher U.S. prices. The one exception is transportation services; since sectors using transportation services are producing less, the demand for transportation services declines. The size of the transportation services demand shift outweighs any supply side cost increases that place upward pressure on service prices (e.g. higher electricity and refined petroleum prices). As a result, the average transportation services price falls.

Social Cost Estimates of Transport Rule

In the short run, the Agency's partial equilibrium multi-market model suggests that industries are able to pass on $0.7 billion (2007$) of the Transport Rule's costs to U.S. households in the form of higher prices (Table 8-2). Existing U.S. industries' surplus falls by $0.2 billion and the net U.S. loss in aggregate, is $0.9 billion (2007$). This is slightly higher than the annualized nationwide compliance cost estimate of the final rule as shown in Chapter 7 of the RIA because it excludes gains to other countries discussed below.

Table 8-1. Short-Term Market-Level Changes (in percent) within the U.S. Economy in 2014

Industry Sector	U.S. Prices	U.S. Production	Imports	U.S. Consumption	Exports
Energy	-0.163%	-0.031%	0.009%	-0.016%	-0.031%
Coal	-0.017	-0.047	-0.048	-0.052	0.003
Crude Oil Extraction	0.004	-0.053	0.027	−0.003	0.000
Electric generation	0.770	-0.059	0.000	-0.059	-0.137
Natural Gas	0.004	-0.033	0.057	-0.018	-0.002
Refined Petroleum	0.002	-0.002	0.003	-0.001	-0.0002
Nonmanufacturing	0.0004	-0.002	0.001	-0.0016	-0.001
Manufacturing					
Food, beverages, and textiles	0.004	-0.005	0.006	-0.003	-0.003

Lumber, paper, and printing	0.008	-0.005	0.009	-0.003	-0.006
Chemicals	0.002	-0.006	0.003	-0.003	-0.002
Plastics and Rubber	0.005	-0.006	0.008	−0.003	-0.005
Nonmetallic Minerals	0.009	−0.006	0.011	-0.003	-0.009
Primary Metals	0.007	−0.007	0.007	-0.004	−0.007
Fabricated Metals	0.006	-0.002	0.007	−0.002	-0.003
Machinery and Equipment	0.0007	-0.002	0.0005	-0.002	-0.0008
Electronic Equipment	0.0007	-0.002	0.0007	-0.002	-0.001
Transportation Equipment	0.0008	-0.003	0.001	-0.002	-0.001
Other	0.002	-0.007	0.004	-0.003	-0.003
Wholesale and Retail Trade	0.001	−0.002	0.001	-0.002	-0.002
Transportation Services	-0.003	−0.003	−0.003	-0.003	0.003
Other Services	0.001	−0.002	0.0007	-0.002	-0.001

Note: Approximated using the IPM cost analysis. For example, with the $0.8 billion increase in costs for the electric power sector, IPM projects a 0.77 percent increase in the retail price of electricity in 2015. All other energy market-level changes are determined within the multimarket model. Appendix B provides additional details.

As U.S. prices rise, other countries are affected through international trade relationships. The price of goods produced in the United States increase, domestic exports decline, and domestic production is replaced to a certain degree by imports; the model estimates a net gain of about $0.04 billion for other countries. The net change in total surplus is *lower* than the annualized nationwide compliance cost estimate of the final rule as shown in Chapter 7 of the RIA. Our estimate of social costs for the rule incorporates the net change in total surplus, and this estimate is $0.81 billion (2007 dollars) as shown in Table 8-2, or nearly identical to the compliance costs.[64] Compliance costs based on the pre-policy output levels would be overstated if we do not consider the new lower levels of consumption as a result of higher market prices.[65]

[64] The same is true for many recent rulemakings, including the Boiler MACT.

[65] There are small additional losses associated with the foregone benefits associated with reduced consumption (e.g. deadweight loss). However, in a perfectly competitive market without pre-existing distortions, the costs represent only a small fraction of total social costs. A more detailed discussion of the economic costs of regulation is found in Chapter 8 of EPA (2010).

Table 8-2. Distribution of Social Costs (billions, 2007$): 2015

Change in U.S. consumer surplus	−$0.68
Change in U.S. producer surplus	−$0.17
Net Change in U.S. Surplus	**−$0.85**
Net change in rest of world surplus	$0.04
Net change in Total Surplus	**−0.81$**

The surplus losses are concentrated in the electric generation sector (percent) and other services (percent). Other services include information, finance and insurance, real estate, professional services, management, administrative services, education, health care, arts, accommodations, and public services. Although electricity costs represent a small share of total service industry production costs, the service sectors represent a significant economic sector within the U.S. economy and use a large amount of electricity. The transition or short-term evaluation using a partial equilibrium model does not allow for resources to be allocated according to price changes. So the results of the model do not capture any distortions in the economy that may results as the price of electricity changes. If the distortions are significant, the "true" social cost would be higher than the compliance cost and the results of this partial equilibrium model.

8.1.3 Alternative Approach to Estimating Social Cost

In the Transport Rule proposed last summer, EPA used a different model to estimate the social cost of the regulatory approach than applied in this RIA. That model, EPA's Economic Model for Policy Analysis (EMPAX), is a computable general equilibrium model (CGE) which dynamically cascades the cost of a regulation through the entire economy. However, since that rule was proposed, an updated version of EMPAX was used to estimate the social cost of the Clean Air Act in a new EPA report entitled ―The Benefits and Costs of the Clean Air Act from 1990 to 2020. This report is available at http://www.epa.gov/air/sect812/feb11/fullreport.pdf.

This updated version of EMPAX added in the benefit-side effects (incorporating labor-force and health care expenditures) which significantly changed the social cost estimate from the previous edition. In December 2010, EPA's Science Advisory Board (SAB) found that ―The inclusion of benefit-side effects (reductions in mortality, morbidity, and healthcare expenditures) in a computable general equilibrium (CGE) model represents a significant step forward in benefit-cost analysis." http://yosemite.epa.gov/sab/sabproduct.nsf/1E6218DE3BFF682E852577FB005D46F1/$File/EPA-COUNCIL-11-001-unsigned.pdf. A description of the changes to the model and implications are covered in detail in chapter 8 of the section 812 report. EPA has determined that it needs to update the EMPAX model version used for RIAs to add this benefit-side effect prior to use in any additional regulatory analysis. In addition, the total nationwide annual compliance costs of the Transport Rule are now much lower than estimated for the proposal, and now are low enough so that EMPAX may not be as appropriate a model to use to for social costs and other economic impact estimation for this final rule. With the benefit-side effects updates now in the process of being incorporated into the model in response to SAB's guidance, and the relatively low nationwide annual compliance cost incurred by the electric power sector for this final rule as mentioned earlier in this RIA, EPA will not use EMPAX for this final RIA.

8.2 Employment Impacts for the Transport Rule

In addition to addressing the costs and benefits of the Transport Rule, EPA has estimated the impacts of this rulemaking on labor demand, and the results are presented in this section.[66] While a standalone analysis of employment impacts is not included in a standard cost-benefit analysis, such an analysis is of particular concern in the current economic climate. Executive Order 13563, states, ―Our regulatory system must protect public health, welfare, safety, and our environment while promoting economic growth, innovation, competitiveness, and job creation" (emphasis added). Therefore, we have provided this partial employment analysis to inform the discussion of labor demand and job impacts. We provide an estimate of the employment impacts on the regulated industry over time. We also provide the short-term employment impacts (increase in labor demand) associated with the construction of needed pollution control equipment.

We have not quantified the rule's effects on all labor in other sectors not regulated by this rule, or the effects induced by changes in workers' incomes. What follows is an

[66] See TSD as part of the Transport Rule Docket: ―Employment Estimates of Direct Labor in Response to the Transport Rule in 2014."

overview of the various ways that environmental regulation can affect employment, followed by a discussion of the estimated impacts of this rule. EPA continues to explore the relevant theoretical and empirical literature and seeks public comment in order to ensure that such estimates are as accurate, useful and informative as possible.

From an economic perspective, labor is an input into producing goods and services; if regulation requires that more labor be used to produce a given amount of output, that additional labor is reflected in an increase in the cost of production. Moreover, when the economy is at full employment, we would not expect an environmental regulation to have an impact on overall employment since labor is being shifted from one sector to another. On the other hand, in periods of high unemployment, an increase in labor demand due to regulation may have the potential to result in a net increase in overall employment. With significant numbers of workers unemployed, the opportunity costs associated with displacing jobs in other sectors are likely to be smaller.

To provide a partial picture of the employment consequences of this rule, EPA takes two approaches. First, the analysis uses the results of Morgenstern, Pizer, and Shih (2002) to estimate the effects of the regulation on the regulated industry, the electric power industry in this case. This approach has been used by EPA in recent Regulatory Impact Analyses. (See, for example, the Regulatory Impact Analysis for the recently finalized Industrial Boilers and Commercial and Institutional Solid Waste (CISWI) rulemakings, promulgated on February 21, 2011). Second, EPA uses projections from IPM to estimate the short-term employment effects resulting from construction and resource requirements as a result of the additional demand for pollution control equipment. Historically, EPA has only reported employment impacts on a few regulations. Section 8.3 discusses the estimates of the employment consequences in the electricity sector, using the Morgenstern, et al. approach. Section 8.4 estimates the employment effects in the environmental protection sector, using the second approach.

8.3 Employment Impacts primarily on the regulated industry: Morgenstern, Pizer, and Shih (2002)

EPA examined possible employment effects within the electric utility sector using a peer-reviewed, published study that explores historical relationships between industrial employment and environmental regulations (Morgenstern, Pizer, and Shih, 2002). The fundamental insight of Morgenstern, et al. is that environmental regulations can be understood as requiring regulated firms to add a new output (environmental quality) to their product mixes. Although legally compelled to satisfy this new demand, regulated firms have to finance this additional production with the proceeds of sales of their other (market) products. Satisfying this new demand requires additional inputs, including labor, and may alter the relative proportions of labor and capital used by regulated firms in their production processes.

Thus, Morgenstern et al. decompose the overall effect of a regulation on employment into the following three subcomponents:

The ―Demand Effect": higher production costs raise market prices, reducing consumption (and production), thereby reducing demand for labor within the regulated industry [67];

The ―Cost Effect": As production costs increase, plants use more of all inputs, including labor, to maintain a given level of output. For example, in order to reduce pollutant emissions while holding output levels constant, regulated firms may require additional labor;

The ―Factor-Shift Effect": Regulated firms' production technologies may be more or less labor intensive after complying with a regulation (i.e., more/less labor is required per dollar of output).

Decomposing the overall employment impact of environmental regulation into three subcomponents clarifies the conceptual relationship between environmental regulation and employment in regulated sectors, and permitted Morgenstern, et al. to provide an empirical estimate of the net impact. For present purposes, the net effect is of particular interest, and is the focus of our analysis.

Using plant-level Census information between the years 1979 and 1991, Morgenstern et al. estimate the size of each effect for four polluting and regulated industries (petroleum,

[67] The Morgenstern et al. results rely on industry demand and supply elasticities to determine cost pass-through and reductions in output.

plastic material, pulp and paper, and steel). On average across the four industries, each additional $1 million ($1987) spending on pollution abatement results in a (statistically insignificant) net increase of 1.55 (+/- 2.24) jobs. As a result, the authors conclude that increases in pollution abatement expenditures do not necessarily cause economically significant employment changes. The conclusion is similar to Berman and Bui (2001) who found that increased air quality regulation in Los Angeles did not cause in large employment changes[68].

Since the Morgenstern, et al. parameter estimates are expressed in jobs per million ($1987)[69] of environmental compliance expenditures, their study offers a transparent and simple way to transfer estimates for other employment analysis. For each of the three job effects outlined above, EPA used the Morgenstern et al. four industry average parameters and standard errors along with the estimated private compliance costs to provide a range of electricity sector employment effects associated with the Transport Rule.

By applying these estimates to pollution abatement costs for the final rule for the electric power sector, we estimated each effect. The results are

Demand effect: −to + jobs in the directly affected sector with a central estimate of −;

Cost effect: + to + jobs in the directly affected sector with a central estimate of +; and

Factor-shift effect: + to + jobs in the directly affected sector with a central estimate of +.

EPA estimates the net employment effect to range from - to + jobs in the directly affected sector with a central estimate of +. [70, 71]

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[68] For alternative views, see Henderson (1996) and Greenstone (2002).

[69] The Morgenstern et al. analysis uses ―production worker" as defined in the US Census Bureau's Annual Survey of Manufactures (ASM) in order to define a job. This definition can be found on the Internet at http://www.census.gov/manufacturing/asm/definitions/index.html.

[70] Since Morgenstern's analysis reports environmental expenditures in $1987, we make an inflation adjustment the IPM costs using the ratio of the consumer price index, U.S. city, all items reported by the U.S. Bureau of Labor Statistics: CPI_{1987}/ CPI_{2007} = (113.6/207.3) = 0.55

These estimates are shown in Table 8-3.

Table 8-3. Employment Impacts Using Peer-Reviewed Study

	Estimates using Morgenstern et al. (2002)			
	Demand Effect	**Cost Effect**	**Factor Shift Effect**	**Net Effect**
Change in Full-Time Jobs per Million Dollars of Environmental Expenditure[a]	−3.56	2.42	2.68	1.55
Standard Error	2.03	0.83	1.35	2.24
EPA estimate for Transport Rule[b]	+200 to -3,000	+400 to 2,000	0 to +2,000	-1,000 to 3,000

[a] Expressed in 1987 dollars. See footnote 8 for inflation adjustment factor used in the analysis.

[b] According to the 2007 Economic Census, the electric power generation, transmission and distribution sector (NAICS 2211) had approximately 510,000 paid employees. Both the midpoint and range for each effect are reported in the last row of the table.

All ranges for these job changes are based on the 95th percentile of results. EPA recognizes there will be other employment effects which are not considered in the Morgenstern et al. study. For example, employment in environmental protection industries may increase as firms purchase more pollution control equipment and services to meet the rule's requirements. EPA does provide such an estimate of employment change later in this section in a separate analysis. On the other hand, industries that use electricity will face higher electricity prices as the result of the transport rule, reduce output, and demand less labor. In the earlier part of Chapter 8 we use a Multimarket Model to estimate that there will be a .002% reduction in output in nonmanufacturing industries and .002 to .007 percent reductions in output in various manufacturing industries. It is difficult, however, to extend these results to an estimate of employment effects across these many different industries;

[71] Net employment effect = 1.55× $832 million × 0.55. This estimated net result is not statistically different from zero.

therefore, we feel we do not currently have sufficient information to quantify these impacts as potential employment losses.

8.3.1 Limitations

Although the Morgenstern et al. paper provides information about the potential job effects of environmental protection programs, there are several caveats associated with using those estimates to analyze the final rule. First, the Morgenstern et al. estimates presented in Table 8-3 and used in EPA‘s analysis represent the weighted average parameter estimates for a set of manufacturing industries (pulp and paper, plastics, petroleum, and steel). Morgenstern, et al. present those industries‘ estimates separately, and they range from -1.13 jobs per $1 million (in 1987 dollars) of environmental expenditures for pulp and paper, to +6.90 jobs for plastics. Only two of the total jobs estimates are statistically significantly different from zero, and the overall weighted average used here, 1.55 jobs per $1 million, is not statistically significant. Moreover, here we are applying the estimate to the electricity generating industry.

Second, relying on Morgenstern et al. implicitly assumes that estimates derived from 1979–1991 data are still applicable. Third, the methodology used in Morgenstern et al. assumes that regulations affect plants in proportion to their total costs. In other words, each additional dollar of regulatory burden affects a plant by an amount equal to that plant‘s total costs relative to the aggregate industry costs. By transferring the estimates, EPA assumes a similar distribution of regulatory costs by plant size and that the regulatory burden does not disproportionately fall on smaller or larger plants.

8.4 Employment Impacts of the Transport Rule - Environmental Protection Sector Approach, by 2014 [72]

The Transport Rule will require additional pollution control equipment and services in order to reduce emissions from the power sector and address nonattainment and the transport of air emissions cross state borders. Historically, new categories of employment have been created in the process of implementing regulations that reduce air emissions and other forms of pollution.. When a regulation is promulgated, the first response of industry is to order pollution control equipment and services in order to comply with the regulation

[72] EPA expects that the installation of retrofit control equipment in response to the requirements of this rule will primarily take place within 2014.

when it becomes effective. Revenue and employment in the environmental technology industry have grown steadily between 2000 and 2008, reaching an industry total of approximately $300 billion in revenues and 1.7 million employees in 2008.[73] While these revenues and employment figures represent gains for the environmental technologies industry, they are costs to the regulated industries required to install the equipment. Moreover, it is not clear the 1.7 million employees in 2008 represent anything other than workers diverted from other productive employment as opposed to new additional employment.

Regulated firms hire workers to design and construct pollution control equipment. Once the equipment is installed, regulated firms hire workers to operate and maintain the pollution control equipment – much like they hire workers to produce more output. Morgenstern, Pizer, and Shih (2002) examined how regulated industries respond to regulation. They found that on average, employment goes up in regulated firms. Of course, these firms may also reassign existing employees to do these activities.

Environmental regulations support employment in many basic industries. In addition to the increase in employment in the environmental protection industry (increased orders for pollution control equipment), environmental regulations also support employment in industries that provide intermediate goods to the environmental protection industry. For example, $1 billion in capital expenditures to reduce air pollution involves the purchase of abatement equipment. The equipment manufacturers, in turn, order steel, tanks, vessels, blowers, pumps, and chemicals to manufacture and install the equipment.

A study (2008) by Bezdek, Wendling, and DiPernab found that ―investments in environmental protection industries create jobs and displace jobs, but the net effect on employment is positive."

[73] In 2008, the industry totaled approximately $315 billion in revenues and 1.9 million employees including indirect employment effects, pollution abatement equipment production employed approximately 4.2 million workers in 2008. These indirect employment effects are based on a multiplier for indirect employment = 2.24 (1982 value from Nestor and Pasurka - approximate middle of range of multipliers 1977-1991). Environmental Business International (EBI), Inc., San Diego, CA. Environmental Business Journal, monthly (copyright). http://www.ebiusa.com/ EBI data taken from the Department of Commerce International Trade Administration Environmental Industries Fact Sheet from April 2010: http://web.ita.doc.gov/ete/eteinfo.nsf/068f3801d047f26e85256883006ffa54/4878b7e2fc08ac6d85256883006c452c?OpenDocument

The focus of this part of the employment analysis is on short-term jobs related to the compliance actions of the affected entities and includes estimates of the employment impacts due to the increased demand for pollution control equipment.[74] Results indicate that the Transport Rule has the potential to result in a net increase of labor in these industries, driven by the increased demand for new pollution controls. Overall, the preliminary results of the environmental protection sector approach indicate that the Transport Rule could support an increase of about 2,230 job-years[75] by 2014.

8.4.1 Overall Approach and Methodology for Environmental Protection Sector Approach

EPA commissioned ICF International to provide estimates for the Environmental Protection Sector, and the analysis utilizes a bottom-up engineering based methodology combined with macroeconomic data on industrial output and productivity, to estimate employment impacts in the environmental control sector of the economy. It relies on projections from the IPM model and projections for new pollution control equipment and related costs, along with data from the Bureau of Labor Statistics and other sources. The approach also relies upon prior EPA studies on similar issues, and in particular uses data and information from an extensive resource study conducted in 2002, which was updated in the Spring of 2011 and reflects more recent information.[76] The approach involves using IPM projected results from the Transport Rule analysis for the set of pollution control technologies expected to be installed to comply with the rule, along with data from secondary sources, to estimate the job impacts using this approach.[77] This includes the labor needed to design, manufacture and install the needed pollution control equipment over the years leading up to compliance in 2014.

For construction labor, the labor needs are derived from the 2002 EPA resource analysis for installing various retrofits (FGD – Flue Gas Desulfurization scrubbers, SCR-

[74] For more detail on methodology, approach, and assumptions, see Appendix D in this RIA: ―Employment Estimates of Direct Labor in Response to the Transport Rule in 2014."

[75] Numbers of job years are not the same as numbers of individual jobs, but represents the amount of work that can be performed by the equivalent of one full-time individual for a year (or FTE). For example, 25 job years may be equivalent to five full-time workers for five years, twenty-five full-time workers for one year, or one full-time worker for twenty-five years.

[76] Engineering and Economic Factors Affecting the Installation of Control Technologies for Multipollutant Strategies EPA-600/R-02/073 (2002).

[77] Detailed results from IPM for the Transport Rule can be found in Chapter 7 of the RIA.

selective catalytic reduction, and DSI - dry sorbent injection) and are further classified into different labor categories, such as boilermakers, engineers and a catch-all ―other installation labor.” For the inputs needed (e.g., steel), the 2002 resource study was used to determine the steel demand for each MW of additional pollution control and combined with labor productivity data from the Economic Census and BLS for relevant industries.

More detail on methodology, assumptions, and data sources can be found in Appendix D of this RIA - ―Employment Estimates of Direct Labor in Response to the Transport Rule in 2014.”

Projections from IPM were used to estimate the incremental retrofit capacities projected in response to the final rule. These additional pollution controls are shown in Table 8-4 below, and reflect the added pollution controls needed to meet the requirements of the rule. Additional information on the power sector impacts can be found in Chapter 7 of the RIA.

Table 8-4. Increased Pollution Control Demand due to the Transport Rule, by 2014 (GW)

Retrofit Type	Existing Controls Induced to Operate	Newly Built Controls
FGD	25	6
SCR	5	0
DSI	0	3

8.4.2 Summary of Employment Estimates from Environmental Protection Sector Approach

Table 8-5 presents additional detail on the estimated employment impacts using the environmental protection sector approach resulting from the Transport Rule. Results for the Environmental Protection Sector Approach indicate the Transport Rule could support or create roughly 2,230 one-time job-years of increased demand for direct labor, driven by the need to design and build the pollution control equipment.

Table 8-5. Employment Effects Using the Environmental Protection Sector Approach for the Transport Rule by 2014 (in Job-Years)

Employment	Incremental Employment
One-Time Employment Changes for Construction	
1. Boilermakers	890
2. Engineers	440
3. General Construction	880
4. Steel Manufacturing	20

8.4.3 Other Employment Impacts of the Transport Rule

We expect ongoing employment impacts on regulated and non-regulated entities for a variety of reasons. These include labor changes in the regulated entities resulting from shifts in demand for fuels, increased demand for materials and the labor required to provide them to operate pollution control equipment, reductions in employment resulting from coal retirements, and reductions in other industries due to slight projected increases in the price of electricity and natural gas. The most notable of the ones we are unable to estimate are the impacts on employment as a result of the increase in electricity and other energy prices in the economy. Because of this inability to estimate all the important employment impacts, EPA neither sums the impacts that the Agency is able to estimate for the ongoing non-regulated group or make any inferences of whether there is a net gain or loss of employment for the non-regulated group. These other ongoing employment impacts are found in Table 8-6, and these employment impacts are not included in the Agency estimate of employment impacts for this Transport Rule for the reasons mentioned in this paragraph. The data in Table 8-6 come from an analysis of short-term employment impacts presented in Appendix D. That analysis focuses on the first-order employment impacts related to the compliance actions of the affected entities within the power sector, but not the ripple effects of these impacts on the broader economy (i.e., the ―multiplier" effect) or economy-wide effects of changes to the energy markets.

Table 8-6. Employment Impacts for Entities Not Regulated by the Transport Rule

Employment Changes for Ongoing Annual Operation

Employment Changes from Changes to Demand in Materials[78]	
1. Limestone (FGD)	2,440
2. Ammonia (SCR)	30
3. Catalyst (SCR)	20
4. Sodium Bicarbonate (DSI)	160
Sub-Total:	**2,650**
Employment Changes for Ongoing Annual Retrofit Operation	**2,320**
Employment Annual Changes due to Coal Capacity Retirements	**(2,710)**
Annual Employment Changes due to Changes in Fuel Use	
1. Coal	(2,030)
2. Natural Gas	810
3. New Natural Gas Pipeline	230
Sub-Total:	**(990)**

8.5 Summary

The two approaches use different analytical techniques and are applied to different industries during different time periods, and they use different units of analysis. These estimates should not be summed because of the different metrics, length and methods of analysis as mentioned in Section 8.4. The Morgenstern estimates are used for the ongoing employment impacts for the regulated entities (the electric power sector). The short term estimates for employment needed to design, construct, and install the pollution control equipment in the period leading up to the compliance date are also provided. Finally some of the other types of employment impacts that will be ongoing are not included in the employment impacts estimated for the final Transport Rule.

Table 8-7 shows the employment impacts of the final Transport Rule as estimated by the environmental protection sector approach and by the Morgenstern approach.

Table 8-7. Estimated Employment Impact Table

	Annual (reoccurring)	**One time (construction during compliance period)**
Environmental Protection Sector approach*	Not Applicable	**2,230**
Net Effect on Electric Utility Sector Employment from Morgenstern et al. approach***	****+700** **- 1,000 to +3,000******	Not Applicable

*These one-time impacts on employment are estimated in terms of job-years.

**This estimate is not statistically different from zero.

***These annual or recurring employment impacts are estimated in terms of production workers as defined by the US Census Bureau's Annual Survey of Manufacturers (ASM).

**** Based on the 95% confidence interval of the Morgenstern study.

8.6 References

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APPENDIX D
EMPLOYMENT ESTIMATES OF DIRECT LABOR IN RESPONSE TO THE FINAL TRANSPORT RULE IN 2014

This appendix presents the short-term employment estimates for the Transport Rule. The focus of the employment analysis in this study is only on the first order employment impacts related to the compliance actions of the affected entities within the power sector. It does not include the ripple effects of these impacts on the broader economy (i.e., the ―multiplier" effect), nor does it include the wider economy-wide effects of the changes to the energy markets (such as higher electricity prices).[92] Moreover, this study provides only a static snapshot of the impacts for 2014 and does not account for the dynamic adjustments of the affected entities as they adapt to the Transport Rule such as those arising from technological innovation and learning-by-doing.

The estimates of the employment impacts are divided into several categories: job gains due to the increased demand for pollution control equipment; job losses due to retirements of coal capacity; and job shifts due to changes in demand for fuels. Results indicate that the Transport Rule has the potential to provide some short-term employment opportunities, primarily driven by the demand for new pollution control equipment. The employment gains related to the new pollution controls are likely to be tempered by losses due to certain coal retirements, although, as discussed below, some of these workers who lose their jobs due to plant retirements could find replacement employment operating the new pollution controls at nearby units. Finally, job losses due to reduced coal demand may be partially offset by job gains due to increased natural gas demand, resulting in small negative (about a thousand) net change in employment due to fuel demand changes. Overall, the preliminary results indicate that the Transport Rule could support a net of about 3,500 job-years in 2014. These results are summarized in Table 1 below.

Table 1: Net Employment Changes (Job-years in 2014)

New Pollution Control Equipment	7,200
Retirements of Generating Units	(2,710)
Changes in Fuel Use	(990)
Net Effect	**3,500**

The job-years estimated here is a snapshot of the first order employment effect of the

92 For more detail on the costs and energy impacts of the proposed rule, see Chapter 7 of the Regulatory Impact Analysis accompanying the Transport Rule.

Transport Rule in 2014. While there is no temporal dimension to this study, most of these jobs are likely to last over an extended time period, some more than the others. Most of the construction-related labor demand, for example, is expected to provide a short-term, temporary boost to employment that could last a few years, along with any multiplier effects that are not included in these job-year estimates. Most of the operational labor n0eeds are likely to be longer term. Thus, in terms of the impacts of the Transport Rule on economy-wide employment over time, this study shows there is likely to be a temporary boost to employment levels starting around 2014, which would likely recede thereafter as the construction phases for the needed pollution controls wind down. Over time, the operational jobs, which constitute a large portion of the pollution control related job impacts, will continue to provide a boost to employment over ―business as usual" baseline employment levels. Note that this synopsis does not account for other employment impacts of the Transport Rule, such as those resulting from higher energy prices.

Overall Approach

The estimates for the near-term employment effects of the proposed rule utilize basic methodologies to estimate these job impacts relying on approaches used in prior EPA studies on similar issues. The basic approach involved using power sector projections and various energy market implications under the Transport Rule from modeling conducted with the EPA Base Case version 4.10, using the Integrated Planning Model (IPM®), along with data from secondary sources, to estimate the first order employment impacts for 2014. Throughout this analysis, incremental employment is measured in job-years, since there is no temporal dimension to this analysis.[93] Also, this TSD does not include estimates of total employment impacts *over time*, though there is a distinction between short-term construction-related labor needs and more long-term operational labor needs for new pollution controls (though these operational labor requirements are also measured in 2014 job-years only).

93 A job-year is defined as the amount of work that can be performed by the equivalent of one full-time individual for one year (or FTE).

Employment Changes due to New Pollution Control Equipment

EPA's Base Case v.4.10 and the Transport Rule policy case IPM projections were used to estimate the incremental pollution control demand.[94] These are shown in Table 2 below:[95]

Table 2: Increased Pollution Control Demand due to the Transport Rule, 2014 (GW)

Pollution Control Type	Existing Controls Induced to Operate	Newly-Built Controls
Scrubbers (FGD)	25	6
Selective Catalytic Reduction (SCR)	5	0
Dry Sorbent Injection (DSI)	0	3

The employment impacts due to increased pollution control demand are divided into four categories, two of which are associated with the construction and installation related labor requirements, while the remaining two are associated with the resources required for the ongoing operation of these equipment. The two categories of labor needed for constructing and installing these controls are for construction-related sectors, such as boilermakers, engineers, and other installation labor; and for the labor needed to manufacture the steel used in the control equipment. The two categories of labor needs for resource requirements include employment in sectors that supply resources needed to run these pollution controls (such as reagents and catalysts); and utility sector jobs to operate these control equipment. The following sections discuss the approach for each:

- For the installation related construction labor, per-unit labor needs were taken from an extensive 2002 EPA resource analysis for multi-pollutant strategies that analyzed the

94 Results for this analysis were developed using various outputs from EPA's Base Case v.4.10 using ICF's Integrated Planning Model (IPM®). This case includes all of the underlying modeling that was developed by EPA with technical support from ICF Consulting, Inc. IPM is a multi-regional, dynamic, deterministic linear programming model of the U.S. electric power sector. It provides forecasts of least cost capacity expansion, electricity dispatch, and emission control strategies while meeting energy demand and environmental, transmission, dispatch, and reliability constraints. See http://www.epa.gov/airmarkets/progsregs/epa-ipm/BaseCasev410.html for more info.

95 According to the EPA Policy Case results, there is some overlap between the different types of pollution control equipment demand at individual facilities. To the extent that there could be some efficiency gains at plants installing multiple controls due to economies of scale, the job estimates presented here could overstate the impacts.

resource requirements for installing various pollution control equipment (including FGD and SCR).[96] For controls not included in the 2002 EPA study, such as DSI, additional information was supplied by Andover Technology Partners (ATP), which was also one of the contributors of the 2002 EPA study. Using the same resource requirement approach as done in the 2002 EPA study, ATP provided estimates of unit labor needs based on scaling the labor requirements for ACIs (to derive estimates for DSI) [97] Thus, all of the unit labor needed for different pollution control installations can be traced back to the 2002 EPA study, with appropriate engineering adjustments. The installation labor was sub-divided into different labor categories, such as boilermakers, engineers and a catch-all ―other installation labor", using information from the 2002 EPA study, adjusted for the new pollution controls, such as DSIs.

- In addition to construction labor, it was assumed that installing the pollution controls requires labor for steel as the primary raw material, leading to employment in the steel manufacturing industry. Again this approach is consistent with the 2002 EPA study. The increased steel demand is estimated using the per-MW steel demand from the EPA study along with the estimated increases in pollution controls. For DSI, the same proportionality assumption is taken from ATP for installation labor to estimate the steel needed for installation.

- For the longer term, and more significant labor associated with operating the pollution controls, per-unit estimates of the main resources needed for these equipment (see Table 3 below for a list of the resources) are taken from the 2002 EPA study, augmented by DSI resource use estimates from ATP. These were then multiplied by the incremental GW for each pollution control to obtain the total (physical) quantity of resources needed.[98] Total tonnage (or volume for SCR catalyst) for each resource was then converted to dollars of increased economic output for these resources using price estimates obtained from publicly available sources (see Table 3). Finally, the labor productivity for each particular sector was used to estimate the number of job-years these would likely create in 2014. Labor productivities for each sector were adjusted to account for increased worker productivity in 2014. Data for baseline worker productivity and corresponding growth rates to account for future productivities came from the Economic Census and the Bureau of Labor Statistics

96 ―*Engineering and Economic Factors Affecting the Installation of Control Technologies for Multi-pollutant Strategies*". EPA/ORD, 2002.

97 DSI and Fabric Filter System Installation Labor Estimate. Memorandum by Andover Technology Partners to ICF International. January 26, 2011.

98 Except for Ammonia, where the usage was calculated based on the total predicted NOx reduced, consistent with the 2002 EPA study approach.

(BLS) estimates.[99]

- The final employment vector estimated was for the utility sector labor needed to operate these pollution control equipment. This estimate was based on the incremental Fixed Operation and Maintenance (FOM) costs from the EPA runs using IPM, excluding costs due to retirements. The assumption in this TSD was that the FOM costs -- defined as the maintenance costs incurred by the utility irrespective of whether the equipment is operated (such as those for payroll) – are a good proxy for estimating the incremental labor demand to operate these pollution controls. The FOM costs were then translated into employment based on estimates of payroll per worker for the power sector taken from the 2007 Economic Census and BLS estimates.[100]

99 Total value of shipments in 2007 and total employees were taken from 2007 Economic Census, Statistics by Industry for Mining and Manufacturing sectors. The average annual growth rate of labor productivity was taken from the Bureau of Labor Statistics. Average growth rate calculated for years 1992-2007, applied to 2007 productivity to determine 2014 estimates of productivity. For steel, limestone, ammonia, and SCR catalyst, the value of shipments and employment estimates were taken from the 2000 Survey of Manufacturers. See the Appendix for more details about the data used for these calculations.

100 Same sources as other productivity estimates (2007 Economic Census and BLS), however, uses employees and total payroll rather than revenue or value of shipments.

Table 3: Estimated Pollution Control Resource Needs (Quantity and Prices Used)

	Amount of Resource Used	Price Used ($/unit)
Steel (tons)	19,906	$ 550
Limestone, FGD (tons) [101]	8,112,715	$ 75
Ammonia, SCR (tons)	77,387	$ 150
Catalyst, SCR (m3)	723	$ 8,475
Sodium Bicarbonate, DSI (tons)	675,725	$ 120

Price Sources: Steel: Platts, Steel Markets Daily, Vol 3 Issue 209, October 29, 2009.

Limestone: FGD Tech Evaluation, March 2007.

Ammonia: Development of Supply Curves for Abatement of GHG from Coal-fired Utility Boilers, Air Pollution Prevention and Control Division, US-EPA, RTP and NC State University, 2009.

Catalyst: EPA Air Pollution Control Cost Manual, Sixth Edition, January 2002. ;

Sodium Bicarbonate: Communication with Andover Technology Partners, Feb 7, 2011.

Results

Table 4 presents the estimated employment impacts in 2014 resulting from the additional pollution controls needed to meet the Transport Rule requirements. The Transport Rule is estimated to lead to a total capital investment of about $4 to $5 billion in order for the regulated entities to meet the limits under the proposed rule (this capital cost will be amortized over many years). According to this analysis, these investments could provide the opportunity to support over 7,000 job-years to design, construct, and operate the needed pollution control equipment in 2014. Note, some of these jobs are expected to start before, and continue beyond 2014 (such as

101 EPA's modeling for the Transport Rule indicates most of the incremental scrubber capacity is likely to be wet scrubbers. EPA assumes a lower price for the limestone used in wet scrubbers relative to the reagent used in dry scrubbers. The $75/ton price for limestone was used to be consistent with a similar analysis conducted for the proposed Mercury and Air Toxics Standards (March 2011) where EPA projected mostly dry scrubbers that use a more expensive lime reagent. This simplification is likely to overestimate the job impacts. However, this study does not include the positive employment impacts arising from the waste disposal costs assumed in EPA's modeling, again to be consistent with the Toxics Rule TSD, which is likely to lead to underestimation of the total job impacts.

the resource related job-years), but this analysis only provides a snapshot for 2014.

Table 4: Jobs Due to Pollution Control Equipment under the Transport Rule (Job-years in 2014)

Jobs for Construction	**Incremental Employment**
Boilermakers	890
Engineers	440
General Construction	880
Steel Manufacturing	20
Sub-Total:	**2,230**
Jobs for Operation	
Jobs from Increased Operating Resource Use	
Limestone (FGD)	2,440
Ammonia (SCR)	30
Catalyst (SCR)	20
Sodium Bicarbonate (DSI)	160
Sub-Total:	**2,650**
Jobs for Pollution Control Operation	**2,320**
Total Labor:	**7,200**

Note: Totals may not add due to rounding

The number of job-years estimated for pollution control installation is driven primarily by incremental FGD capacity. As shown in Table 2, up to 31 GW of additional FGD capacity is projected to be used in 2014 to comply with the Transport Rule. Out of this, only about 6 GW is estimated to be new scrubber capacity requiring construction and installation of the pollution control equipment. While the remaining 25 GW is projected to be existing scrubbers that were not operated under the EPA base case assumptions, and hence are not likely to lead to jobs due to construction, these scrubbers do provide significant operational employment opportunities. The results above show a higher proportion of operational jobs than, for example, was estimated for the utility Toxics Rule. This implies while the jobs due to the Transport Rule are only a fraction of the total estimated for the Toxics Rule, these jobs are more likely to last longer over time since there is less need for installing new pollution control equipment but a higher demand for operating equipment that may not be operated in absence of the Transport Rule (i.e. under the ―business-as-usual" base case).

Moreover, of the roughly 7,200 job-years estimated in Table 4, over 2,300 job-years, or over 30 percent, are estimated to occur within the utility sector for labor needed to operate the pollution controls (referred to as ―Jobs for Pollution Control Operation" in Table 4). The rest of the labor demand will benefit the pollution control industry and other economic sectors. The increased demand for resources and chemicals needed to operate the pollution controls will provide a boost to employment in sectors such as mining, chemicals, other manufacturing sectors, and to a smaller extent, in construction-related sectors.

Employment Changes due to Coal Retirements

Employment changes due to plant retirements were estimated by first identifying the retiring units from EPA's modeling using IPM,all of which are coal-fired units. EPA projects that there will be roughly 4.8 GW of additional coal retirements by 2014 with the Transport Rule in place.[102]

In order to convert the retired coal capacity into potential employment losses, it was assumed that changes in the operating costs for the retired coal units can be used as a proxy for the lost economic output due to fossil retirements. Thus, the changes in the O&M costs (both FOM and VOM) for these particular retiring units were derived from the EPA Base Case and Transport Rule policy case runs using IPM, and converted to lost jobs using data from the Economic Census and BLS output/worker estimates for the utility sector.[103]

Note that the lost economic output due to fossil retirements is likely to affect not just the utility sector, but others as well. Employment losses due to plant retirements will not only affect those that are directly working at the plant (i.e., plant operators), but would also affect administrative and other ―back-office" workers for those utilities and their support organizations. This TSD assumes that the FOM costs related to retiring plants are a good proxy for these types of job losses. Moreover, because the VOM costs represent the variable costs of operating the plant, including costs of materials needed to run any installed pollution control equipment (such as cost of reagents, etc.), this TSD assumes that the VOM costs can be used as an indicator of the employment effects on the resource suppliers to these plants and units. Thus, the retirement

102 Retirement estimates are based on system-level results for the EPA runs using IPM. Where applicable, parsed data from the IPM for the relevant EPA runs were adjusted to account for partial retirements.

103 The same specific sources as cited before, however, used workers and total payroll.

related employment losses shown below are assumed to include losses directly affecting the utility sector as well as other ―upstream" sectors that provide material inputs needed to operate these plants. Table 5 shows those results.

Table 5: Job Losses due to Coal Capacity Retirements

O&M Decrease from Retirements ($MM)	303
Workers Per Million$ in payroll	8.9
Workers lost due to retirements (job-year):	**2,710**

Results indicate there could potentially be about 2,700 job losses (measured in job-years for 2014, but any *net* job losses under this category are likely to be permanent), due to coal retirements. However, two mitigating factors could reduce the negative employment impacts due to retirements. First, many of the retiring units are at plants that are likely to have other units operating under the policy scenario. In such cases, some of the excess labor pool at the retiring units could well be absorbed at other units within the same firm.[104]

Second, as Table 4 indicates, utilities are expected to have the need to fill over two thousand additional job slots to operate the pollution controls needed to meet the requirements of the Transport Rule. If workers with experience at existing coal facilities become available through plant retirements, it would seem logical for many of these workers to be absorbed in operating these new pollution controls. While it is not possible to determine how many of these workers from particular coal retirements could be employed to operate the new pollution controls, it is likely that a significant portion of them could find gainful employment at nearby units.

Employment Changes due to Changes in Fuel Use

Two types of employment impacts due to projected fuel use changes are estimated in this TSD. First, employment losses due to reductions in coal demand were estimated using an approach similar to EPA's coal employment analyses under Title IV of the Clean Air Act

104 According to EPA modeling results, approximately 70 percent of the coal retirements (in terms of capacity) occur at plants with other operating units under the Transport Rule policy case.

Amendments.[105] Using this approach, changes in coal demand (in short tons) for various coal supplying regions were taken from EPA's Base and Policy Case runs. These changes were converted to job-years using EIA data on regional coal mining productivity (in short tons per employee hour), using 2008 labor productivity estimates.[106] [107] Results of the coal employment impacts of the Transport Rule are presented in Table 6 below.

Table 6: Employment Due To Changes in Coal Use

Coal by Region	Change in Coal Demand (MM Tons)	Labor Productivity	Job-year Change
Appalachia	3.8	2.91	630
Interior	(27.2)	4.81	(2,720)
West	2.9	19.91	70
Waste Coal	(0.03)	5.96	(0)
Net Total	**(20.5)**	**--**	**(2,030)**

Notes: Used US national coal productivity for waste coal
Totals may not add due to rounding

For natural gas demand, labor productivity per unit of natural gas was unavailable, unlike coal labor productivities used above. Most secondary data sources (such as Census and EIA) provide estimates for the combined oil and gas extraction sector. This TSD thus uses an adjusted labor productivity estimate for the combined oil and gas sector that accounts for the relative contributions of oil and natural gas in the total sector output (in terms of the value of energy output in MMBtu). This estimate of labor productivity is then used with the incremental natural gas demand for the Transport Rule to estimate the job-years for 2014. In addition, the pipeline construction costs were estimated using proportionality assumptions from those used for the

105 Impacts of the Acid Rain Program on Coal Industry Employment. EPA 430-R-01-002 March 2001.

106 From US Energy Information Administration (EIA) Annual Energy Review, Coal Mining Productivity Data. Used 2008.

107 Unlike the labor productivity estimates for various equipment resources which were forecasted to 2014 using BLS average growth rates, this study uses the most recent historical productivity estimates for fuel sectors. In general, labor productivity for the fuel sectors (both coal and natural gas) showed a significantly higher degree of variability in recent years than the manufacturing sectors, which would have introduced a high degree of uncertainty in forecasting productivity growth rates for future years.

Toxics Rule TSD.[108] These results are summarized in Table 7 below.

Table 7: Total Employment Impact due to Changes in Fuel Use (2014)

Fuel Type	Employment
Coal Job Years Lost	**(2,030)**
Natural Gas	
Incremental Natural Gas Use (MMBtu)	212,279,900
Labor Productivity (MMBtu/job-year)	261,840
Job-years gained	**810**
Gas Pipeline	
Capital Cost for New Pipeline Capacity (US total: MM $/year)	44.2
Workers/million $ in Pipeline Construction	5.1
Job-years gained	**230**
Net Employment Effects of Fuel use changes	**(990)**

Note: Totals may not add due to rounding

Thus, about 2,000 job losses in the coal mining sector are likely to be partially offset by about 1,000 job gains in the production and transportation-related jobs in the natural gas related sectors, for a net effect of less than a thousand job losses due to changes in fuel use.

Conclusion

Overall, the impact of the Transport Rule on short-term employment resulting from investments in pollution control equipment is expected to be small. The Transport Rule is estimated to lead to a total pollution control-related capital investment of about $4 to $5 billion. Of the jobs associated with pollution controls, over two-thirds are likely to be associated with operating these controls while the remaining one-third is estimated to be driven by the need to install new controls. Employment losses due to coal retirements that will likely have a negative effect on some utilities and the coal mining sector could offset some of the positive gains from

108 See ―Employment Estimates of Direct Labor in Response to the Proposed Toxics Rule in 2015". Technical Support Document, March 2011.

pollution control and in the natural gas sector. As previously discussed, this assessment does not account for the long-run economy-wide effects of the Transport Rule. The employment impacts estimated in this study are mostly based on approaches in prior EPA studies on similar topics. The main source for resource estimates used here is the 2002 EPA multi-pollutant resource analysis, which was also the basis for subsequent EPA labor analyses, such as the 2005 Clean Air Interstate Rule (CAIR) TSD on boilermaker labor, as well as the more recent utility Toxics Rule employment TSD.[109] Thus, results presented here are consistent with prior EPA studies on similar topics.

109 CAIR Technical Support Document. Boilermaker Labor Analysis and Installation Timing. March 2005.

Supplemental Information

This section provides further details on the inputs and methodology used in the labor calculations presented above. The Appendix begins with the pollution control labor section, presenting the inputs for the four primary sections of equipment labor and describing the process by which the labor estimates were obtained from the available data, followed by similar discussions for coal retirements and fuel use change employment analysis.

Pollution Control Equipment Labor

- **Installation Labor**

Table 8: Installation Labor Requirement

Pollution Control Type	Incremental GW Installed	Man-hours/MW	Boilermakers (%)	Engineers (%)	Others (%)
FGD	6	760	40	20	40
SCR	0	700	45	7	48
DSI	3	44	50	17	33

Source: EPA Multi-pollutant Strategies 2002 report; DSI and FF adjustments based on Andover Technology Partners.

Installation labor is estimated using the incremental GW installed for each pollution control type from EPA's modeling using IPM. This was then converted into total man-hours needed for installation using estimates of man-hours/MW from the 2002 EPA study, supplemented by information from ATP. Total man-hours for each pollution control type were then converted into man-years assuming 2,080 working hours per year.

Total man-years for each pollution control type were then broken down into various sectors using the percentages, shown in Table 8. These percentages were estimated from the 2002 study and supplemented by ATP information for DSI.

- **Installation Resource Labor**

Table 9: Installation Resource Needs

Pollution Control Type	Steel (Tons/MW)
FGD	2.25
SCR	2.5
DSI	2.2

Sources: Steel and Catalyst Usage: EPA Multi-pollutant Strategies 2002 report; Steel Price: Platts, Steel Markets Daily, Vol 3 Issue 209, October 29 2009; Productivity: 2000 Annual Survey of Manufacturers: Iron and Steel Pipes and Tube Manufacturing, BLS for Productivity Growth Rate.

For installation resource labor, steel is the primary resource input used for new pollution control installations, consistent with the 2002 EPA multi-pollutant study. The first step used the incremental installed pollution control capacity and estimates of steel usage (tons/MW), as shown in Table 9 above, to calculate the total steel needed in tons, by pollution control type. Steel usage estimates were used from the 2002 EPA study, supplemented by ATP information for DSI. The total amount of steel was then converted into a dollar value for steel expenditure using an average steel price ($550/ton), using data from Platts Steel Markets Daily (see notes to Table 9 above). Resulting total steel expenditure was then converted to labor using the productivity estimates calculated from the Economic Census data using workers per $ Million in total output for the iron and steel manufacturing industry (= 2.2 workers/$Million).[110]

- **Operating Resource Labor**

Table 10: Resources Needed for Operation

Pollution Control Type	Incremental Total GW (Includes Existing Units)	Resource (Units in parenthesis)	Usage Estimates	Price ($/unit)	Industry Assumed for Productivity Calculations	Productivity*
FGD	30.3	Limestone (Tons/MWh)	0.036	75	Lime Manufacturing	4.0

110 In general, the productivity estimates for various sectors were derived using data from the 2000 Annual Survey of Manufacturers or 2007 Economic Census. These were then forecasted to 2014 using corresponding average growth rates estimated using data from the Bureau of Labor Statistic (BLS) information on productivity growth rates.

SCR	5 (NOx reduction: 396,870,600 lbs)	Ammonia (lbs/lb NOx Reduced)	0.39	150	All Other Basic Inorganic Chemical Manufacturing	2.1
		Initial Catalyst (m3/MW)	1.2	8,475	Combined: Other Nonferrous Metal Primary and Secondary Smelting and Refining	3.2
		Operational Catalyst (m3/MWh)	0.00002			
DSI	3	Sodium Bicarbonate (Tons/MWh)	0.03	120	Potash Soda and Borate Mineral Mining	2.0

**Workers/$Million in Output, Forecasted to 2014*
Sources: Usage: EPA Multi-pollutant Strategies 2002 report, DSI from Andover Technology Partners;
Prices: Limestone: FGD Tech Evaluation, March 2007
Ammonia: Development of Supply Curves for Abatement of GHG from Coal-fired Utility Boilers, Air Pollution Prevention and Control Division, US-EPA, RTP and NC State University, 2009
Catalyst: EPA Air Pollution Control Cost Manual, Sixth Edition, January 2002.
Sodium Bicarbonate: Communication with Andover Technology Partners, Feb 7 2011;
Productivity: 2000 and 2007 Economic Census, Productivity Growth rates from BLS.

Labor related to resources used in operating pollution control equipment was estimated using the total incremental GW of pollution control capacity which was first converted to total MWh of incremental capacity assuming 85 percent capacity factor. For each pollution control type, the next step involved choosing the primary operating resource, except for SCRs for which two resources – ammonia and catalyst – were chosen. [111] This approach is consistent with the 2002 EPA study. The next step involved estimating the resource needs by each control type, generally in tons of material (cubic meters (m3) for catalyst), using the resource usage estimates as shown in Table 10.[112] Using the total usage for each pollution control input (in tons or m3) and associated average prices, total expenditure by each resource type was then calculated. This total expenditure was then converted to labor using workers per $Million in total output for the industry associated with producing each respective input material.

111 SCRs have an operational input of catalyst as well as an initial input needed when the unit is first installed. While the initial value is calculated using only the installed new control capacity, that number and the associated labor needs are included to estimate the total volume of catalyst required.

112 Ammonia has a usage rate based on lbs of NOx reduced, so we estimated our ammonia usage using the total NOx reduced between the base and policy cases.

- **Operating Labor**

Table 11: Operating Labor Assumptions

Incremental FOM ($ Million)	259
Productivity*	8.9

**Workers per $Million in Payroll for Electricity Generating Sector, Forecast to 2014*
Sources: Productivity from 2007 Economic Census and Growth Rate from BLS.

Labor requirement to operate the controls is estimated for all equipment types combined, using the incremental FOM costs based on EPA modeling assumptions for the Transport Rule. Resulting FOM cost estimate was then converted to labor needs using the workers/$ Million in total payroll for the Electric Generating Sector.

Retirement Labor

Table 12: Inputs to Labor from Retirements

Capacity of Incremental Retirements (MW)	4,772
O&M Decrease scaled to SSR Retirements ($MM) (To account for Partial Retirements)	302.8
Workers Per $Million in payroll, forecast to 2014	8.9

Sources: Productivity from 2007 Economic Census and Growth Rate from BLS.

Retirement labor was estimated by first identifying the retiring units from the parsed outputs (using incremental retirements in EPA's Transport Rule policy case run). The next step involved estimating the capacity of incremental retirements as well as the change in the O&M costs due to these retirements. Because of the discrepancies between partial retirements in parsed outputs and System Summary Reports (SSR), O&M costs were scaled proportionately to reflect the lower SSR-based estimates, as shown in Table 12 above. O&M cost decreases were then converted to job-years lost due to retirements using workers per $Million in payroll.

Fuel Use Labor

Table 13: Inputs to Labor for Fuel Use

Coal by Region	**Incremental Fuel Use (Tons)**	**2008 Short Tons/Employee hour**
Appalachia	3,780,000	2.9
Interior	(27,190,000)	4.8
West	2,870,000	19.9
Waste Coal	(30,000)	6.0

Natural Gas		
EIA Total Natural Gas Production 2007 (TCF)		24.664
EIA Total Crude Oil Production 2007 (Barrels)		1,848,450,000
EIA Natural Gas Heat Content 2007 (Btu/cf)		1,027
EIA Petroleum Heat Content (MMBtu/Barrel)		6.151
Total Crude Oil and Natural Gas Production (MMBtu)		36,699,744,000
Economic Census 2007 Oil and Gas Extraction Employees		140,160
MMBtu per Man-year for Oil and Gas Extraction		261,842
Incremental Natural Gas from EPA (IPM) Results (TCF)		0.207
Incremental Natural Gas from EPA (IPM) Results (Converted to MMBtu)		212,279,903
Pipeline	Capital Cost of New Pipeline ($MM)	Productivity
	44.2	5.1

Note: Heat Contents from EIA are assumed to be for fuels used in Electric Power Sector
Sources: Short Tons per hour from US EIA, Coal Industry Annual. Total Production from 2009 EIA Annual Energy Review. Heat Contents from EIA, Heat Content of Natural Gas Consumed and 2009 Annual Energy Review. Employment Data from 2007 Economic Census.

Fuel use related employment impacts were estimated using EPA‘s Base Case and the Transport Rule runs using IPM for incremental changes in coal and natural gas use. For coal, estimates of coal use in tons by region from the relevant EPA runs were used in conjunction with labor productivity estimates from EIA for each region (in short tons/ employee hour), to calculate the change in job-hours needed. These were then converted to job-years, assuming 2,080 working hours per year. As discussed in the main report above, because of the high variability in coal mining labor productivity in recent years, no attempt was made to forecast coal (and natural gas, for consistency) productivities, instead the most recent historical estimates were used in this TSD (which was the 2008 labor productivity for coal).

For natural gas, the first step was estimating labor productivity since such information was not available directly from any reliable source. EIA production data from the Annual Energy Review for natural gas and crude oil (in TCF and barrels, respectively), along with EIA heat content estimates were used to find total crude oil and natural gas production in MMBtu for 2007. Labor productivity in MMBtu per job-year for the Oil and Gas Extraction sector was then estimated using data from the Census on oil and gas extraction employment. Then, incremental natural gas demand (in Tcf) from the relevant EPA runs was converted to MMBtu of natural gas demand using EIA data on natural gas heat content. This was then used with the labor productivity estimated above to calculate the total job-years needed for increased natural gas demand for the Transport Rule.

Jobs related to pipeline construction were estimated in proportion to the increased natural gas demand under this rule relative to those estimated for the utility Toxics Rule. More details on the approach used to convert pipeline information into jobs for the Toxics Rule are provided in the Toxics Rule employment TSD.

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EXHIBIT 16

Draft Regulatory Impact Analysis:

Tier 3 Motor Vehicle Emission and Fuel Standards

United States
Environmental Protection
Agency

Draft Regulatory Impact Analysis:

Tier 3 Motor Vehicle Emission and Fuel Standards

Assessment and Standards Division
Office of Transportation and Air Quality
U.S. Environmental Protection Agency

NOTICE

This technical report does not necessarily represent final EPA decisions or positions. It is intended to present technical analysis of issues using data that are currently available. The purpose in the release of such reports is to facilitate the exchange of technical information and to inform the public of technical developments.

EPA United States Environmental Protection Agency

EPA-420-D-13-002
March 2013

List of Acronyms

A/F	air/fuel ratio
AAM	Alliance of Automobile Manufacturers
ABT	averaging, banking, and trading
ACS	American Cancer Society
AGO	atmospheric gasoil
AHS	U.S. Census Bureau's American Housing Survey
AIRS	Aerometric Information Retrieval System
AML	acute myeloid leukemia
ANPRM	Advanced Notice of Proposed Rulemaking
API	American Petroleum Institute
ASTM	American Society for Testing and Materials
bbl	barrel
BCA	benefit-cost analysis
BenMAP	Environmental Benefits Mapping and Analysis Program
BTU	British Thermal Unit
C-R	concentration response
CAA	Clean Air Act
CAP	Compliance Assurance Program (2000)
CARB	California Air Resources Board
CASAC	Clean Air Science Advisory Committee
CBI	confidential business information
DF	Deterioration Factor
CG	conventional gasoline
CMAQ	Community Multiscale Air Quality model
CML	chronic myeloid leukemia
CO	carbon monoxide
CO_2	carbon dioxide
COI	cost of illness
COPD	chronic obstructive pulmonary disease
cpsi	cells per square inch
CR	concentration-response
CRC	Coordinating Research Council
CRDM	Climatological Regional Dispersion Model
DMC	direct manufacturing costs
DOE	U.S. Department of Energy
E0	ethanol-free gasoline
E10	gasoline containing 10 percent ethanol by volume
E15	gasoline containing 15 percent ethanol by volume
ECA	Emission Control Area
EGR	exhaust gas recirculation
EHC	electrically heated catalyst
EIA	Energy Information Administration
EISA	Energy Independence and Security Act of 2007
EPA or Agency	U.S. Environmental Protection Agency

EPAct	Energy Policy Act of 2005
ERIC	Emissions Reduction and Intercept Control (system)
ESPN	EPA speciation network
EvOH	ethyl vinyl alcohol
FBP	final boiling point
FCC	fluidized catalytic cracker
FTP	Federal Test Procedure
GC/MS	gas chromatography/mass spectrometry
GDI	gasoline direct injection
GDP	gross domestic product
GPA	Geographic Phase-in Area
GVWR	gross vehicle weight rating
HAP	Hazardous Air Pollutant
HAPEM	Hazardous Air Pollutant Exposure Model
HC	hydrocarbon
HCUP	Healthcare Cost and Utilization Program
HDGV	heavy-duty gasoline vehicle
HDV	heavy-duty vehicle
HEGO	heated exhaust gas oxygen (sensor)
HEI	Health Effects Institute
I/M	inspection/maintenance
IBP	initial boiling point
ICI	independent commercial importer
ICM	indirect cost multiplier
IRFA	initial regulatory flexibility analysis
IRIS	Integrated Risk Information System
LCO	light cycle oil
LDT	light-duty truck
LDV	light-duty vehicle
LEV	low emission vehicle
LM	locomotive and marine diesel fuel
LML	lowest measured level
LPG	liquid petroleum gas
MDPV	medium-duty passenger vehicle
MECA	Manufacturers of Emission Controls Association
MLE	maximum likelihood estimate
MRAD	minor restricted activity days
MSAT	mobile source air toxic
MSAT2	Regulations for Control of Hazardous Air Pollutants from Mobile Sources, 72 FR 8428, 2/26/07
MSCF	thousand standard cubic feet
MTBE	methyl tertiary-butyl ether
MY	model year
NAAQS	National Ambient Air Quality Standards
NAC	NO_X adsorption catalyst
NAICS	North American Industrial Classification System
NAPAP	National Acid Precipitation Assessment Program

NATA	National-Scale Air Toxics Assessment
NEMA	Northeast Mid-Atlantic
NESHAP	National Emissions Standards for Hazardous Air Pollutants
NFRAQS	Northern Front Range Air Quality Study
NGL	natural gas liquids
NLEV	national low emission vehicle
NMHC	non-methane hydrocarbons
NMMAPS	National Morbidity, Mortality, and Air Pollution Study
NMOG	non-methane organic gases
NO_2	nitrogen dioxide
NO_X	oxides of nitrogen
NPC	National Petroleum Council
NPRA	National Petrochemical & Refiners Association
NPRM	Notice of Proposed Rulemaking
NRC	National Research Council
NSR	New Source Review
OAQPS	Office of Air Quality Planning and Standards
OAR	EPA's Office of Air and Radiation
OBD	on-board diagnostics
OC/EC	organic carbon/elemental carbon
OMB	Office of Management and Budget
OMS	Office of Mobile Sources
ORNL	Oak Ridge National Laboratory
OSC	oxygen storage components
OSTP	(White House) Office of Science and Technology Policy
OTAG	Ozone Transport Assessment Group
PADD	Petroleum Administrative Districts for Defense
PAN	peroxy acetyl nitrate
PCM	powertrain control module
Pd	palladium
PFI	port fuel injection
PGM	platinum group metals
PM	particulate matter
PNGV	Partnership for a New Generation of Vehicles
POM	polycyclic organic matter
ppm	part per million
PSD	Prevention of Significant Deterioration
Pt	platinum
R+M/2	average octane, or antiknock index
R&D	research and development
REL	reference exposure level
RFA	Regulatory Flexibility Act
RfC	reference concentration
RfD	reference dose
RFG	reformulated gasoline
RFS2	Renewable Fuel Standard Program, 75 FR 14670, 3/26/2010

Rh	rhodium
ROI	return on investment
ROTR	Regional Ozone Transport Rule
RPE	retail price equivalent
RRF	relative reduction factor
RVP	Reid vapor pressure
S-R	Source-Receptor Matrix
S&P DRI	Standard & Poor's Data Research International
SAB	Science Advisory Board
SBA	U.S. Small Business Administration
SBARP or the Panel	Small Business Advocacy Review Panel
SBREFA	Small Business Regulatory Enforcement Fairness Act
SCR	selective catalytic reduction
SER	Small Entity Representative
SFTP	Supplemental Federal Test Procedure
SIC	Standard Industrial Classification
SIGMA	Society of Independent Gasoline Marketers of America
SIP	State Implementation Plan
SMAT	Speciated Modeled Attainment Test
SO_2	sulfur dioxide
SO_X	oxides of sulfur
SRU	sulfur recovery unit
SULEV	super ultra low emission vehicle
SVM	small volume manufacturer (of vehicles)
SVOC	semivolatile organic compound
SwRI	Southwest Research Institute
T10	average temperature at which 10 percent of gasoline is distilled
T50	average temperature at which 50 percent of gasoline is distilled
T90	average temperature at which 90 percent of gasoline is distilled
TC	total technology costs
TGDI	turbocharged gasoline direct injection
THC	total hydrocarbons
TOG	total organic gases
TW	test weight
UAM	Urban Airshed Model
UCL	upper confidence limit
UEGO	universal exhaust gas oxygen (sensor)
ULEV	ultra low emission vehicle
UMRA	Unfunded Mandates Reform Act
UV	ultra violet
VGO	vacuum gasoil
VTB	vacuum tower bottoms
VMT	vehicle miles traveled
VNA	Voronoi Neighbor Averaging
VOC	volatile organic compound
VSL	value of a statistical life

WLD	work loss days
WTP	willingness to pay

Executive Summary

EPA is proposing a comprehensive program to address air pollution from passenger cars and trucks. The proposed program, known as "Tier 3," would establish more stringent vehicle emissions standards and reduce the sulfur content of gasoline, considering the vehicle and its fuel as an integrated system The proposed Tier 3 standards would reduce levels of multiple air pollutants (ambient levels of ozone, particulate matter (PM), nitrogen dioxide (NO_2), and mobile source air toxics (MSATs)) across the country and help state and local agencies in their efforts to attain and maintain health-based National Ambient Air Quality Standards (NAAQS).

This Regulatory Impact Analysis provides technical, economic, and environmental analyses of the proposed new standards. Chapter 1 contains our technical feasibility justification for the proposed vehicle emission standards, and Chapter 2 contains the estimated costs of the proposed vehicle standards. In addition to the vehicle emission and gasoline standards, we are proposing to update the specifications of the emission test fuel with which vehicles demonstrate compliance with emissions standards; our analysis of the proposed emission test fuel parameter changes is found in Chapter 3. Chapters 4 and 5 contain our technical feasibility and cost analyses for the proposed gasoline sulfur standards, respectively. Chapter 6 describes the health and welfare effects associated with the air pollutants that would be impacted by the rule. Chapter 7 describes our analysis of the emission and air quality impacts of the Tier 3 rule. Our estimates of the program-wide costs, the societal benefits, and the cost per ton of emissions reduced due to the proposed Tier 3 program are presented in Chapter 8. Chapter 9 contains our analysis of the proposed rule's economic impacts, and Chapter 10 provides the results of our small business flexibility analysis.

Proposed Tier 3 Standards

Vehicle Emission Standards

The proposed Tier 3 standards include light- and heavy-duty vehicle tailpipe emission standards and evaporative emission standards.

Light-Duty Vehicle, Light-Duty Truck, and Medium-Duty Passenger Vehicle Tailpipe Emission Standards

The proposed standards in this category would apply to all light-duty vehicles (LDVs, or passenger cars), light-duty trucks (LDT1s, LDT2s, LDT3s, and LDT4s) and Medium-Duty Passenger Vehicles, or MDPVs. We are proposing new standards for the sum of NMOG and NO_X emissions, presented as NMOG+NO_X, and for PM. For these pollutants, we are proposing standards as measured on test procedures that represent a range of vehicle operation, including the Federal Test Procedure (or FTP, simulating typical driving) and the Supplemental Federal Test Procedure (or SFTP, a composite test simulating higher temperatures, higher speeds, and quicker accelerations).

The proposed FTP and SFTP NMOG+NO_X standards would be fleet-average standards, meaning that a manufacturer would calculate the weighted average emissions of the vehicles it sells in each model year and compare that average to the applicable standard for that model year. The proposed fleet average standards for NMOG+NO_X evaluated over the FTP would begin in MY 2017 and then decline through MY 2025, as summarized in Table ES-1. Similarly, the proposed NMOG+NO_X standards measured over the SFTP would also be fleet-average standards, declining from MY 2017 until MY 2025, as shown in Table ES-2.

Table ES-1 Proposed LDV, LDT, and MDPV Fleet Average NMOG+NO_X FTP Standards (mg/mi)

	Model Year								
	2017[a]	2018	2019	2020	2021	2022	2023	2024	2025 and later
LDV/LDT1[b]	86	79	72	65	58	51	44	37	30
LDT2,3,4 and MDPV	101	92	83	74	65	56	47	38	30

[a] For vehicles above 6000 lbs GVWR, the fleet average standards would apply beginning in MY 2018

[b] These proposed standards would apply for a 150,000 mile useful life. Manufacturers could choose to certify their LDVs and LDV1s to a useful life of 120,000 miles. If any of these families are certified to the shorter useful life, a proportionally lower numerical fleet-average standard would apply, calculated by multiplying the respective 150,000 mile standard by 0.85 and rounding to the nearest mg.

Table ES-2 Proposed LDV, LDT, and MDPV Fleet-Average NMOG+NO_X SFTP Fleet Average Standards (mg/mi)

	Model Year								
	2017[a]	2018	2019	2020	2021	2022	2023	2024	2025 and later
NMOG + NO_X	103	97	90	83	77	70	63	57	50

[a] For vehicles above 6000 lbs GVWR, the fleet average standards would apply beginning in MY 2018.

The proposed PM standard on the FTP for certification testing is 3 mg/mi for all vehicles and for all model years. Manufacturers could phase in their vehicle models as a percent of sales through MY 2022. The proposed FTP PM standards would apply to each vehicle separately (i.e., not as a fleet average). The proposed program also includes a separate FTP PM requirement of 6 mg/mi for the testing of in-use vehicles that would apply during the percent phase-in period only. Table ES-3 presents the FTP certification and in-use PM standards and the phase-in percentages.

Table ES-3 Phase-In for Proposed PM Standards

	2017[a]	2018	2019	2020	2021	2022 and later
Phase-In (percent of U.S. sales)	20	20	40	70	100	100
Certification Standard (mg/mi)	3	3	3	3	3	3
In-Use Standard (mg/mi)	6	6	6	6	6	3

[a] For vehicles above 6000 lbs GVWR, the proposed FTP PM standards would apply beginning in MY 2018.

The proposed Tier 3 program also includes certification PM standards evaluated over the SFTP (specifically the US06 component of the SFTP procedure) at a level of 10 mg/mi for lighter vehicles and 20 mg/mi for heavier vehicles. As with the FTP PM standard, we propose separate in-use US06 PM standards during the percent phase-in only of 15 and 25 mg/mi for cars and trucks, respectively. The US06 PM standards would also phase in on the same schedule as the FTP PM standards.

Heavy-Duty Tailpipe Emission Standards

We are proposing Tier 3 exhaust emissions standards for complete heavy-duty vehicles (HDVs) between 8,501 and 14,000 lb GVWR. Vehicles in this GVWR range are often referred to as Class 2b (8,501-10,000 lb) and Class 3 (10,001-14,000 lb) vehicles, and are typically full-size pickup trucks and work vans. The key elements of these proposed standards include a combined NMOG+NO_X declining fleet average standard, new stringent PM standards phasing in on a separate schedule, extension of the regulatory useful life to 150,000 miles, and a new requirement to meet standards over the SFTP that would address real-world driving modes not well-represented by the FTP cycle alone. Table ES-4 presents the proposed HDV fleet average NMOG+NO_X standard, which becomes more stringent in successive model years from 2018 to 2022, with voluntary standards available in 2016 and 2017.

The proposed PM standards are 8 mg/mi for Class 2b vehicles and 10 mg/mi for Class 3 vehicles, to be phased in on a percent-of-sales basis at 20-40-70-100 percent in 2018-2019-2020-2021, respectively.

Table ES-4 Proposed HDV Fleet Average NMOG+NO_X Standards (mg/mi)

	Voluntary		Required Program				
Model Year	2016	2017	2018	2019	2020	2021	2022 and later
Class 2b	333	310	278	253	228	203	178
Class 3	548	508	451	400	349	298	247

The proposed new SFTP requirements for HDVs include NMOG+NO_X, carbon monoxide (CO) and PM standards. Compliance would be evaluated from a weighted composite of measured emissions from testing over the FTP cycle, the SC03 cycle, and an aggressive driving cycle, with the latter tailored to various HDV sub-categories: the US06 cycle for most HDVs, the highway portion of the US06 cycle for low power-to-weight Class 2b HDVs, and the LA-92 cycle for Class 3 HDVs.

Evaporative Emission Standards

To control evaporative emissions, EPA is proposing more stringent standards that would require covered vehicles to have essentially zero fuel vapor emissions in use, including more stringent evaporative emissions standards, new test procedures, and a new fuel/evaporative system leak emission standard. The Tier 3 proposal also includes refueling emission standards for a portion of heavy-duty gasoline vehicles (HDGVs) over 10,000 lbs GVWR. EPA is proposing phase-in flexibilities as well as credit and allowance programs. The proposed standards, harmonized with California's zero evaporative emissions standards, are designed to essentially eliminate fuel vapor-related evaporative emissions.

Table ES-5 presents the proposed evaporative hot soak plus diurnal emission standards by vehicle class. Manufacturers may comply on average within each of the four vehicle categories but not across these categories. The proposal also includes separate high altitude emission standards for these vehicle categories.

Table ES-5 Proposed Evaporative Emission Standards (g/test)

Vehicle Category	Highest Diurnal + Hot Soak Level (over both 2-day and 3-day diurnal tests)
LDV, LDT1	0.300
LDT2	0.400
LDT3, LDT4, MDPV	0.500
HDGVs	0.600

EPA is proposing a new testing requirement referred to as the bleed emission test procedure. Under the proposal, manufacturers would be required to measure diurnal emissions over the 2-day diurnal test procedure from just the fuel tank and the evaporative emission canister and comply with a 0.020 g/test standard for all LDVs, LDTs, and MDPVs without averaging. The canister bleed emission standard test would apply only for low altitude testing conditions, but EPA expects proportional control at higher altitudes.

EPA is proposing to include these Tier 3 evaporative emission controls for HDGVs as part of the overall scheme for LDVs and LDTs. The individual vehicle emission standard would be 0.600 g/test for both the 2-day and 3-day evaporative emission tests, the high altitude standard would be 1.75 g/test and the canister bleed test standard would be 0.030 g/test.

We are also proposing to add a new emission standard and test procedure related to controlling vapor leaks from vehicle fuel and vapor control systems. The standard, which would apply to all LDVs, LDTs, MDPVs, and Class 2b/3 HDGVs, would prohibit leaks larger than 0.02 inches of cumulative equivalent diameter in the fuel/evaporative system. The proposed Tier 3 evaporative emission standards program requirements would be phased in over a period of six model years between MYs 2017 and 2022, with the leak test phasing in beginning in 2018 MY as a vehicle is certified to meet Tier 3 evaporative emission requirements.

EPA is proposing new refueling emission control requirements for HDGVs equal to or less than 14,000 lbs GVWR (i.e., Class 2b/3 HDGVs), starting in the 2018 model year. Under this proposal, EPA would extend current refueling emission control requirements for Class 2b HDGVs to Class 3 HDGVs.

We are also proposing to adopt and incorporate by reference the current CARB onboard diagnostic system (OBD) regulations effective for the 2017 MY plus two minor provisions to enable OBD-based leak detection to be used in IUVP testing. EPA would retain the provision that certifying with CARB's program would permit manufacturers to seek a separate EPA certificate on that basis.

Emissions Test Fuel Requirements

We are proposing several changes to our federal gasoline emissions test fuel. Key changes include:

- Moving away from "indolene" (E0) to a test fuel containing 15 percent ethanol by volume (E15);
- Lowering octane to match regular-grade gasoline (except for premium-required vehicles);
- Adjusting distillation temperatures, aromatics and olefins to better match today's in-use fuel and to be consistent with anticipated E15 composition; and
- Lowering the existing sulfur specification and setting a benzene specification to be consistent with proposed Tier 3 gasoline sulfur requirements and recent MSAT2 gasoline benzene requirements.

Gasoline Sulfur Standards

Under the Tier 3 fuel program, we are proposing that federal gasoline contain no more than 10 parts per million (ppm) sulfur on an annual average basis by January 1, 2017. We are proposing an averaging, banking, and trading (ABT) program that would allow refiners and importers to spread out their investments through an early credit program and rely on ongoing nationwide averaging to meet the 10-ppm sulfur standard. We are also proposing a three-year delay for small refiners and "small volume refineries" processing less than or equal to 75,000 barrels of crude oil per day. In addition, we also proposing to either maintain the current 80-ppm refinery gate and 95-ppm downstream per-gallon caps or lower them to 50 and 65 ppm, respectively. A summary of the proposed Tier 3 sulfur standards is provided in Table ES-6.

Table ES-6 Proposed Tier 3 Gasoline Sulfur Standards

Proposed Tier 3 Gasoline Sulfur Standards	Cap Option 1		Cap Option 2	
	Limit	Effective	Limit	Effective
Refinery annual average standard	10 ppm	January 1, 2017[a]	10 ppm	January 1, 2017[a]
Refinery gate per-gallon cap	80 ppm	Already	50 ppm	January 1, 2020
Downstream per-gallon cap	95 ppm	Already	65 ppm	March 1, 2020

[a] Effective January 1, 2020 for eligible small refiners and small volume refineries.

Projected Impacts

Emission and Air Quality Impacts

The proposed Tier 3 vehicle and fuel-related standards would together reduce emissions of NO_X, VOC, $PM_{2.5}$, and air toxics. The gasoline sulfur standards, which would take effect in 2017, would provide large immediate reductions in emissions from existing gasoline vehicles and engines. The emission reductions would increase over time as newer vehicles become a larger percentage of the fleet, e.g., in 2030, when 80 percent of the light-duty fleet (and 90 percent of the vehicle miles travelled) consists of Tier 3 vehicles. Projected emission reductions from the Tier 3 standards for 2017 and 2030 are shown in Table ES-7. We expect these reductions to continue beyond 2030 as more of the fleet continues to turn over to Tier 3 vehicles.

Table ES-7 Estimated Emission Reductions from the Proposed Tier 3 Standards (Annual U.S. short tons)[a]

	2017		2030	
	Tons	Percent of Onroad Inventory	Tons	Percent of Onroad Inventory
NO_X	284,381	8%	524,790	28%
VOC	44,782	3%	226,028	23%
CO	746,683	4%	5,765,362	30%
Direct $PM_{2.5}$	121	0.1%	7,458	10%
Benzene	1,625	4%	8,582	36%
SO_2	16,261	51%	17,267	51%
1,3-Butadiene	322	5%	1,087	37%
Formaldehyde	727	3%	2,707	12%
Acetaldehyde	762	3%	4,414	26%
Acrolein	23	1%	184	15%
Ethanol	2,684	2%	27,821	23%

[a] This analysis assumed emissions reductions from the Tier 3 vehicle standards would occur in all states. For the final rule we will account for LEV III vehicle standards in states that have subsequently adopted it.

Reductions in emissions of NO_X, VOC, $PM_{2.5}$ and air toxics are projected to lead to nationwide decreases in ambient concentrations of ozone, $PM_{2.5}$, NO_2, CO, and air toxics. Specifically, the proposed Tier 3 standards would significantly decrease ozone concentrations across the country, with a population-weighted average decrease of 0.47 ppb in 2017 and 1.55 ppb in 2030. The magnitude of reductions is significant enough to bring ozone levels in some areas from above the standard to below the standard, even without any additional controls. Few other strategies exist that would deliver the reductions needed for states to meet the current ozone standards. The proposed Tier 3 standards would decrease ambient annual $PM_{2.5}$ concentrations across the county as well, with a population-weighted average decrease of 0.06 $\mu g/m^3$ by 2030. Decreases in ambient concentrations of air toxics are also projected with the proposed standards, including notable nationwide reductions in benzene concentrations.

Costs and Benefits

The costs that would be incurred from our proposed program fall into two categories – costs from the Tier 3 vehicle exhaust and evaporative standards and from reductions in sulfur content of gasoline. All costs represent the fleet-weighted average of light-duty vehicles and trucks. All costs are represented in 2010 dollars.

Vehicle Costs

The vehicle costs include the technology costs projected to meet the proposed exhaust and evaporative standards, as show in Table ES-8. The fleet mix of light-duty vehicles, light duty trucks, and medium-duty trucks represents the 2016 MY fleet used in the 2012-2016 MY light-duty GHG final rulemaking.

Table ES-8 Annual Vehicle Technology Costs, 2010$

Year	Vehicle Exhaust Emission Control Costs ($Million)	Vehicle Evaporative Emission Control Costs ($Million)	Facility Costs ($Million)	Total Vehicle Costs ($Million)[a]
2017	$634	$71	$4	$709
2030	$1,790	$253	$4	$2,050

[a] These estimates include costs associated with the proposed Tier 3 vehicle standards in all states except California.

Fuel Costs

The fuel costs consist of the additional operating costs and capital costs to the refiners to meet the proposed sulfur average of 10 ppm. The sulfur control costs assume a cost of 0.89 cents per gallon which includes the refinery operating and capital costs. The annual fuel costs of the proposed program are listed in Table ES-9.

Table ES-9 Annual Fuel Costs, 2010$

Year	Fuel Sulfur Control Costs ($Million)[a]
2017	$1,289
2030	$1,320

[a] These estimates include costs associated with the proposed Tier 3 fuel standards in all states except California.

Total Costs

The sum of the vehicle technology costs to control exhaust and evaporative emissions, in addition to the costs to control the sulfur level in the fuel, represent the total costs of the proposed program, as shown in Table ES-10. The proposed fuel standards are projected to lead to an average cost of 0.89 cents per gallon of gasoline, and the proposed vehicle standards would have an average cost of $134 per vehicle

Table ES-10: Total Annual Vehicle and Fuel Control Costs, 2010$

Year	Total Vehicle and Fuel Control Costs ($Million)[a]
2017	$1,999
2030	$3,367

[a] These estimates include costs associated with the proposed Tier 3 vehicle and fuel standards in all states except California.

Cost Per Ton of Emissions Reduced

We have calculated the aggregate cost per ton of the emissions reduced due to the proposed program using the projected costs and emission reductions. Note that, even though we are setting new standards for PM, we believe that those standards will be met in complying with the NMOG+NO_X standards with additional care being given to proper engineering/calibration, so there is no cost associated with the new PM standard and therefore no separate cost per ton of emissions reduced analysis for PM.

The total program costs, NO_X+VOC reductions, and results of our cost per ton of emissions reduced analysis are provided in Table ES-11. The costs of the proposed program would be higher immediately after it is implemented than they would be after several years, since both vehicle manufacturers and refiners can take advantage of decreasing capital and operating costs over time. In addition, the reductions in NO_X and VOC emissions would become greater as a larger percentage of the fleet contains the technologies required to meet the proposed standards.

Table ES-11 Cost Per Ton of Emissions Reduced in 2017 and 2030

Year	Total Proposed Program Cost ($million, 2010$)	Total NO_X + VOC Reductions (tons)	Cost Per Ton of Emissions Reduced ($/ton)
2017	$1,999	329,162	$6,072
2030	$3,367	750,818	$4,484

Benefits

Exposure to ambient concentrations of ozone, $PM_{2.5}$, and air toxics is linked to adverse human health impacts such as premature deaths as well as other important public health and environmental effects. The proposed Tier 3 standards would reduce these adverse impacts and yield significant benefits, including those we can monetize and those we are unable to quantify.

The range of quantified and monetized benefits associated with this program are estimated based on the risk of several sources of PM- and ozone-related mortality effect estimates, along with other PM and ozone non-mortality related benefits information. Overall, we estimate that the proposed rule would lead to a net decrease in $PM_{2.5}$- and ozone-related health and environmental impacts. The range of total monetized ozone- and PM-related health impacts is presented in Table ES-12.

Table ES-12: Estimated 2030 Monetized PM-and Ozone-Related Health Benefits[a]

Description	2030
Total Estimated Health Benefits[b,c,d,e,f]	
3 percent discount rate	$8.0 - $23
7 percent discount rate	$7.4 - $21

Notes:

[a] Totals are rounded to two significant digits and may not sum due to rounding.

[b] The benefits presented in this table have been adjusted to remove emission reductions attributed to the Tier 3 program in California. We will account for emissions in states that have adopted California's LEV III program in the baseline air quality modeling for the final rule.

[c] Total includes ozone and PM2.5 benefits. Range was developed by adding the estimate from the Bell et al., 2004 ozone premature mortality function to $PM_{2.5}$-related premature mortality derived from the American Cancer Society cohort study (Pope et al., 2002) for the low estimate and ozone premature mortality derived from the Levy et al., 2005 study to $PM_{2.5}$-related premature mortality derived from the Six-Cities (Laden et al., 2006) study for the high estimate.

[d] Annual benefits analysis results reflect the use of a 3 percent and 7 percent discount rate in the valuation of premature mortality and nonfatal myocardial infarctions, consistent with EPA and OMB guidelines for preparing economic analyses.

[e] Valuation of premature mortality based on long-term PM exposure assumes discounting over the SAB recommended 20-year segmented lag structure described in the Regulatory Impact Analysis for the 2006 PM National Ambient Air Quality Standards (September, 2006).

[f] Not all possible benefits are quantified and monetized in this analysis; the total monetized benefits presented here may therefore be underestimated.

We estimate that by 2030, the annual emission reductions of the Tier 3 standards would annually prevent between 670 and 1,700 PM-related premature deaths, between 160 and 710 ozone-related premature deaths, 81,000 work days lost, and approximately 1.4 million minor restricted-activity days. The estimated annual monetized health benefits of the proposed Tier 3 standards in 2030 (2010$) would be between $8.0 and $23 billion, assuming a 3-percent discount rate (or between $7.4 billion and $21 billion assuming a 7-percent discount rate).

Note that the air quality modeling conducted for the Tier 3 program included emission reductions both in California (which was recently granted a waiver for the adoption of its LEV III program) and in several other states that have adopted the LEV III program under Section 177 of the Clean Air Act. As a result, the benefits cited here have been adjusted to remove emission reductions attributed to the Tier 3 program in California. We will account for emissions in states that have adopted California's LEV III program in the baseline air quality modeling for the final rule. Refer to Chapter 8 for more information about the benefits estimated for the proposal.

Comparison of Costs and Benefits

The estimated annual monetized health benefits of the proposed Tier 3 standards in 2030 (2010$) would be between $8.0 and $23 billion, assuming a 3 percent discount rate (or between $7.4 billion and $21 billion assuming a 7 percent discount rate). The annual benefits of the Tier 3 standards outweigh the annual cost of the overall program in 2030, which would be approximately $3.4 billion.

Economic Impact Analysis

The proposed rule will affect two sectors directly: vehicle manufacturing and petroleum refining. The estimated increase in vehicle production cost because of the proposed rule is expected to be small relative to the costs of the vehicle. Some or all of this production cost increase would be expected to be passed through to consumers. This increase in price is expected to lower the quantity of vehicles sold, though because the expected cost increase is small, we expect the decrease in sales to be negligible. This decrease in vehicle sales is expected to decrease employment in the vehicle manufacturing sector. However, costs related to compliance with the rule should also increase employment in this sector. While it is unclear which of these effects will be larger, because the increase in vehicle production costs and the decrease in vehicle sales are minor, the impact of the rule on employment in the vehicle manufacturing sector is expected to be small as well. The key change for refiners from the proposed standards would be more stringent sulfur requirements. Analogous to vehicle sales, this change to fuels is expected to increase manufacturers' costs of fuel production. Some or all of this increase in production costs is expected to be passed through to consumers which should lead to a decrease in fuel sales. As with the vehicle manufacturing sector, we would expect the decrease in fuel sales to negatively affect employment in this sector, while the costs of compliance with the rule would be expected to increase employment. It is not evident whether the proposed rule would increase or decrease employment in the refining sector as a whole. However, given the small anticipated increase in production costs of less than one cent per gallon and the small likely decrease in fuel sales, we expect that the rule would not have major employment consequences for this sector.

Chapter 9 Economic Impact Analysis

9.1 Introduction

The proposed rule will affect two sectors directly: vehicle manufacturing and petroleum refining. For these two regulated sectors, the economic impact analysis discusses the market impacts from the proposed rule, the changes in price and quantity sold. In addition, although analysis of employment impacts is not part of a benefit-cost analysis (except to the extent that labor costs contribute to costs), employment impacts of federal rules are of particular concern in the current economic climate of sizeable unemployment. The recently issued Executive Order 13563, "Improving Regulation and Regulatory Review" (January 18, 2011), states, "Our regulatory system must protect public health, welfare, safety, and our environment while promoting economic growth, innovation, competitiveness, and job creation" (emphasis added). For this reason, we are examining the effects of this proposal on employment in the regulated sectors.

9.2 Impacts on Vehicle Manufacturing Sector

9.2.1 Vehicle Sales Impacts

This rule takes effect from MY 2017-2025. In the intervening years, it is possible that the assumptions underlying a quantitative analysis, as well as market conditions, might change. For this reason, we present a qualitative discussion of the effects on vehicle sales of the proposed standards at the aggregate market level. Light-duty vehicle manufacturers are expected to comply with the proposed standards primarily through technological changes to vehicles. These changes to vehicle design and manufacturing are expected to increase manufacturers' costs of vehicle production. The calculation is performed for an average car, an average truck and an average Class 2b/3 vehicle rather than for individual vehicles. The analysis conducted for this rule does not have the precision to examine effects on individual manufacturers or different vehicle classes.

Section VII.A estimates the increase in vehicle costs due to the proposed standards. These costs differ across years and range from $71 to $102 for cars, $93 to $150 for trucks and $36 to $59 for Class 2b/3 vehicles (see Section VII.A). These costs are small relative to the cost of a vehicle. In a fully competitive industry, these costs would be entirely passed through to consumers. However in an oligopolistic industry such as the automotive sector, these increases in cost may not fully pass through to the purchase price, and the consumers may face an increase in price that is less than the increased manufacturers' costs of vehicle production.[A] We do not quantify the expected level of cost pass-through or the ultimate vehicle price increase consumers

[A] See, for instance, Gron, Ann, and Deborah Swenson, 2000. "Cost Pass-Through in the U.S. Automobile Market," Review of Economics and Statistics 82: 316-324 (Docket EPA-HQ-OAR-2011-0135), who found significantly less than full-cost pass-through using data from 1984-1994. Using full-cost pass-through overstates costs and thus contributes to lower vehicle sales than using a lower estimate. To the extent that the auto industry has become more competitive over time, full-cost pass-through may be more appropriate than a result based on this older study.

are expected to face, apart from noting that prices are expected to increase by an amount up to the increased manufacturers' costs.

This increase in price is expected to lower the quantity of vehicles sold. Given that we expect that vehicle prices will not change by more than the cost increase, we expect that the decrease in vehicle sales will be negligible.

The effect of this rule on the use and scrappage of older vehicles will be related to its effects on new vehicle prices and the total sales of new vehicles. The increase in price is likely to cause the turnover of the vehicle fleet (i.e., the retirement of used vehicles and their replacement by new models) to slow slightly, thus reducing the anticipated effect of the rule on fleet-wide emissions. Because we do not estimate the effect of the rule on new vehicle price changes nor do we have a good estimate of the effect of new vehicle price changes on vehicle turnover, we have not attempted to estimate explicitly the effects of the rule on scrappage of older vehicles and the turnover of the vehicle fleet.

9.2.2 Employment Impacts in the Auto Sector

This chapter describes changes in employment in the auto sector due to this rule. As with the refinery sector, discussed below, we focus on the auto manufacturing sector because it is directly regulated, and because it is likely to bear a substantial share of changes in employment due to this rule. We include discussion of effects on the parts manufacturing sector, because the auto manufacturing sector can either produce parts internally or buy them from an external supplier, and we do not have estimates of the likely breakdown of effort between the two sectors.

When the economy is at full employment, an environmental regulation is unlikely to have much impact on net overall U.S. employment; instead, labor would primarily be shifted from one sector to another. These shifts in employment impose an opportunity cost on society, approximated by the wages of the employees, as regulation diverts workers from other activities in the economy. In this situation, any effects on net employment are likely to be transitory as workers change jobs (e.g., some workers may need to be retrained or require time to search for new jobs, while shortages in some sectors or regions could bid up wages to attract workers).

On the other hand, if a regulation comes into effect during a period of high unemployment, a change in labor demand due to regulation may affect net overall U.S. employment because the labor market is not in equilibrium. Schmalansee and Stavins point out that net positive employment effects are possible in the near term when the economy is at less than full employment due to the potential hiring of idle labor resources by the regulated sector to meet new requirements (e.g., to install new equipment) and new economic activity in sectors related to the regulated sector.[1] In the longer run, the net effect on employment is more difficult to predict and will depend on the way in which the related industries respond to the regulatory requirements. As Schmalansee and Stavins note, it is possible that the magnitude of the effect on employment could vary over time, region, and sector, and positive effects on employment in some regions or sectors could be offset by negative effects in other regions or sectors. For this reason, they urge caution in reporting partial employment effects since it can "paint an inaccurate picture of net employment impacts if not placed in the broader economic context."

We follow the theoretical structure proposed in a study by Morgenstern, Pizer, and Shih[2] of the impacts of regulation in employment in the regulated sectors. In particular, Morgenstern et al. identify three separate ways that employment levels may change in the regulated industry in response to a new or more stringent regulation.

- Demand effect: higher production costs due to the regulation will lead to higher market prices; higher prices in turn reduce demand for the good, reducing the demand for labor to make that good. In the authors' words, the "extent of this effect depends on the cost increase passed on to consumers as well as the demand elasticity of industry output."

- Cost effect: as costs go up, plants add more capital and labor (holding other factors constant), with potentially positive effects on employment; in the authors' words, as "production costs rise, more inputs, including labor, are used to produce the same amount of output."

- Factor-shift effect: post-regulation production technologies may be more or less labor-intensive (i.e., more/less labor is required per dollar of output). In the authors' words, "environmental activities may be more labor intensive than conventional production," meaning that "the amount of labor per dollar of output will rise," though it is also possible that "cleaner operations could involve automation and less employment, for example."

The authors note that the demand effect is expected to have a negative effect on employment, the cost effect to have a positive effect on employment, and the factor-shift effect to have an ambiguous effect on employment. Without more information with respect to the magnitudes of these competing effects, it is not possible to predict the total effect environmental regulation will have on employment levels in a regulated sector.

Morgenstern et al. estimated the effects on employment of spending on pollution abatement for four highly polluting/regulated industries (pulp and paper, plastics, steel, and petroleum refining) using data for six years between 1979 and 1991. They conclude that increased abatement expenditures generally have not caused a significant change in employment in those sectors. More specifically, their results show that, on average across the industries studied, each additional $1 million (1987$) spent on pollution abatement results in a (statistically insignificant) net increase of 1.5 jobs. In the petroleum refining industry in particular, they found statistically significant and positive cost and factor shift effects and an insignificant demand effect, for a net (statistically significant) increase of 2.17 jobs per $1 million (1987$).

Following the Morgenstern et al. framework for the impacts of regulation on employment in the regulated sector, we consider three effects for the auto sector: the demand effect, the cost effect, and the factor shift effect.

9.2.2.1 The Demand Effect

The demand effect depends on the effects of this proposal on vehicle sales. If vehicle sales decrease, employment associated with these activities will decrease. As discussed in

Chapter 9.2.1, we do not make a quantitative estimate on the effect of the proposed rule on vehicle sales, but we note that the decrease in vehicle sales is expected to be negligible. Thus we expect any decrease in employment in the auto sector through the demand effect to be small as well.

9.2.2.2 The Cost Effect

The demand effect, above, measures the effect due to new vehicle sales only. The cost effect measures the impacts due to the changes in technologies for vehicles that would have been sold in the absence of the rule.

One way to estimate the cost effect, given the cost estimates for complying with the rule, is to use the ratio of workers to each $1 million of expenditures in that sector. The use of these ratios has both advantages and limitations. It is often possible to estimate these ratios for quite specific sectors of the economy: for instance, it is possible to estimate the average number of workers in the light-duty vehicle manufacturing sector per $1 million spent in the sector, rather than use the ratio from another, more aggregated sector, such as motor vehicle manufacturing. As a result, it is not necessary to extrapolate employment ratios from possibly unrelated sectors. On the other hand, these estimates are averages for the sectors, covering all the activities in those sectors; they may not be representative of the labor required when expenditures are required on specific activities, as the factor-shift effect indicates. For instance, the ratio for the motor vehicle manufacturing sector represents the ratio for all vehicle manufacturing, not just for emissions reductions. In addition, these estimates do not include changes in sectors that supply these sectors, such as steel or electronics producers. They thus may best be viewed as the effects on employment in the auto sector due to the changes in expenditures in that sector, rather than as an assessment of all employment changes due to these changes in expenditures.

Some of the costs of this proposal will be spent directly in the auto manufacturing sector, but it is also likely that some of the costs will be spent in the auto parts manufacturing sector. We separately present the ratios for both the auto manufacturing sector and the auto parts manufacturing sector.

There are several public sources for estimates of employment per $1 million expenditures. The U.S. Bureau of Labor Statistics (BLS) provides its Employment Requirements Matrix (ERM),[3] which provides direct estimates of the employment per $1 million in sales of goods in 202 sectors. The values considered here are for Motor Vehicle Manufacturing (NAICS 3361) and Motor Vehicle Parts Manufacturing (NAICS 3363).

The Census Bureau provides both the Annual Survey of Manufacturers[4] (ASM) and the Economic Census. The ASM is a subset of the Economic Census, based on a sample of establishments; though the Census itself is more complete, it is conducted only every 5 years, while the ASM is annual. Both include more sectoral detail than the BLS ERM: for instance, while the ERM includes the Motor Vehicle Manufacturing sector, the ASM and Economic Census have detail at the 6-digit NAICS code level (e.g., light truck and utility vehicle manufacturing). While the ERM provides direct estimates of employees/$1 million in expenditures, the ASM and Economic Census separately provide number of employees and value of shipments; the direct employment estimates here are the ratio of those values. The values reported are for Motor Vehicle Manufacturing (NAICS 3361), Automobile and Light Duty Motor Vehicle Manufacturing (NAICS 33611), and Motor Vehicle Parts Manufacturing (NAICS 3363).

The values used here are adjusted to remove the employment effects of imports through use of a ratio of domestic production to domestic sales of 0.667.[B]

Table 9-1 provides the values, either given (BLS) or calculated (ASM, Economic Census) for employment per $1 million of expenditures, all based on 2010 dollars, though the underlying data come from different years (which may account for some of the differences). The different data sources provide similar magnitudes for the estimates for the sectors. Parts manufacturing appears to be more labor-intensive than vehicle manufacturing; light-duty vehicle manufacturing appears to be slightly less labor-intensive than motor vehicle manufacturing as a whole.

Table 9-1 Employment per $1 Million Expenditures (2010$) in the Motor Vehicle Manufacturing Sector[a]

Source	Sector	Ratio of workers per $1 million expenditures	Ratio of workers per $1 million expenditures, adjusted for domestic vs. foreign production
BLS ERM	Motor Vehicle Mfg	0.770	0.514
ASM	Motor Vehicle Mfg	0.655	0.437
ASM	Light Duty Vehicle Mfg	0.609	0.406
Economic Census	Motor Vehicle Mfg	0.665	0.443
Economic Census	Light Duty Vehicle Mfg	0.602	0.402
BLS ERM	Motor Vehicle Parts Mfg	2.614	1.743
ASM	Motor Vehicle Parts Mfg	2.309	1.540
Economic Census	Motor Vehicle Parts Mfg	2.712	1.809

Note:
[a] BLS ERM refers to the U.S. Bureau of Labor Statistics' Employment Requirement Matrix. ASM refers to the U.S. Census Bureau's Annual Survey of Manufactures. Economic Census refers to the U.S. Census Bureau's Economic Census.

Over time, the amount of labor needed in the auto industry has changed: automation and improved methods have led to significant productivity increases. The BLS ERM, for instance, provided estimates that, in 1993, 1.64 workers in the Motor Vehicle Manufacturing sector were needed per $1 million of 2005$, but only 0.86 workers by 2010 (in 2005$).[5] Because the ERM is available annually for 1993-2010, we used these data to estimate productivity improvements over time. We regressed logged ERM values on year for both the Motor Vehicle Manufacturing and Motor Vehicle Parts Manufacturing sectors. We used this approach because the coefficient

[B] To estimate the proportion of domestic production affected by the change in sales, we use data from Ward's Automotive Group for total car and truck production in the U.S. compared to total car and truck sales in the U.S. For the period 2001-2010, the proportion is 66.7 percent.

describing the relationship between time and productivity is a direct measure of the percent change in productivity per year. The results suggest a 3.9 percent per year productivity improvement in the Motor Vehicle Manufacturing Sector, and a 3.8 percent per year improvement in the Motor Vehicle Parts Manufacturing Sector. We then used the equation resulting from the regression to project the ERM through 2025. In the results presented below, these projected values (adjusted to 2010$) were used directly for the BLS ERM estimates. For the ASM, we used the ratio of the projected value in each future year to the projected value in 2010 (the base year for the ASM) to determine how many workers will be needed per $1 million of 2010$; for the Economic Census estimates, we used the ratio of the projected value in the future years to the projected value in 2007 (the base year for that estimate).

Section 2.1 of the draft RIA discusses the vehicle cost estimates developed for this rule. The maximum value for employment impacts per $1 million (before adjustments for changes in productivity, after accounting for the share of domestic production) is 1.809 in 2010 if all the additional costs are in the parts sector; the minimum value is 0.402 in 2010, if all the additional costs are in the light-duty vehicle manufacturing sector. Increased costs of vehicles and parts would, by itself, be expected to increase employment between 2017 and 2025 by somewhere between a few hundred to a few thousand jobs.

While we estimate employment impacts, measured in job-years, beginning with program implementation, some of these employment gains may occur earlier as auto manufacturers and parts suppliers hire staff in anticipation of compliance with the standard. A job-year is a way to calculate the amount of work needed to complete a specific task. For example, a job-year is one year of work for one person.

Table 9-2 Employment Effects due to Increased Costs of Vehicles and Parts, in job-years

Year	Costs (Millions of 2010$)	Maximum Employment Due to Cost Effect (if all expenditures are in the Parts Sector)	Minimum Employment Due to Cost Effect (if all expenditures are in the Light Duty Vehicle Mfg Sector)
2016	$ 23	0	0
2017	$ 709	900	200
2018	$ 1,340	1,700	400
2019	$ 1,440	1,800	400
2020	$ 1,600	1,900	400
2021	$ 1,730	2,000	400
2022	$ 1,900	2,100	400
2023	$ 1,920	2,000	400
2024	$ 2,040	2,100	400
2025	$ 2,130	2,100	400

9.2.2.3 The Factor Shift Effect

The factor shift effect looks at the changes in labor intensity associated with a regulation. As noted above, the estimates of the cost effect assume constant labor per $1 million in expenditures, though the new technologies may be either more or less labor-intensive than the existing ones. We have no evidence on the factor shift effect for the compliance technologies and therefore do not quantify it. An estimate of the factor shift effect would either increase or decrease the estimate used for the cost effect.

9.2.2.4 Summary of Employment Effects in the Auto Sector

The overall effect of the proposed rule on auto sector employment depends on the relative magnitude of the cost effect, the demand effect and the factor shift effect. Because we do not have quantitative estimates of the demand and factor shift effects we cannot reach a quantitative estimate of the overall employment effects of the proposed rule on auto sector employment or even whether the total effect would be positive or negative. However, given that the expected increase in production costs to the auto manufacturers is relatively small, we expect that the magnitudes of all these effects will be small as well. Additionally, the cost and demand effects are expected to work in opposite directions. Thus while we do not have an estimate of the direction of the overall effect of the proposed rule on auto sector employment, we expect it will be imperceptible.

The proposed rule is not expected to provide incentives for manufacturers to shift employment between domestic and foreign production. This is because the proposed standards would apply to vehicles sold in the U.S. regardless of where they are produced. If foreign manufacturers already have increased expertise in satisfying the requirements of the proposal, there may be some initial incentive for foreign production, but the opportunity for the U.S. to sell in other markets might increase. To the extent that the requirements of this proposal might lead to installation and use of technologies that other countries may seek now or in the future, developing this capacity for domestic production now may provide some additional ability to serve those markets. This potential benefit would not apply if other countries are not likely to have similar standards.

9.3 Impacts on Petroleum Refinery Sector

9.3.1 Refinery Sales Impacts

The key change for refiners from the proposed standards would be more stringent sulfur requirements. This change to fuels is expected to increase manufacturers' costs of gasoline production by about 0.9 cents per gallon (see Section VII.B of the Preamble).

In a perfectly competitive industry, this cost would be passed along completely to consumers. In an imperfectly competitive industry, as noted above, full cost pass-through is not necessary: firms may choose to reduce impacts on sales by not passing along full costs. In 2004, the Federal Trade Commission reported that "concentration for most levels of the petroleum industry has remained low to moderate."[6] Thus the assumption of competitive markets has some foundation in this industry. We do not estimate the price increase that consumers are likely to face, though we note that it should be positive and up to the increase in manufacturers' costs of gasoline production.

The effect of higher gasoline prices on gasoline sales is expected to be different over the short and long term. In the long run, in response to the increase in fuel costs, consumers can more easily change their driving habits, including where they live or what vehicles they use. Because of this, we expect that gasoline sales will decrease more in the long run compared to the short run as a result of the price increase due to the proposed rule. However, because manufacturers' costs are expected to increase less than one cent per gallon, we expect that the decrease in gasoline sales will be negligible over all time horizons.

9.3.2 Refinery Employment Impacts

The Morgenstern et al. framework of demand effects, cost effects and factor shift effects can also be applied to the impact of the proposed rule on employment in the refinery sector. [7] Here we use a fully qualitative approach. A qualitative discussion allows for a wider incorporation of additional considerations, such as timing of impacts and the effects of the rule on imports and exports. Because the discussion is qualitative, we do not sum the net effects on employment. The demand effect on refining sector employment is expected to be negative. The discussion in Chapter 9.3.1 above suggested that the proposed rule would cause a small decrease in the quantity of gasoline demanded due to higher production costs being passed through to consumers. This slightly reduced level of sales would likely have a negative impact on employment in the refining sector. This effect will persist as long as the increase in price is in place. The higher long-run elasticity suggests that sales would be lower in the long run than in the short run, leading to a greater reduction in employment due to the demand effect over time. While we do not quantify the level of job losses that could be expected here, recall that the quantity of gasoline sold as a result of the standards proposed here is expected to decrease by only a very small amount over any time horizon.

The cost effect of the proposed rule on employment in the refining sector is expected to be positive as usual in the Morgenstern et al. framework. In order to satisfy the requirements of the proposed rule, firms in the refining industry are expected to need to perform additional work that will require hiring more employees. This effect may be larger in the short run, when initial investments for compliance need to be made; over time, the increase in employment due to these investments may be reduced. Section V.A.2.c of the Preamble discusses the expected employment needed to reduce the sulfur content of fuels; as noted there, to meet the proposed Tier 3 sulfur standards, refiners are expected to invest $2.2 billion between 2014 and 2019 and utilize approximately 1,000 front-end design and engineering jobs and 6,000 construction jobs. As the petroleum sector employed approximately 65,000 workers in 2009, this increase in employment would be comparable to an increase of over 10 percent when compared to 2009 levels.

As with our analysis of the vehicle manufacturing sector, we do not have information on the direction the factor shift effect might take. It is unclear whether the refining industry would become more or less capital intensive as a result of the proposed rule. Thus the direction of the factor shift effect is ambiguous.

This rule is not expected to provide incentives to shift employment between domestic and foreign production. First, the proposed standards would apply to gasoline sold in the U.S. regardless of where it has been produced. U.S. gasoline demand is projected to continue to decline for the foreseeable future in response to higher gasoline prices, more stringent vehicle and engine greenhouse gas and fuel economy standards as well as increased use of renewable fuels. As a result, this analysis of incentives to shift employment between domestic and foreign production focuses on investments for existing capacity instead of expanding capacity.[C] In this case, what is relevant is whether the necessary modifications to comply with Tier 3 would be significantly cheaper overseas than in the U.S.

The main impacts on capital and operating costs to comply with Tier 3 associated with adding hydrotreating capacity are likely to be similar overseas as in the U.S. This is particularly true when analyzing likely sources of U.S. imports. The majority of gasoline imported to the U.S. today comes into the East Coast and is sourced out of either Europe or refineries in Canada or the Caribbean that exist almost solely to supply the U.S. market.

These Canadian and Caribbean refineries, by virtue of their focus on the U.S. market, are very similar to U.S. based refineries and would be expected to have to incur similar capital and operating costs as their U.S. based competitors meeting the 10-ppm standard. Furthermore, the European refineries are already producing gasoline to a 10-ppm sulfur cap for Europe. To the extent they have refinery streams that are more difficult to hydrotreat, the U.S. market currently serves as an outlet for their higher sulfur gasoline streams. As a result, they may incur capital and operating costs on a per gallon basis at least as high as for their U.S. based competitors for these remaining higher sulfur gasoline streams. Alternatively, they may instead choose to find markets outside the U.S., opening the way for increased U.S. based refinery demand.

Finally, despite refining industry projections that previously imposed diesel rules would lead to greater U.S. reliance on imports through major negative impacts on domestic refining, the reverse has actually occurred. Over the last 8 years, imports of gasoline and diesel fuel have continued to be the marginal supply, and have even dropped precipitously so that the U.S. is now a net exporter of diesel fuel and is importing half the gasoline that it did at its peak in 2006. With the projected decline in future gasoline demand in the U.S. as vehicle fuel efficiency improves, gasoline imports are expected to continue to decline.

Thus it is expected that for the refining sector, the demand effect would lower employment, the cost effect would raise employment, and the factor shift effect would have an ambiguous effect on employment. As a whole then, it is not evident whether the proposed rule would increase or decrease employment in the refining sector. However, given the small anticipated reduction in quantity sold, it appears that the rule would not have major employment consequences for this sector.

The petroleum industry is one of the four industries studied by Morgenstern et al. (2002) when they looked at the effect of environmental expenditures on employment. They found a small but statistically significant increase in employment in this sector (2.17 jobs per million dollars of expenditures, using 1987$). Using this factor (adjusted to 2010$), the estimated sulfur fuel control costs in 2017 of $1,289 million would imply an increase of approximately 1,600 jobs in the refinery sector. We note that the regulations that this estimate is derived from are not

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[C] While refinery capacity has been increasing around the world in recent years, it has been designed primarily to supply foreign markets other than the U.S. (e.g., increasing demand in China and India).

directly comparable to the current proposed rule; it is based on the costs of reductions in refinery emissions instead of changing fuel properties, and therefore may not be applicable for the standards proposed here.

Section VII.B.5 of the Preamble contains some historical discussion regarding the impact on refineries and refining capacity of earlier rules which resulted in higher costs for refiners. Over the period 2003-2011, when a number of rules were being implemented, EIA data show a net of two net refinery closures on its website. Meanwhile, over this same period the average size of U.S. refineries increased from 113,000 barrels per day to 123,000 barrels per day, and total U.S. refining capacity increased by six percent. Thus, historically during a time when rules with much larger expected impacts were being implemented (the 2003 ultra-low sulfur nonroad diesel proposal alone was expected to have a cost impact on refineries more than five times greater than the current proposed rule), U.S. refining capacity increased even as the number of U.S. refineries slightly fell. While closing refineries has a negative effect on industry employment, it is likely that the increased refining capacity at many of the remaining plants had a positive effect on industry employment.

The proposed rule is also likely to have a positive impact on employment among producers of equipment that refiners will use to comply with the standards. Chapter 5 notes that some refiners are expected to need to revamp their current treatment units and others will need to add additional treatment units. Producers of this equipment would be expected to hire additional labor to meet this increased demand. We also note that the employment effects may be different in the immediate implementation phase than in the ongoing compliance phase. It is expected that the employment increases through the cost effect from revamping old equipment and installing additional equipment should occur in the near term, when current unemployment levels are high, and the opportunity cost of workers is relatively low. Meanwhile, the employment decreases in the refining sector from the demand effect would not start until 2017, when compliance would be required, and when unemployment is expected to be reduced; in a time of full employment, any changes in employment levels in the regulated sector are mostly expected to be offset by changes in employment in other sectors.

References

[1] Schmalensee, Richard, and Robert N. Stavins. "A Guide to Economic and Policy Analysis of EPA's Transport Rule." White paper commissioned by Excelon Corporation, March 2011.

[2]Morgenstern, Richard D., William A. Pizer, and Jhih-Shyang Shih. "Jobs Versus the Environment: An Industry-Level Perspective." Journal of Environmental Economics and Management 43 (2002): 412-436.

[3] http://www.bls.gov/emp/ep_data_emp_requirements.htm

[4] http://www.census.gov/manufacturing/asm/index.html

[5] http://www.bls.gov/emp/ep_data_emp_requirements.htm; this analysis used data for sectors 88 (Motor Vehicle Manufacturing) and 90 (Motor Vehicle Parts Manufacturing) from "Chain-weighted (2000 dollars) real domestic employment requirements table. . . adjusted to remove imports."

[6] Federal Trade Commission, Bureau of Economics. "The Petroleum Industry: Mergers, Structural Change, and Antitrust Enforcement." http://www.ftc.gov/os/2004/08/040813mergersinpetrolberpt.pdf , accessed 8/16/11.

[7] Morgenstern, Richard D., William A. Pizer, and Jhih-Shyang Shih. "Jobs Versus the Environment: An Industry-Level Perspective." Journal of Environmental Economics and Management 43 (2002): 412-436.

EXHIBIT 17

Control of Air Pollution from Motor Vehicles: Tier 3 Motor Vehicle Emission and Fuel Standards Final Rule

Regulatory Impact Analysis

United States
Environmental Protection
Agency

Control of Air Pollution from Motor Vehicles: Tier 3 Motor Vehicle Emission and Fuel Standards Final Rule

Regulatory Impact Analysis

Assessment and Standards Division
Office of Transportation and Air Quality
U.S. Environmental Protection Agency

EPA United States Environmental Protection Agency

EPA-420-R-14-005
March 2014

List of Acronyms

A/F	air/fuel ratio
AAM	Alliance of Automobile Manufacturers
ABT	averaging, banking, and trading
ACS	American Cancer Society
AGO	atmospheric gasoil
AHS	U.S. Census Bureau's American Housing Survey
AIRS	Aerometric Information Retrieval System
AML	acute myeloid leukemia
ANPRM	Advanced Notice of Proposed Rulemaking
API	American Petroleum Institute
ASTM	American Society for Testing and Materials
bbl	barrel
BCA	benefit-cost analysis
BenMAP	Environmental Benefits Mapping and Analysis Program
BTU	British Thermal Unit
C-R	concentration response
CAA	Clean Air Act
CAP	Compliance Assurance Program (2000)
CARB	California Air Resources Board
CASAC	Clean Air Science Advisory Committee
CBI	confidential business information
DF	Deterioration Factor
CG	conventional gasoline
CMAQ	Community Multiscale Air Quality model
CML	chronic myeloid leukemia
CO	carbon monoxide
CO_2	carbon dioxide
COI	cost of illness
COPD	chronic obstructive pulmonary disease
cpsi	cells per square inch
CR	concentration-response
CRC	Coordinating Research Council
CRDM	Climatological Regional Dispersion Model
DMC	direct manufacturing costs
DOE	U.S. Department of Energy
E0	ethanol-free gasoline
E10	gasoline containing 10 percent ethanol by volume
E15	gasoline containing 15 percent ethanol by volume
ECA	Emission Control Area
EGR	exhaust gas recirculation
EHC	electrically heated catalyst
EIA	Energy Information Administration
EISA	Energy Independence and Security Act of 2007
EPA or Agency	U.S. Environmental Protection Agency

EPAct	Energy Policy Act of 2005
ERIC	Emissions Reduction and Intercept Control (system)
ESPN	EPA speciation network
EvOH	ethyl vinyl alcohol
FBP	final boiling point
FCC	fluidized catalytic cracker
FTP	Federal Test Procedure
GC/MS	gas chromatography/mass spectrometry
GDI	gasoline direct injection
GDP	gross domestic product
GPA	Geographic Phase-in Area
GVWR	gross vehicle weight rating
HAP	Hazardous Air Pollutant
HAPEM	Hazardous Air Pollutant Exposure Model
HC	hydrocarbon
HCUP	Healthcare Cost and Utilization Program
HDGV	heavy-duty gasoline vehicle
HDV	heavy-duty vehicle
HEGO	heated exhaust gas oxygen (sensor)
HEI	Health Effects Institute
I/M	inspection/maintenance
IBP	initial boiling point
ICI	independent commercial importer
ICM	indirect cost multiplier
IRFA	Initial Regulatory Flexibility Analysis
IRIS	Integrated Risk Information System
LCO	light cycle oil
LDT	light-duty truck
LDV	light-duty vehicle
LEV	low emission vehicle
LM	locomotive and marine diesel fuel
LML	lowest measured level
LPG	liquid petroleum gas
MDPV	medium-duty passenger vehicle
MECA	Manufacturers of Emission Controls Association
MLE	maximum likelihood estimate
MRAD	minor restricted activity days
MSAT	mobile source air toxic
MSAT2	Regulations for Control of Hazardous Air Pollutants from Mobile Sources, 72 FR 8428, 2/26/07
MSCF	thousand standard cubic feet
MTBE	methyl tertiary-butyl ether
MY	model year
NAAQS	National Ambient Air Quality Standards
NAC	NO_X adsorption catalyst
NAICS	North American Industrial Classification System
NAPAP	National Acid Precipitation Assessment Program

NATA	National-Scale Air Toxics Assessment
NEMA	Northeast Mid-Atlantic
NESHAP	National Emissions Standards for Hazardous Air Pollutants
NFRAQS	Northern Front Range Air Quality Study
NGL	natural gas liquids
NLEV	national low emission vehicle
NMHC	non-methane hydrocarbons
NMMAPS	National Morbidity, Mortality, and Air Pollution Study
NMOG	non-methane organic gases
NO_2	nitrogen dioxide
NO_X	oxides of nitrogen
NPC	National Petroleum Council
NPRA	National Petrochemical & Refiners Association
NPRM	Notice of Proposed Rulemaking
NRC	National Research Council
NSR	New Source Review
OAQPS	Office of Air Quality Planning and Standards
OAR	EPA’s Office of Air and Radiation
OBD	on-board diagnostics
OC/EC	organic carbon/elemental carbon
OMB	Office of Management and Budget
OMS	Office of Mobile Sources
ORNL	Oak Ridge National Laboratory
OSC	oxygen storage components
OSTP	(White House) Office of Science and Technology Policy
OTAG	Ozone Transport Assessment Group
PADD	Petroleum Administrative Districts for Defense
PAN	peroxy acetyl nitrate
PCM	powertrain control module
Pd	palladium
PFI	port fuel injection
PGM	platinum group metals
PM	particulate matter
PNGV	Partnership for a New Generation of Vehicles
POM	polycyclic organic matter
ppm	part per million
PSD	Prevention of Significant Deterioration
Pt	platinum
R+M/2	average octane, or antiknock index
R&D	research and development
REL	reference exposure level
RFA	Regulatory Flexibility Act
RfC	reference concentration
RfD	reference dose
RFG	reformulated gasoline
RFS2	Renewable Fuel Standard Program, 75 FR 14670, 3/26/2010

Rh	rhodium
ROI	return on investment
ROTR	Regional Ozone Transport Rule
RPE	retail price equivalent
RRF	relative reduction factor
RVP	Reid vapor pressure
S-R	Source-Receptor Matrix
S&P DRI	Standard & Poor's Data Research International
SAB	Science Advisory Board
SBA	U.S. Small Business Administration
SBAR or the Panel	Small Business Advocacy Review Panel
SBREFA	Small Business Regulatory Enforcement Fairness Act
SCR	selective catalytic reduction
SER	Small Entity Representative
SFTP	Supplemental Federal Test Procedure
SIC	Standard Industrial Classification
SIGMA	Society of Independent Gasoline Marketers of America
SIP	State Implementation Plan
SMAT	Speciated Modeled Attainment Test
SO_2	sulfur dioxide
SO_X	oxides of sulfur
SRU	sulfur recovery unit
SULEV	super ultra low emission vehicle
SVM	small volume manufacturer (of vehicles)
SVOC	semivolatile organic compound
SwRI	Southwest Research Institute
T10	average temperature at which 10 percent of gasoline is distilled
T50	average temperature at which 50 percent of gasoline is distilled
T90	average temperature at which 90 percent of gasoline is distilled
TC	total technology costs
TGDI	turbocharged gasoline direct injection
THC	total hydrocarbons
TOG	total organic gases
TW	test weight
UAM	Urban Airshed Model
UCL	upper confidence limit
UEGO	universal exhaust gas oxygen (sensor)
ULEV	ultra low emission vehicle
UMRA	Unfunded Mandates Reform Act
UV	ultra violet
VGO	vacuum gasoil
VTB	vacuum tower bottoms
VMT	vehicle miles traveled
VNA	Voronoi Neighbor Averaging
VOC	volatile organic compound
VSL	value of a statistical life

WLD	work loss days
WTP	willingness to pay

Executive Summary

EPA is adopting a comprehensive program to address air pollution from passenger cars and trucks. The final program, known as "Tier 3," will establish more stringent vehicle emissions standards and reduce the sulfur content of gasoline, considering the vehicle and its fuel as an integrated system The final Tier 3 standards will reduce concentrations of multiple air pollutants (ambient concentrations of ozone, particulate matter (PM), nitrogen dioxide (NO_2), and mobile source air toxics (MSATs)) across the country and help state and local agencies in their efforts to attain and maintain health-based National Ambient Air Quality Standards (NAAQS).

This Regulatory Impact Analysis provides technical, economic, and environmental analyses of the new standards. Chapter 1 contains our technical feasibility justification for the final vehicle emission standards, and Chapter 2 contains the estimated costs of the final vehicle standards. In addition to the vehicle emission and gasoline standards, we are adopting an update to the specifications of the emission test fuel with which vehicles demonstrate compliance with emissions standards; our analysis of the emission test fuel parameter changes is found in Chapter 3. Chapters 4 and 5 contain our technical feasibility and cost analyses for the final gasoline sulfur standards, respectively. Chapter 6 describes the health and welfare effects associated with the air pollutants that will be impacted by the rule. Chapter 7 describes our analysis of the emission and air quality impacts of the Tier 3 rule. Our estimates of the program-wide costs, the societal benefits, and the cost per ton of emissions reduced due to the final Tier 3 program are presented in Chapter 8. Chapter 9 contains our analysis of the final rule's economic impacts, and Chapter 10 provides the results of our small business final regulatory flexibility analysis.

Tier 3 Standards

Vehicle Emission Standards

The Tier 3 standards include light- and heavy-duty vehicle tailpipe emission standards and evaporative emission standards.

Light-Duty Vehicle, Light-Duty Truck, and Medium-Duty Passenger Vehicle Tailpipe Emission Standards

The standards in this category apply to all light-duty vehicles (LDVs, or passenger cars), light-duty trucks (LDT1s, LDT2s, LDT3s, and LDT4s) and Medium-Duty Passenger Vehicles, or MDPVs. The new standards are for the sum of NMOG and NO_X emissions, presented as NMOG+NO_X, and for PM. For these pollutants, the standards are measured on test procedures that represent a range of vehicle operation, including the Federal Test Procedure (or FTP, simulating typical driving) and the Supplemental Federal Test Procedure (or SFTP, a composite test simulating higher temperatures, higher speeds, and quicker accelerations).

The FTP and SFTP NMOG+NO_X standards are fleet-average standards, meaning that a manufacturer will calculate the weighted average emissions of the vehicles it sells in each model year and compare that average to the applicable standard for that model year. The fleet average standards for $NMOG+NO_X$ evaluated over the FTP will begin in MY 2017 and then decline through MY 2025, as summarized in Table ES-1. Similarly, the $NMOG+NO_X$ standards measured over the SFTP will also be fleet-average standards, declining from MY 2017 until MY 2025, as shown in Table ES-2.

Table ES-1 LDV, LDT, and MDPV Fleet Average $NMOG+NO_X$ FTP Standards (mg/mi)

	Model Year								
	2017[a]	2018	2019	2020	2021	2022	2023	2024	2025 and later
LDV/LDT1[b]	86	79	72	65	58	51	44	37	30
LDT2,3,4 and MDPV	101	92	83	74	65	56	47	38	30

[a] For vehicles above 6000 lbs GVWR, the fleet average standards will apply beginning in MY 2018.
[b] These standards will apply for a 150,000 mile useful life. Manufacturers can choose to certify their LDVs and LDV1s to a useful life of 120,000 miles. If any of these families are certified to the shorter useful life, a proportionally lower numerical fleet-average standard will apply, calculated by multiplying the respective 150,000 mile standard by 0.85 and rounding to the nearest mg.

Table ES-2 LDV, LDT, and MDPV Fleet-Average $NMOG+NO_X$ SFTP Fleet Average Standards (mg/mi)

	Model Year								
	2017[a]	2018	2019	2020	2021	2022	2023	2024	2025 and later
$NMOG + NO_X$	103	97	90	83	77	70	63	57	50

[a] For vehicles above 6000 lbs GVWR, the fleet average standards will apply beginning in MY 2018.

The PM standard on the FTP for certification testing is 3 mg/mi for all vehicles and for all model years. Manufacturers can phase in their vehicle models as a percent of sales through MY 2022. The FTP PM standards will apply to each vehicle separately (i.e., not as a fleet average). The program also includes a separate FTP PM requirement of 6 mg/mi for the testing of in-use vehicles that will apply during the percent phase-in period only. Table ES-3 presents the FTP certification and in-use PM standards and the phase-in percentages.

Table ES-3 Phase-In for FTP PM Standards

	2017[a]	2018	2019	2020	2021	2022 and later
Phase-In (percent of U.S. sales)	20	20	40	70	100	100
Certification Standard (mg/mi)	3	3	3	3	3	3
In-Use Standard (mg/mi)	6	6	6	6	6	3

[a] For vehicles above 6000 lbs GVWR, the FTP PM standards will apply beginning in MY 2018.

The Tier 3 program also includes certification PM standards evaluated over the SFTP (specifically the US06 component of the SFTP procedure) of 10 mg/mi for MYs 2017 and MY 2018, and a single final standard of 6 mg/mi for MY 2019 and later. For MYs 2019 through 2023, an in-use standard of 10 mg/mi will also apply.

Heavy-Duty Tailpipe Emission Standards

There are new Tier 3 exhaust emissions standards for complete heavy-duty vehicles (HDVs) between 8,501 and 14,000 lb GVWR. Vehicles in this GVWR range are often referred to as Class 2b (8,501-10,000 lb) and Class 3 (10,001-14,000 lb) vehicles, and are typically full-size pickup trucks and work vans. The key elements of these standards include a combined NMOG+NO_X declining fleet average standard, new stringent PM standards phasing in on a separate schedule, extension of the regulatory useful life to 150,000 miles, and a new requirement to meet standards over the SFTP that will address real-world driving modes not well-represented by the FTP cycle alone. Table ES-4 presents the HDV fleet average NMOG+NO_X standard, which becomes more stringent in successive model years from 2018 to 2022, with voluntary standards available in 2016 and 2017.

The PM standards are 8 mg/mi for Class 2b vehicles and 10 mg/mi for Class 3 vehicles, to be phased in on a percent-of-sales basis at 20-40-70-100 percent in 2018-2019-2020-2021, respectively.

Table ES-4 HDV Fleet Average NMOG+NO_X Standards (mg/mi)

	Voluntary		Required Program				
Model Year	2016	2017	2018	2019	2020	2021	2022 and later
Class 2b	333	310	278	253	228	203	178
Class 3	548	508	451	400	349	298	247

The new SFTP requirements for HDVs include NMOG+NO_X, carbon monoxide (CO) and PM standards. Compliance will be evaluated from a weighted composite of measured emissions from testing over the FTP cycle, the SC03 cycle, and an aggressive driving cycle, with the latter tailored to various HDV sub-categories: the US06 cycle for most HDVs, the highway portion of the US06 cycle for low power-to-weight Class 2b HDVs, and the LA-92 cycle for Class 3 HDVs.

Evaporative Emission Standards

To control evaporative emissions, more stringent standards will require covered vehicles to have essentially zero fuel vapor emissions in use, including more stringent evaporative emissions standards, new test procedures, and a new fuel/evaporative system leak standard. Tier 3 also includes refueling emission standards for complete heavy-duty gasoline vehicles (HDGVs) over 10,000 lbs GVWR. There are phase-in flexibilities as well as credit and allowance programs. The standards, harmonized with California's zero evaporative emissions standards, are designed to essentially eliminate fuel vapor-related evaporative emissions. The Tier 3 evaporative emission standards will be phased in over a period of six MYs 2017-2022 as shown in Table ES-5.

Table ES-5 Default Phase-in Schedule for Tier 3 Evaporative Emission Standards

Model year	Minimum percentage of vehicles subject to the Tier 3 standards
2017	40%[1,2,3]
2018	60%
2019	60%
2020	80%
2021	80%
2022	100%

[1] The phase-in percentage for model year 2017 applies only for vehicles at or below 6,000 pounds GVWR.
[2] The leak standard does not apply for model year 2017.
[3] There are three options for the 2017 MY, only one is shown here.

Table ES-6 presents the evaporative hot soak plus diurnal emission standards by vehicle class. Manufacturers may comply on average within each of the four vehicle categories but not across these categories. Tier 3 also includes separate high altitude emission standards for these vehicle categories.

Table ES-6 Evaporative Emission Standards (g/test)

Vehicle Category	Highest Diurnal + Hot Soak Level (over both 2-day and 3-day diurnal tests)
LDV, LDT1	0.300
LDT2	0.400
LDT3, LDT4, MDPV	0.500
HDGVs	0.600

There is a new testing requirement referred to as the bleed emission test procedure. Manufacturers will be required to measure diurnal emissions over the 2-day diurnal test procedure from just the fuel tank and the evaporative emission canister and comply with a 0.020 g/test standard for all LDVs, LDTs, and MDPVs without averaging. The canister bleed emission standard test will apply only for low altitude testing conditions, but there is proportional control at higher altitudes.

EPA is including these Tier 3 evaporative emission controls for HDGVs as part of the overall scheme for LDVs and LDTs. The individual vehicle emission standard will be 0.600 g/test for both the 2-day and 3-day evaporative emission tests, the high altitude standard will be 1.75 g/test and the canister bleed test standard will be 0.030 g/test.

We are adding a new standard and test procedure related to controlling vapor leaks from vehicle fuel and vapor control systems. The standard, which will apply to all LDVs, LDTs, MDPVs, and Class 2b/3 HDGVs, will prohibit leaks larger than 0.02 inches of cumulative equivalent diameter in the fuel/evaporative system. The Tier 3 evaporative emission standards program requirements will be phased in over a period of six model years between MYs 2017 and 2022, with the leak test phasing in beginning in 2018 MY as a vehicle is certified to meet Tier 3 evaporative emission requirements.

There are new refueling emission control requirements for complete HDGVs equal to or less than 14,000 lbs GVWR (i.e., Class 2b/3 HDGVs), that start in the 2018 model year. For complete HDGVs > 14,000 lbs GVWR the refueling emission control requirement start in the 2022 model year.

We are adopting and incorporating by reference the current CARB onboard diagnostic system (OBD) regulations effective for the 2017 MY plus two minor provisions to enable OBD-based leak detection to be used in IUVP testing. EPA will retain the provision that certifying with CARB's program will permit manufacturers to seek a separate EPA certificate on that basis.

Emissions Test Fuel Requirements

There are several changes to our federal gasoline emissions test fuel. Key changes include:

- Moving away from "indolene" (E0) to a test fuel containing 10 percent ethanol by volume (E10);
- Lowering octane to match regular-grade gasoline (except for premium-required vehicles);
- Adjusting distillation temperatures, aromatics and olefins to better match today's in-use fuel and to be consistent with anticipated E10 composition; and
- Lowering the existing sulfur specification and setting a benzene specification to be consistent with proposed Tier 3 gasoline sulfur requirements and recent MSAT2 gasoline benzene requirements.

- E85 and premium test fuel specifications.

Gasoline Sulfur Standards

Under the Tier 3 fuel program, federal gasoline will contain no more than 10 parts per million (ppm) sulfur on an annual average basis beginning January 1, 2017. There will be an averaging, banking, and trading (ABT) program that would allow refiners and importers to spread out their investments through an early credit program and rely on ongoing nationwide averaging to meet the 10 ppm sulfur standard. There will be a three-year delay for small refiners and "small volume refineries" (refiners processing less than or equal to 75,000 barrels per calendar day). In addition, we are maintaining the current refinery gate and downstream sulfur caps of 80 ppm and 95 ppm, respectively.

Projected Impacts

Changes to Analyses Since Proposal

Since the proposal, we have made several updates to the analyses that estimate the projected impacts of the Tier 3 standards. We made several changes to our baseline (also referred to as the "reference case"), which is our projection of future conditions if the Tier 3 standards were not finalized. Specifically, our baseline now accounts for the fact that California and twelve additional states have adopted California's Low Emission Vehicle III (LEV III) program. This change reduces the emissions and air quality impacts of the Tier 3 standards (and thus the monetized benefits), and it also reduces the cost of the Tier 3 vehicle standards. In addition, the baseline now accounts for the light-duty greenhouse gas emissions standards for 2017 and later model years, and the greenhouse gas emissions standards for medium- and heavy-duty engines and vehicles. This update affects the per-vehicle technology costs but has little impact on the emissions and air quality benefits of the Tier 3 program, because it is included in both the baseline and control cases. Finally, the baseline now uses the U.S. Energy Information Administration's Annual Energy Outlook 2013 (AEO2013) as the source for future renewable fuel volumes and blends and future gasoline consumption. AEO2013 projects significantly lower gasoline consumption than AEO2011 (which was used in the proposal's analysis), and this reduces the total cost of the Tier 3 fuel program. There are a number of other updates to our cost, emissions, air quality, and benefits analyses, as detailed in the RIA. Among the most significant are the changes to the vehicle and fuel cost estimates, which have resulted in costs that are lower than projected in the proposal. The updates with the most significant impacts on the per-vehicle costs include a more robust estimate of catalyst loading costs and the new baseline fleet that reflects implementation of the most recent greenhouse gas emissions standards. Both of these updates reduced per-vehicle costs. Total vehicle program costs were also significantly reduced because costs are no longer incurred for vehicles sold in states that have adopted the California LEV III program. With respect to fuel costs, the change with the most significant impact on per-gallon costs is the inclusion of nationwide credit trading (i.e., between companies). The proposal's primary cost analysis was based only on trading within companies (although we also presented in the proposal the cost if trading between firms occurred). The reduction in per-gallon costs, when combined with significantly lower projections of gasoline consumption from AEO2013, resulted in lower fuel program costs than the proposal had estimated.

Emission and Air Quality Impacts

The Tier 3 vehicle and fuel-related standards together will reduce emissions of NO_X, VOC, $PM_{2.5}$, and air toxics. The gasoline sulfur standards, which will take effect in 2017, will provide large immediate reductions in emissions from existing gasoline vehicles and engines. The emission reductions will increase over time as newer vehicles become a larger percentage of the fleet (e.g., in 2030, 70 percent of the miles travelled are from vehicles that meet the fully phased-in Tier 3 standards). Projected emission reductions from the Tier 3 standards for 2018 and 2030 are shown in Table ES-7. We expect these reductions to continue beyond 2030 as more of the fleet continues to turn over to Tier 3 vehicles.

Table ES-7 Estimated Emission Reductions from the Final Tier 3 Standards (Annual U.S. short tons)

	2018		2030	
	Tons	Percent of Onroad Inventory	Tons	Percent of Onroad Inventory
NO_X	264,369	10%	328,509	25%
VOC	47,504	3%	167,591	16%
CO	278,879	2%	3,458,041	24%
Direct $PM_{2.5}$	130	0.1%	7,892	10%
Benzene	1,916	6%	4,762	26%
SO_2	14,813	56%	12,399	56%
1,3-Butadiene	257	5%	677	29%
Formaldehyde	513	2%	1,277	10%
Acetaldehyde	600	3%	2,067	21%
Acrolein	40	3%	127	15%
Ethanol	2,704	2%	19,950	16%

We project that the Tier 3 vehicle and fuel standards will reduce nitrous oxide (N_2O) and methane (CH_4) emissions from vehicles. The reductions in these potent greenhouse gases will be partially offset by the increase in CO_2 emissions from refineries. The combined impact is a net decrease on a CO_2-equivalent basis (2.5 to 2.7 million metric tons of CO_2-equivalent reduced in 2030).

Reductions in emissions of NO_X, VOC, $PM_{2.5}$ and air toxics are projected to lead to nationwide decreases in ambient concentrations of ozone, $PM_{2.5}$, NO_2, CO, and air toxics. Specifically, the Tier 3 standards will significantly decrease ozone concentrations across the country, with an estimated population-weighted average decrease of 0.49 ppb in 2018 and 0.98 ppb in 2030. Few other strategies exist that would deliver the reductions needed for states to meet the current ozone standards. The Tier 3 standards will decrease ambient annual $PM_{2.5}$ concentrations across the county as well, with an estimated population-weighted average decrease of 0.04 $\mu g/m^3$ by 2030. Decreases in ambient concentrations of air toxics are also projected with the Tier 3 standards, including notable nationwide reductions in benzene concentrations.

Costs and Benefits

The costs that will be incurred from our final program fall into two categories – costs from the Tier 3 vehicle exhaust and evaporative standards and from reductions in sulfur content of gasoline. All costs represent the fleet-weighted average of light-duty vehicles and trucks. All costs are represented in 2011 dollars.

Vehicle Costs

The vehicle costs include the technology costs projected to meet the exhaust and evaporative standards, as show in Table ES-8. The fleet mix of light-duty vehicles, light duty trucks, and medium-duty trucks reflects the MY 2017-2025 light-duty and MY2014-2018 heavy-duty GHG final rulemakings.

Table ES-8 Annual Vehicle Technology Costs, 2011$

Year	Vehicle Exhaust Emission Control Costs ($Million)	Vehicle Evaporative Emission Control Costs ($Million)	Operating Costs ($Million)	Facility Costs ($Million)	Total Vehicle Costs ($Million)[a]
2017	$268	$26	$0	$4	$297
2030	$664	$113	-$19	$4	$761

[a] These estimates include costs associated with the Tier 3 vehicle standards in all states except California and states that have adopted the LEV III program.

Fuel Costs

The fuel costs consist of the additional operating costs and capital costs to the refiners to meet the sulfur average of 10 ppm. The sulfur control costs assume a cost of 0.65 cents per gallon which includes the refinery operating and capital costs. The annual fuel costs of the program are listed in Table ES-9.

Table ES-9 Annual Fuel Costs, 2011$

Year	Fuel Sulfur Control Costs ($Million)[a]
2017	$804
2030	$696

[a] These estimates include costs associated with the Tier 3 fuel standards in all states except California.

Total Costs

The sum of the vehicle technology costs to control exhaust and evaporative emissions, in addition to the costs to control the sulfur level in the fuel, represent the total costs of the program, as shown in Table ES-10. The final fuel standards are projected to lead to an average cost of 0.65 cents per gallon of gasoline, and the vehicle standards would have an average technology cost of $72 per vehicle

Table ES-10: Total Annual Vehicle and Fuel Control Costs, 2011$

Year	Total Vehicle and Fuel Control Costs ($Million)[a]
2017	$1,101
2030	$1,457

[a] These estimates include costs associated with both the Tier 3 vehicle standards in all states except California and states that have adopted the LEV III program, and the Tier 3 fuel standards in all states except California.

Benefits

Exposure to ambient concentrations of ozone, $PM_{2.5}$, and air toxics is linked to adverse human health impacts such as premature deaths as well as other important public health and environmental effects. The final Tier 3 standards are expected to reduce these adverse impacts and yield significant benefits, including those we can monetize and those we are unable to quantify.

The range of quantified and monetized benefits associated with this program are estimated based on the risk of several sources of PM- and ozone-related mortality effect estimates, along with other PM and ozone non-mortality related benefits information. Overall, we estimate that the final rule will lead to a net decrease in $PM_{2.5}$- and ozone-related health and environmental impacts. The estimated range of total monetized ozone- and PM-related health impacts is presented in Table ES-11.

Table ES-11: Estimated 2030 Monetized PM-and Ozone-Related Health Benefits (Billions, 2011$)[a]

Description	**2030**
Total Estimated Health Benefits[b,c,d,e]	
3 percent discount rate	$7.4 - $19
7 percent discount rate	$6.7 - $18

Notes:
[a] Totals are rounded to two significant digits and may not sum due to rounding.
[b] Total includes ozone and $PM_{2.5}$ estimated benefits. Range was developed by adding the estimate from the Bell et al., 2004 ozone premature mortality function to $PM_{2.5}$-related premature mortality derived from the American Cancer Society cohort study (Krewski et al., 2009) for the low estimate and ozone premature mortality derived from the Levy et al., 2005 study to $PM_{2.5}$-related premature mortality derived from the Six-Cities (Lepeule et al., 2012) study for the high estimate.
[c] Annual benefits analysis results reflect the use of a 3 percent and 7 percent discount rate in the valuation of premature mortality and nonfatal myocardial infarctions, consistent with EPA and OMB guidelines for preparing economic analyses.

[d] Valuation of premature mortality based on long-term PM exposure assumes discounting over the SAB recommended 20-year segmented lag structure described in the Regulatory Impact Analysis for the 2006 PM National Ambient Air Quality Standards (September, 2006).
[e] Not all possible benefits are quantified and monetized in this analysis; the total monetized benefits presented here may therefore be underestimated.

We estimate that by 2030, the annual emission reductions of the Tier 3 standards will annually prevent between 660 and 1,500 PM-related premature deaths, between 110 and 500 ozone-related premature deaths, 81,000 work days lost, and approximately 1.1 million minor restricted-activity days. The estimated annual monetized health benefits of the proposed Tier 3 standards in 2030 (2011$) will be between $7.4 and $19 billion, assuming a 3-percent discount rate (or between $6.7 billion and $18 billion assuming a 7-percent discount rate).

Comparison of Costs and Benefits

Using a conservative benefits estimate, the 2030 benefits outweigh the costs by a factor of 4.5. Using the upper end of the benefits range, the benefits could outweigh the costs by a factor of 13. Thus, even taking the most conservative benefits assumptions, benefits of the final standards are projected to outweigh the costs. The results are shown in Table ES-12.

Table ES-12 Summary of Annual Benefits and Cost Associated with the Final Tier 3 Program (Billions, 2011$)[a]

Description	**2030**
Vehicle Program Costs	$0.76
Fuels Program Costs	$0.70
Total Estimated Costs[b]	$1.5
Total Estimated Health Benefits[c,d,e,f]	
3 percent discount rate	$7.4 - $19
7 percent discount rate	$6.7 - $18
Annual Net Benefits (Total Benefits – Total Costs)	
3 percent discount rate	$5.9 - $18
7 percent discount rate	$5.2 - $17

Notes:
[a] All estimates represent annual benefits and costs anticipated for the year 2030. Totals are rounded to two significant digits and may not sum due to rounding.
[b] The calculation of annual costs does not require amortization of costs over time. Therefore, the estimates of annual cost do not include a discount rate or rate of return assumption (see Chapter 2 of the RIA for more information on vehicle costs, Chapter 5 for fuel costs, and Section 8.1.1 for a summary of total program costs).
[c] Total includes ozone and $PM_{2.5}$ estimated benefits. Range was developed by adding the estimate from the Bell et al., 2004 ozone premature mortality function to $PM_{2.5}$-related premature mortality derived from the American Cancer Society cohort study (Krewski et al., 2009) for the low estimate and ozone premature mortality derived from the Levy et al., 2005 study to $PM_{2.5}$-related premature mortality derived from the Six-Cities (Lepeule et al., 2012) study for the high estimate.
[d] Annual benefits analysis results reflect the use of a 3 percent and 7 percent discount rate in the valuation of premature mortality and nonfatal myocardial infarctions, consistent with EPA and OMB guidelines for preparing economic analyses.

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[e] Valuation of premature mortality based on long-term PM exposure assumes discounting over the SAB recommended 20-year segmented lag structure described in the Regulatory Impact Analysis for the 2012 PM National Ambient Air Quality Standards (December, 2012).
[f] Not all possible benefits or disbenefits are quantified and monetized in this analysis. Potential benefit categories that have not been quantified and monetized are listed in Table 8-5.

Economic Impact Analysis

The rule will affect two sectors directly: vehicle manufacturing and petroleum refining. The estimated increase in vehicle production cost because of the rule is expected to be small relative to the costs of the vehicle. Some or all of this production cost increase will be expected to be passed through to consumers. This increase in price is expected to lower the quantity of vehicles sold, though because the expected cost increase is small, we expect the decrease in sales to be negligible. This decrease in vehicle sales is expected to decrease employment in the vehicle manufacturing sector. However, costs related to compliance with the rule should also increase employment in this sector. While it is unclear which of these effects will be larger, because the increase in vehicle production costs and the decrease in vehicle sales are minor, the impact of the rule on employment in the vehicle manufacturing sector is expected to be small as well. The key change for refiners from the proposed standards will be more stringent sulfur requirements. Analogous to vehicle sales, this change to fuels is expected to increase manufacturers' costs of fuel production. Some or all of this increase in production costs is expected to be passed through to consumers which should lead to a decrease in fuel sales. As with the vehicle manufacturing sector, we expect the decrease in fuel sales to negatively affect employment in this sector, while the costs of compliance with the rule will be expected to increase employment. It is not evident whether the rule will increase or decrease employment in the refining sector as a whole. However, given the small anticipated increase in production costs of less than one cent per gallon and the small likely decrease in fuel sales, we expect that the rule will not have major employment consequences for this sector.

Chapter 9 Economic Impact Analysis

9.1 Introduction

The standards will affect two sectors directly: vehicle manufacturing and petroleum refining. For these two regulated sectors, the economic impact analysis discusses the market impacts from the standards: the changes in price and quantity sold. In addition, although analysis of employment impacts is not part of a benefit-cost analysis (except to the extent that labor costs contribute to costs), employment impacts of federal rules are of particular concern in the current economic climate of sizeable unemployment. Executive Order 13563, "Improving Regulation and Regulatory Review" (January 18, 2011), states, "Our regulatory system must protect public health, welfare, safety, and our environment while promoting economic growth, innovation, competitiveness, and job creation" (emphasis added). For this reason, we are examining the effects of these standards on employment in the regulated sectors.

The employment effects of environmental regulation are difficult to disentangle from other economic changes and business decisions that affect employment, over time and across regions and industries. In light of these difficulties, economic theory provides a constructive framework for approaching these assessments and for better understanding the inherent complexities in such assessments. Neoclassical microeconomic theory describes how profit-maximizing firms adjust their use of productive inputs in response to changes in their economic conditions.[A] In this framework, labor demand impacts for regulated sectors can be decomposed into output and substitution effects. For the output effect, by affecting the marginal cost of production, regulation affects the profit-maximizing quantity of output. The substitution effect describes how, holding output constant, regulation affects the labor-intensity of production. Because the output and substitution effects may be both positive, both negative or some combination, standard neoclassical theory alone does not point to a definitive net effect of regulation on labor demand at regulated firms.

In the labor economics literature there is an extensive body of peer-reviewed empirical work analyzing various aspects of labor demand, relying on the above theoretical framework.[B] This work focuses primarily on the effects of employment policies, e.g. labor taxes, minimum wage, etc.[C] In contrast, the peer-reviewed empirical literature specifically estimating employment effects of environmental regulations is very limited. Several empirical studies, including Berman and Bui (2001)[1] and Morgenstern et al (2002),[2] suggest that net employment impacts may be zero or slightly positive but small even in the regulated sector. Other research suggests that more highly regulated counties may generate fewer jobs than less regulated ones.[3] However, since these latter studies compare more regulated to less regulated counties, they

[A] See Layard, P.R.G., and A. A. Walters (1978), Microeconomic Theory (McGraw-Hill, Inc.), Chapter 9 (Docket EPA-HQ-OAR-2011-0135), a standard microeconomic theory textbook treatment, for a discussion.
[B] See Hamermesh (1993), Labor Demand (Princeton, NJ: Princeton University Press), Chapter 2 (Docket EPA-HQ-OAR-2011-0135) for a detailed treatment.
[C] See Ehrenberg, Ronald G., and Robert S. Smith (2000), Modern Labor Economics: Theory and Public Policy (Addison Wesley Longman, Inc.), Chapter 4 (Docket EPA-HQ-OAR-2011-0135), for a concise overview.

overstate the net national impact of regulation to the extent that regulation causes plants to locate in one area of the country rather than another. List et al. (2003)[4] find some evidence that this type of geographic relocation may be occurring. Overall, the peer-reviewed literature does not contain evidence that environmental regulation has a large impact on net employment (either negative or positive) in the long run across the whole economy.

Analytic challenges make it very difficult to accurately produce net employment estimates for the whole economy that would appropriately capture the way in which costs, compliance spending, and environmental benefits propagate through the macro-economy. Quantitative estimates are further complicated by the fact that macroeconomic models often have very little sectoral detail and usually assume that the economy is at full employment. The EPA is currently in the process of seeking input from an independent expert panel on modeling economy-wide impacts, including employment effects. For more information, see: https://federalregister.gov/a/2014-02471.

9.2 Impacts on Vehicle Manufacturing Sector

9.2.1 Vehicle Sales Impacts

This rule takes effect from MY 2017-2025. In the intervening years, it is possible that the assumptions underlying a quantitative analysis, as well as market conditions, might change. For this reason, we present a qualitative discussion of the effects on vehicle sales of the standards at the aggregate market level. Light-duty vehicle manufacturers are expected to comply with the standards primarily through technological changes to vehicles. These changes to vehicle design and manufacturing are expected to increase manufacturers' costs of vehicle production. The calculation is performed for an average car, an average truck and an average Class 2b/3 vehicle rather than for individual vehicles. The analysis conducted for this rule does not have the precision to examine effects on individual manufacturers or different vehicle classes.

Section VII.A estimates the increase in vehicle costs due to the standards. These costs differ across years and range from $46 to $65 for cars, $73 to $88 for trucks and $33 to $75 for Class 2b/3 vehicles (see Section VII.A). These costs are small relative to the cost of a vehicle. In a fully competitive industry, these costs would be entirely passed through to consumers. However in an oligopolistic industry such as the automotive sector, these increases in cost may not fully pass through to the purchase price, and the consumers may face an increase in price that is less than the increased manufacturers' costs of vehicle production.[D] We do not quantify the expected level of cost pass-through or the ultimate vehicle price increase consumers are expected to face, apart from noting that prices are expected to increase by an amount up to the increased manufacturers' costs.

[D] See, for instance, Gron, Ann, and Deborah Swenson, 2000. "Cost Pass-Through in the U.S. Automobile Market," Review of Economics and Statistics 82: 316-324 (Docket EPA-HQ-OAR-2011-0135-0056), who found significantly less than full-cost pass-through using data from 1984-1994. Using full-cost pass-through overstates costs and thus contributes to lower vehicle sales than using a lower estimate. To the extent that the auto industry has become more competitive over time, full-cost pass-through may be more appropriate than a result based on this older study.

This increase in price is expected to lower the quantity of vehicles sold. Given that we expect that vehicle prices will not change by more than the cost increase, we expect that the decrease in vehicle sales will be negligible.

The effect of these standards on the use and scrappage of older vehicles will be related to its effects on new vehicle prices and the total sales of new vehicles. The increase in price is likely to cause the turnover of the vehicle fleet (i.e., the retirement of used vehicles and their replacement by new models) to slow slightly, thus reducing the anticipated effect of the standards on fleet-wide emissions. Because we do not estimate the effect of the standards on new vehicle price changes nor do we have a good estimate of the effect of new vehicle price changes on vehicle turnover, we have not attempted to estimate explicitly the effects of the standards on scrappage of older vehicles and the turnover of the vehicle fleet.

9.2.2 Employment Impacts in the Auto Sector

This chapter describes changes in employment in the auto sector due to this rule. As with the refinery sector, discussed below, we focus on the auto manufacturing sector because it is directly regulated, and because it is likely to bear a substantial share of changes in employment due to this rule. We include discussion of effects on the parts manufacturing sector, because the auto manufacturing sector can either produce parts internally or buy them from an external supplier, and we do not have estimates of the likely breakdown of effort between the two sectors.

When the economy is at full employment, an environmental regulation is unlikely to have much impact on net overall U.S. employment; instead, labor would primarily be shifted from one sector to another. These shifts in employment impose an opportunity cost on society, approximated by the wages of the employees, as regulation diverts workers from other activities in the economy. In this situation, any effects on net employment are likely to be transitory as workers change jobs (e.g., some workers may need to be retrained or require time to search for new jobs, while shortages in some sectors or regions could bid up wages to attract workers).

On the other hand, if a regulation comes into effect during a period of high unemployment, a change in labor demand due to regulation may affect net overall U.S. employment because the labor market is not in equilibrium. Schmalansee and Stavins point out that net positive employment effects are possible in the near term when the economy is at less than full employment due to the potential hiring of idle labor resources by the regulated sector to meet new requirements (e.g., to install new equipment) and new economic activity in sectors related to the regulated sector.[5] In the longer run, the net effect on employment is more difficult to predict and will depend on the way in which the related industries respond to the regulatory requirements. As Schmalansee and Stavins note, it is possible that the magnitude of the effect on employment could vary over time, region, and sector, and positive effects on employment in some regions or sectors could be offset by negative effects in other regions or sectors. For this reason, they urge caution in reporting partial employment effects since it can "paint an inaccurate picture of net employment impacts if not placed in the broader economic context."

We follow the theoretical structure in a study by Berman and Bui [6] of the impacts of regulation in employment in the regulated sectors. In Berman and Bui's (2001, p. 274-75) theoretical model, the change in a firm's labor demand arising from a change in regulation is decomposed into two main components: output and substitution effects.[E]

- The output effect describes how, if labor-intensity of production is held constant, a decrease in output generally leads to a decrease in labor demand. However, as noted by Berman and Bui, although it is often assumed that regulation increases marginal cost, and thereby reduces output, it need not be the case. A regulation could induce a firm to upgrade to less polluting and more efficient equipment that lowers marginal production costs, for example. In such a case, output could theoretically increase.

- The substitution effect describes how, holding output constant, regulation affects the labor-intensity of production. Although increased environmental regulation generally results in higher utilization of production factors such as pollution control equipment and energy to operate that equipment, the resulting impact on labor demand is ambiguous. For example, equipment inspection requirements, specialized waste handling, or pollution technologies that are added to the production process may affect the number of workers necessary to produce a unit of output. Berman and Bui (2001) model the substitution effect as the effect of regulation on pollution control equipment and expenditures that are required by the regulation and the corresponding change in labor-intensity of production.

In summary, as the output and substitution effects may be both positive, both negative or some combination, standard neoclassical theory alone does not point to a definitive net effect of regulation on labor demand at regulated firms.

Following the Berman and Bui framework for the impacts of regulation on employment in the regulated sector, we consider two effects for the auto sector: the output effect and the substitution effect.

9.2.2.1 The Output Effect

The output effect depends on the effects of this rule on vehicle sales. If vehicle sales decrease, employment associated with these activities will decrease. As discussed in Chapter 9.2.1, we do not make a quantitative estimate on the effect of the rule on vehicle sales, but we note that the decrease in vehicle sales is expected to be negligible. Thus we expect any decrease in employment in the auto sector through the output effect to be small as well.

[E] The authors also discuss a third component, the impact of regulation on factor prices, but conclude that this effect is unlikely to be important for large competitive factor markets, such as labor and capital. Morgenstern, Pizer and Shih (2002) use a very similar model, but they break the employment effect into three parts: 1) the demand effect; 2) the cost effect; and 3) the factor-shift effect. See Morgenstern, Richard D., William A. Pizer, and Jhih-Shyang Shih. "Jobs Versus the Environment: An Industry-Level Perspective." Journal of Environmental Economics and Management 43 (2002): 412-436 (Docket EPA-HQ-OAR-2011-0135-0057).

9.2.2.2 The Substitution Effect

The output effect, above, measures the effect due to new vehicle sales only. The substitution effect includes the impacts due to the changes in technologies needed for vehicles to meet the standards, separate from the effect on output (that is, as though holding output constant). This effect includes both changes in employment due to incorporation of abatement technologies and overall changes in the labor intensity of manufacturing.

One way to estimate this effect, given the cost estimates for complying with the rule, is to use the ratio of workers to each $1 million of expenditures in that sector. The use of these ratios has both advantages and limitations. It is often possible to estimate these ratios for quite specific sectors of the economy: for instance, it is possible to estimate the average number of workers in the light-duty vehicle manufacturing sector per $1 million spent in the sector, rather than use the ratio from another, more aggregated sector, such as motor vehicle manufacturing. As a result, it is not necessary to extrapolate employment ratios from possibly unrelated sectors. On the other hand, these estimates are averages for the sectors, covering all the activities in those sectors; they may not be representative of the labor required when expenditures are required on specific activities, or when manufacturing processes change sufficiently that labor intensity changes. For instance, the ratio for the motor vehicle manufacturing sector represents the ratio for all vehicle manufacturing, not just for emissions reductions associated with compliance activities. In addition, these estimates do not include changes in sectors that supply these sectors, such as steel or electronics producers. They thus may best be viewed as the effects on employment in the auto sector due to the changes in expenditures in that sector, rather than as an assessment of all employment changes due to these changes in expenditures. In addition, this approach estimates the effects of increased expenditures while holding constant the labor intensity of manufacturing; it does not take into account changes in labor intensity due to changes in the nature of production. This latter effect could either increase or decrease the employment impacts estimated here.[F]

Some of the costs of this rule will be spent directly in the auto manufacturing sector, but it is also likely that some of the costs will be spent in the auto parts manufacturing sector. We separately present the ratios for both the auto manufacturing sector and the auto parts manufacturing sector.

There are several public sources for estimates of employment per $1 million expenditures. The U.S. Bureau of Labor Statistics (BLS) provides its Employment Requirements Matrix (ERM),[7] which provides direct estimates of the employment per $1 million in sales of goods in 202 sectors. The values considered here are for Motor Vehicle Manufacturing (NAICS 3361) and Motor Vehicle Parts Manufacturing (NAICS 3363) for 2010.

The Census Bureau provides both the Annual Survey of Manufacturers[8] (ASM) and the Economic Census. The ASM is a subset of the Economic Census, based on a sample of

[F] As noted above, Morgenstern et al. (2002) separate the effect of holding output constant into two effects: the cost effect, which holds labor intensity constant, and the factor shift effect, which estimates those changes in labor intensity.

establishments; though the Census itself is more complete, it is conducted only every 5 years, while the ASM is annual. Both include more sectoral detail than the BLS ERM: for instance, while the ERM includes the Motor Vehicle Manufacturing sector, the ASM and Economic Census have detail at the 6-digit NAICS code level (e.g., light truck and utility vehicle manufacturing). While the ERM provides direct estimates of employees/$1 million in expenditures, the ASM and Economic Census separately provide number of employees and value of shipments; the direct employment estimates here are the ratio of those values. The values reported are for Motor Vehicle Manufacturing (NAICS 3361), Automobile and Light Duty Motor Vehicle Manufacturing (NAICS 33611), and Motor Vehicle Parts Manufacturing (NAICS 3363), for 2011 for the ASM, and 2007 for the Economic Census.

The values used here are adjusted to remove the employment effects of imports through use of a ratio of domestic production to domestic sales of 0.667.[G]

Table 9-1 provides the values, either given (BLS) or calculated (ASM, Economic Census) for employment per $1 million of expenditures, all based on 2011 dollars, though the underlying data come from different years (which may account for some of the differences). These values have changed from the Draft RIA to use the most recent values for the ASM, and to put them all in 2011$. The different data sources provide similar magnitudes for the estimates for the sectors. Parts manufacturing appears to be more labor-intensive than vehicle manufacturing; light-duty vehicle manufacturing appears to be slightly less labor-intensive than motor vehicle manufacturing as a whole.

Table 9-1 Employment per $1 Million Expenditures (2011$) in the Motor Vehicle Manufacturing Sector[a]

Source	Sector	Ratio of workers per $1 million expenditures	Ratio of workers per $1 million expenditures, adjusted for domestic vs. foreign production
BLS ERM	Motor Vehicle Mfg	0.754	0.503
ASM	Motor Vehicle Mfg	0.633	0.422
ASM	Light Duty Vehicle Mfg	0.583	0.389
Economic Census	Motor Vehicle Mfg	0.651	0.434
Economic Census	Light Duty Vehicle Mfg	0.590	0.393
BLS ERM	Motor Vehicle Parts Mfg	2.558	1.706
ASM	Motor Vehicle Parts Mfg	2.190	1.461
Economic Census	Motor Vehicle Parts Mfg	2.656	1.771

Note:

[G] To estimate the proportion of domestic production affected by the change in sales, we use data from Ward's Automotive Group for total car and truck production in the U.S. compared to total car and truck sales in the U.S. For the period 2001-2010, the proportion is 66.7 percent (Docket EPA-HQ-OAR-2011-0135).

[a] BLS ERM refers to the U.S. Bureau of Labor Statistics' Employment Requirement Matrix. ASM refers to the U.S. Census Bureau's Annual Survey of Manufactures. Economic Census refers to the U.S. Census Bureau's Economic Census.

Over time, the amount of labor needed in the auto industry has changed: automation and improved methods have led to significant productivity increases. The BLS ERM, for instance, provided estimates that, in 1993, 1.64 workers in the Motor Vehicle Manufacturing sector were needed per $1 million of 2005$, but only 0.86 workers by 2010 (in 2005$).[9] Because the ERM is available annually for 1993-2010, we used these data to estimate productivity improvements over time. We regressed logged ERM values on year for both the Motor Vehicle Manufacturing and Motor Vehicle Parts Manufacturing sectors. We used this approach because the coefficient describing the relationship between time and productivity is a direct measure of the percent change in productivity per year. The results suggest a 3.9 percent per year productivity improvement in the Motor Vehicle Manufacturing Sector, and a 3.8 percent per year improvement in the Motor Vehicle Parts Manufacturing Sector. We then used the equation resulting from the regression to project the ERM through 2025. In the results presented below, these projected values (adjusted to 2011$) were used directly for the BLS ERM estimates. For the ASM, we used the ratio of the projected value in each future year to the projected value in 2011 (the base year for the ASM) to determine how many workers will be needed per $1 million of 2011$; for the Economic Census estimates, we used the ratio of the projected value in the future years to the projected value in 2007 (the base year for that estimate).

Section 2.7 of the RIA discusses the vehicle cost estimates developed for this rule. The maximum value for employment impacts per $1 million (before adjustments for changes in productivity, after accounting for the share of domestic production) is 1.771 in 2011$ if all the additional costs are in the parts sector; the minimum value is 0.389 in 2011, if all the additional costs are in the light-duty vehicle manufacturing sector. Increased costs of vehicles and parts would, by itself, and holding labor intensity constant, be expected to increase employment between 2017 and 2025 by some hundreds of jobs each year.

While we estimate employment impacts, measured in job-years, beginning with program implementation, some of these employment gains may occur earlier as auto manufacturers and parts suppliers hire staff in anticipation of compliance with the standard. A job-year is a way to calculate the amount of work needed to complete a specific task. For example, a job-year is one year of work for one person. The decline in maximum employment between 2024 and 2025 is due to a combination of expected higher productivity and rounding, which makes an employment decrease from 760 to 743 job-years appear larger than it is.

Table 9-2 Employment Effects due to Increased Costs of Vehicles and Parts, in job-years

Year	Costs (Millions of 2011$)	Maximum Employment Due to Substitution Effect (if all expenditures are in the Parts Sector)	Minimum Employment Due to Substitution Effect (if all expenditures are in the Light Duty Vehicle Mfg Sector)
2016	$ 21	0	0
2017	$ 297	400	100
2018	$ 615	800	200
2019	$ 653	800	200

2020	$ 697	800	200
2021	$ 725	800	200
2022	$ 758	800	200
2023	$ 751	800	200
2024	$ 761	800	200
2025	$ 773	700	200

9.2.2.3 Summary of Employment Effects in the Auto Sector

The overall effect of the rule on auto sector employment depends on the relative magnitude of the output effect and the substitution effect. Because we do not have quantitative estimates of the output effect, and only a partial estimate of the substitution effect, we cannot reach a quantitative estimate of the overall employment effects of the rule on auto sector employment or even whether the total effect will be positive or negative. However, given that the expected increase in production costs to the auto manufacturers is relatively small, we expect that the magnitudes of all effects combined will be small as well.

The standards are not expected to provide incentives for manufacturers to shift employment between domestic and foreign production. This is because the standards will apply to vehicles sold in the U.S. regardless of where they are produced. If foreign manufacturers already have increased expertise in satisfying the requirements of the standards, there may be some initial incentive for foreign production, but the opportunity for domestic manufacturers to sell in other markets might increase. To the extent that the requirements of this rule might lead to installation and use of technologies that other countries may seek now or in the future, developing this capacity for domestic production now may provide some additional ability to serve those markets. This potential benefit will not apply if other countries are not likely to have similar standards.

9.3 Impacts on Petroleum Refinery Sector

9.3.1 Refinery Sales Impacts

The key change for refiners from the standards will be more stringent sulfur requirements. This change to fuels is expected to increase manufacturers' costs of gasoline production by about 0.7 cents per gallon (see Section VII.B of the Preamble).

In a perfectly competitive industry, this cost would be passed along completely to consumers. In an imperfectly competitive industry, as noted above, full cost pass-through is not necessary: firms may choose to reduce impacts on sales by not passing along full costs. In 2004, the Federal Trade Commission reported that "concentration for most levels of the petroleum industry has remained low to moderate."[10] Thus the assumption of competitive markets has some foundation in this industry. We estimate that the price increase that consumers are likely to face should be positive and up to the increase in manufacturers' costs of gasoline production.

The effect of higher gasoline prices on gasoline sales is expected to be different over the short and long term. In the long run, in response to the increase in fuel costs, consumers can more easily change their driving habits, including where they live or what vehicles they use.

Because of this, we expect that gasoline sales will decrease more in the long run compared to the short run as a result of the price increase due to the rule. However, because manufacturers' costs are expected to increase less than one cent per gallon, we expect that the decrease in gasoline sales will be negligible over all time horizons.

9.3.2 Refinery Employment Impacts

The Berman and Bui framework of output and substitution effects can also be applied to the impact of the rule on employment in the refinery sector.[11] Here we use a fully qualitative approach. A qualitative discussion allows for a wider incorporation of additional considerations, such as timing of impacts and the effects of the rule on imports and exports. Because the discussion is qualitative, we do not sum the net effects on employment.

The output effect on refining sector employment is expected to be negative. The discussion in Chapter 9.3.1 above suggests that the standards will cause a small decrease in the quantity of gasoline demanded due to higher production costs being passed through to consumers. This slightly reduced level of sales will likely have a negative impact on employment in the refining sector. This effect will persist as long as the increase in price is in place. The higher long-run elasticity suggests that sales will be lower in the long run than in the short run, leading to a greater reduction in employment due to the output effect over time. While we do not quantify the level of job losses that are expected here, recall that the quantity of gasoline sold as a result of the standards here is expected to decrease by only a very small amount over any time horizon.

The substitution effect of the rule on employment in the refining sector can be either positive or negative in the Berman and Bui framework; here, we expect a small, possibly positive impact. In order to satisfy the requirements of the rule, firms in the refining industry are expected to need to perform additional work that will require hiring more employees. This effect may be larger in the short run, when initial investments for compliance need to be made; over time, the increase in employment due to these investments may be reduced. Chapter 4.5.1 discusses the expected employment needed to reduce the sulfur content of fuels; as noted there, to meet the Tier 3 sulfur standards, refiners are expected to invest $2 billion between 2012 and 2019 and utilize approximately 250 front-end design and engineering jobs and 15000 construction jobs. As the petroleum sector employed approximately 71,000 workers in 2011, this increase in employment is small when compared to 2011 levels.

These standards are not expected to provide incentives to shift employment between domestic and foreign production. First, the standards apply to gasoline sold in the U.S. regardless of where it has been produced. U.S. gasoline demand is projected to continue to decline for the foreseeable future in response to higher gasoline prices, more stringent vehicle and engine greenhouse gas and fuel economy standards as well as increased use of renewable fuels. As a result, this analysis of incentives to shift employment between domestic and foreign production focuses on investments for existing capacity instead of expanding capacity.[H] In this

[H] While refinery capacity has been increasing around the world in recent years, it has been designed primarily to supply foreign markets other than the U.S. (e.g., increasing demand in China and India).

case, what is relevant is whether the necessary modifications to comply with Tier 3 would be significantly cheaper overseas than in the U.S.

The main impacts on capital and operating costs to comply with Tier 3 associated with adding hydrotreating capacity are likely to be similar overseas as in the U.S. This is particularly true when analyzing likely sources of U.S. imports. The majority of gasoline imported to the U.S. today comes into the East Coast and is sourced out of either Europe or refineries in Canada or the Caribbean that exist almost solely to supply the U.S. market.

These Canadian and Caribbean refineries, by virtue of their focus on the U.S. market, are very similar to U.S.-based refineries and are expected to have to incur similar capital and operating costs as their U.S.-based competitors meeting the 10-ppm standard. Furthermore, the European refineries are already producing gasoline to a 10-ppm sulfur cap for Europe. To the extent they have refinery streams that are more difficult to hydrotreat, the U.S. market currently serves as an outlet for their higher sulfur gasoline streams. As a result, they may incur capital and operating costs on a per gallon basis at least as high as for their U.S.-based competitors for these remaining higher sulfur gasoline streams. Alternatively, they may instead choose to find markets outside the U.S., opening the way for increased U.S.-based refinery demand.

Finally, despite refining industry projections that previously imposed diesel rules would lead to greater U.S. reliance on imports through major negative impacts on domestic refining, the reverse has actually occurred. Over the last 8 years, imports of gasoline and diesel fuel have continued to be the marginal supply, and have even dropped precipitously so that the U.S. is now a net exporter of diesel fuel and is importing half the gasoline that it did at its peak in 2006. With the projected decline in future gasoline demand in the U.S. as vehicle fuel efficiency improves, gasoline imports are expected to continue to decline.

Thus it is expected that for the refining sector, the output effect will lower employment, and the substitution effect may raise employment. As a whole then, it is not evident whether the rule will increase or decrease employment in the refining sector. However, given the small anticipated reduction in quantity sold, it appears that the standards will not have major employment consequences for this sector.

The petroleum refining industry is one of the manufacturing industries studied by Berman and Bui (2001)[7] when they looked at the effect of environmental expenditures on employment. They found that "Employment effects are very small, generally positive, but not statistically different from zero" (p. 281) [Berman and Bui, Table 3]. Berman and Bui also state that the estimates rule out large negative effects (p. 282). Because most of the abatement cost of the regulations they analyze is incurred by refineries, in their sample, they report separate employment effects for refineries and non-refineries "which are also all small." (p. 282). Berman and Bui suggest some explanations for the zero or small estimates, particularly for oil refineries: they are capital-intensive industries with relatively little employment when compared to other manufacturing; they face relatively inelastic demand because they sell output in local markets and/or because there are no unregulated refineries to compete with; and, finally, regulations may have been associated with productivity gains in petroleum refineries. We note that the regulations that these estimate are derived from are not directly comparable to the current rule; it is based on the costs of reductions in refinery air pollution emissions instead of changing fuel properties, and therefore may not be applicable for the standards here.

Section VII.B.5 of the Preamble contains some historical discussion regarding the impact on refineries and refining capacity of earlier rules which resulted in higher costs for refiners. Over the period 2003-2011, when a number of rules were being implemented, EIA data show a net of two refinery closures on its website. Meanwhile, over this same period the average size of U.S. refineries increased from 113,000 barrels per day to 123,000 barrels per day, and total U.S. refining capacity increased by six percent. Thus, historically during a time when rules with much larger expected impacts were being implemented (the 2003 ultra-low sulfur nonroad diesel proposal alone was expected to have a cost impact on refineries more than five times greater than the current rule), U.S. refining capacity increased even as the number of U.S. refineries slightly fell. While closing refineries has a negative effect on industry employment, it is likely that the increased refining capacity at many of the remaining plants had a positive effect on industry employment.

The standards are also likely to have a positive impact on employment among producers of equipment that refiners will use to comply with the standards. Chapter 5 notes that some refiners are expected to revamp their current treatment units, and others will need to add additional treatment units. Producers of this equipment are expected to hire additional labor to meet this increased demand. We also note that the employment effects may be different in the immediate implementation phase than in the ongoing compliance phase. It is expected that the employment increases through the substitution effect from revamping old equipment and installing additional equipment should occur in the near term, when current unemployment levels are high, and the opportunity cost of workers is relatively low. Meanwhile, the employment decreases in the refining sector from the output effect will not start until 2017, when compliance is required, and when unemployment is expected to be reduced; in a time of full employment, any changes in employment levels in the regulated sector are mostly expected to be offset by changes in employment in other sectors.

References

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[7] http://www.bls.gov/emp/ep_data_emp_requirements.htm.

[8] http://www.census.gov/manufacturing/asm/index.html.

[9] http://www.bls.gov/emp/ep_data_emp_requirements.htm; this analysis used data for sectors 88 (Motor Vehicle Manufacturing) and 90 (Motor Vehicle Parts Manufacturing) from “Chain-weighted (2000 dollars) real domestic employment requirements table. . . adjusted to remove imports.”

[10] Federal Trade Commission, Bureau of Economics. “The Petroleum Industry: Mergers, Structural Change, and Antitrust Enforcement.” http://www.ftc.gov/os/2004/08/040813mergersinpetrolberpt.pdf , accessed 8/16/11 (Docket EPA-HQ-OAR-2011-0135-0055).

[11] Berman, E. and L. T. M. Bui (2001). “Environmental Regulation and Labor Demand: Evidence from the South Coast Air Basin.” Journal of Public Economics 79(2): 265-295 (Docket EPA-HQ-OAR-2011-0135).

EXHIBIT 18

Regulatory Impact Analysis:

Final Rulemaking for 2017-2025 Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards

United States Environmental Protection Agency

Regulatory Impact Analysis:

Final Rulemaking for 2017-2025 Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards

Assessment and Standards Division
Office of Transportation and Air Quality
U.S. Environmental Protection Agency

EPA United States Environmental Protection Agency

EPA-420-R-12-016
August 2012

Executive Summary

The Environmental Protection Agency (EPA) and the National Highway Traffic Safety Administration (NHTSA) are issuing a joint Notice of Final Rulemaking (FRM) to establish standards for light-duty highway vehicles that will reduce greenhouse gas emissions (GHG) and improve fuel economy. EPA is issuing greenhouse gas emissions standards under the Clean Air Act, and NHTSA is issuing Corporate Average Fuel Economy standards under the Energy Policy and Conservation Act (EPCA), as amended. These standards apply to passenger cars, light-duty trucks, and medium-duty passenger vehicles, covering model years (MY) 2017 through 2025. The standards will require these vehicles to meet an estimated combined average emissions level of 163 grams of CO_2 per mile in MY 2025 under EPA's GHG program. These standards are designed such that compliance can be achieved with a single national vehicle fleet whose emissions and fuel economy performance improves year over year. The National Program will result in approximately 2 billion metric tons of CO_2 equivalent emission reductions and approximately 4 billion barrels of oil savings over the lifetime of vehicles sold in model years 2017 through 2025.

Mobile sources are significant contributors to air pollutant emissions (both GHG and non-GHG) across the country, internationally, and into the future. The Agency has determined that these emissions cause or contribute to air pollution which may reasonably be anticipated to endanger public health or welfare, and is therefore establishing standards to control these emissions as required by section 202 (a) of the Clean Air Act.[A] The health- and environmentally-related effects associated with these emissions are a classic example of an externality-related market failure. An externality occurs when one party's actions impose uncompensated costs on another party. EPA's final rule will deliver additional environmental and energy benefits, as well as cost savings, on a nationwide basis that would likely not be available if the rule were not in place.

Table 1 shows EPA's estimated lifetime discounted cost, benefits and net benefits for all vehicles projected to be sold in model years 2017-2025. It is important to note that there is significant overlap in costs and benefits for NHTSA's CAFE program and EPA's GHG program and therefore combined program costs and benefits are not a sum of the individual programs.

[A] "Technical Support Document for Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clean Air Act" Docket: EPA-HQ-OAR-2010-0799, http://epa.gov/climatechange/endangerment.html. See also State of Massachusetts v. EPA, 549 U.S. 497, 533 ("If EPA makes a finding of endangerment, the Clean Air Act requires the agency to regulate emissions of the deleterious pollutant from new motor vehicles").

Table 1 EPA's Estimated 2017-2025 Model Year Lifetime Discounted Costs, Benefits, and Net Benefits assuming the 3% discount rate SCC Value[a,b,c,d] (Billions of 2010 dollars)

Lifetime Present Value[c] – 3% Discount Rate	
Program Costs	$150
Fuel Savings	$475
Benefits	$126
Net Benefits[d]	$451
Annualized Value[e] – 3% Discount Rate	
Annualized costs	$6.49
Annualized fuel savings	$20.5
Annualized benefits	$5.46
Net benefits	$19.5
Lifetime Present Value[c] - 7% Discount Rate	
Program Costs	$144
Fuel Savings	$364
Benefits	$106
Net Benefits[d]	$326
Annualized Value[e] – 7% Discount Rate	
Annualized costs	$10.8
Annualized fuel savings	$27.3
Annualized benefits	$7.96
Net benefits	$24.4

Notes:
[a] The agencies estimated the benefits associated with four different values of a one ton CO_2 reduction (model average at 2.5% discount rate, 3%, and 5%; 95[th] percentile at 3%), which each increase over time. For the purposes of this overview presentation of estimated costs and benefits, however, we are showing the benefits associated with the marginal value deemed to be central by the interagency working group on this topic: the model average at 3% discount rate, in 2010 dollars. Section III.H provides a complete list of values for the 4 estimates.
[b] Note that net present value of reduced GHG emissions is calculated differently than other benefits. The same discount rate used to discount the value of damages from future emissions (SCC at 5, 3, and 2.5 percent) is used to calculate net present value of SCC for internal consistency. Refer to Section III.H for more detail.
[c] Projected results using 2008 based fleet projection analysis.
[d] Present value is the total, aggregated amount that a series of monetized costs or benefits that occur over time is worth in a given year. For this analysis, lifetime present values are calculated for the first year of each model year for MYs 2017-2025 (in year 2010 dollar terms). The lifetime present values shown here are the present values of each MY in its first year summed across MYs.
[e] Net benefits reflect the fuel savings plus benefits minus costs.
[f] The annualized value is the constant annual value through a given time period (the lifetime of each MY in this analysis) whose summed present value equals the present value from which it was derived. Annualized SCC values are calculated using the same rate as that used to determine the SCC value, while all other costs and benefits are annualized at either 3% or 7%.

This Regulatory Impact Analysis (RIA) contains supporting documentation to the EPA rulemaking. NHTSA has prepared its own RIA in support of its CAFE standards (see

NHTSA's docket for the rulemaking, NHTSA-2010-0131). While the two sets of standards are similar, there are also differences in the analyses that require separate discussion. This is largely because EPA and NHTSA act under different statutes. EPA's authority comes under the Clean Air Act, and NHTSA's authority comes under EPCA (Energy Policy and Conservation Act of 1975) and EISA (Energy Independence and Security Act), and each statute has somewhat different requirements and flexibilities. As a result, each agency has followed a unique approach where warranted by these differences. Where each agency has followed the same approach or rely on the same inputs —e.g., development of technology costs and effectiveness—the supporting documentation is contained in the joint Technical Support Document (joint TSD can be found in EPA's docket EPA-HQ-OAR-2010-0799). Therefore, this RIA should be viewed as a companion document to the Joint TSD and the two documents together provide the details of EPA's technical analysis in support of its rulemaking.

This document contains the following;

Chapter 1: Technology Packages, Cost and Effectiveness, The details of the vehicle technology costs and packages used as inputs to EPA's Optimization Model for Emissions of Greenhouse gases from Automobiles (OMEGA) are presented. These vehicle packages represent potential ways of meeting the CO_2 stringency established by this rule and are based on the technology costs and effectiveness analyses discussed in Chapter 3 of the Joint TSD. This chapter also contains details on the lumped parameter model, which is a major part of EPA's determination of the effectiveness of these packages. More detail on the effectiveness of technologies and the Lumped Parameter model can be found in Chapter 3 of the Joint TSD.

Chapter 2: EPA's Vehicle Simulation Tool, The development and application of the EPA vehicle simulation tool, called ALPHA (Advanced Light-Duty Powertrain and Hybrid Analysis), are discussed. This chapter first provides a detailed description of the simulation tool including overall architecture, systems, and components of the vehicle simulation model. The chapter also describes applications and results of the vehicle simulation runs for estimating impact of A/C usage on fuel consumption and calculating off-cycle credits particularly for active aerodynamic technologies. For the result of the A/C study, the impact of A/C usage was estimated at for cars and trucks separately using the ALPHA tool. The result corresponds to an impact of approximately 14.0 CO_2 g/mile for the (2012) fleet, which is comparable to the 2012-2016 final rule result. For the off-cycle credits, EPA based its analysis on manufacturer data as well as the ALPHA tool, where active grill shutters (one of the active aerodynamic technologies considered) provide a reduction of 0-5% in aerodynamic drag (C_d) when deployed. EPA expects that most other active aerodynamic technologies will provide a reduction of drag in the same range as active grill shutters. Based on this analysis, EPA will provide a credit for active aerodynamic technologies that can demonstrate a reduction in aerodynamic drag of 3% or more.

Chapter3: Results of Final and Alternative Standards, This chapter provides the methodology for and results of the technical assessment of the future vehicle scenarios presented in this final rulemaking. As in the analysis of the MY 2012-2016 rulemaking, evaluating these scenarios included identifying potentially available technologies and assessing their effectiveness, cost, and impact on relevant aspects of vehicle performance and utility. The wide number of technologies which are available and likely to be used in combination required a method to account for their combined cost and effectiveness, as well as estimates of their availability to be applied to vehicles. These topics are discussed.

Chapter 4: Projected Impacts on Emissions, Fuel Consumption, and Safety, This chapter documents EPA's analysis of the emission, fuel consumption and safety impacts of the final emission standards for light duty vehicles. These final standards significantly decrease the magnitude of greenhouse gas emissions from light duty vehicles. Because of anticipated changes to driving behavior, fuel production, and electricity generation, a number of co-pollutants would also be affected by this rule. This analysis quantifies the program's impacts on the greenhouse gases (GHGs) carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and hydrofluorocarbons (HFC-134a); program impacts on "criteria" air pollutants, including carbon monoxide (CO), fine particulate matter ($PM_{2.5}$) and sulfur dioxide (SOx) and the ozone precursors hydrocarbons (VOC) and oxides of nitrogen (NOx); and impacts on several air toxics including benzene, 1,3-butadiene, formaldehyde, acetaldehyde, and acrolein.

CO_2 emissions from automobiles are largely the product of fuel combustion, and consequently, reducing CO_2 emissions will also produce a significant reduction in projected fuel consumption. EPA's projections of these impacts (in terms of gallons saved) are also shown in this chapter. RIA Chapter 5 presents the monetized fuel savings.

In addition to the intended effects of reducing CO_2 emission, the agencies also consider the potential of the standards to affect vehicle safety. This topic is introduced in Preamble Section II.G. EPA's analysis of the change in fatalities due to projected usage of mass reduction technology is shown in this chapter.

Chapter 5: Vehicle Program Costs Including Fuel Consumption Impacts, This chapter contains the program costs and fuel savings associated with EPA's final rulemaking. In Chapter 5, we present briefly some of the outputs of the OMEGA model (costs per vehicle) and how we use those outputs to estimate the annual program costs which include the addition of new technology and the potential maintenance associated with that new technology. We also discuss repair costs and our thoughts on the difficulty associated with estimating repair costs. In this chapter, we also present the estimated fuel savings associated with the final standards. We present all of these program costs and the fuel savings for calendar years 2017 through 2050 and for the lifetimes of each of the model years 2017 through 2025 that are the focus of the final rulemaking. We also present our cost per ton analysis showing the cost incurred for each ton of GHG reduced by the program.

Also presented in Chapter 5 is our estimated consumer cost of ownership and what we call our "payback analysis" which looks at how quickly the improved fuel efficiency of new vehicles provides savings to buyers despite the vehicles having new technology (and new costs). The consumer payback analysis shows that fuel savings will outweigh incremental costs in less than four years for people purchasing new 2025MY vehicles with either cash or credit. Further, for those purchasing new vehicles with a typical five-year car loan, the fuel savings will outweigh increased costs in the first month of ownership. We have also looked at the payback periods for buyers of used vehicles meeting the final standards. For buyers that purchase a 5 and/or a 10 year old vehicle meeting the final standards, the payback periods occur in half a year or roughly one year depending on whether the vehicle is purchased with cash or credit.

Chapter 6: Environmental and Health Impacts, This Chapter provides details on both the climate impacts associated with changes in atmospheric CO_2 concentrations and the non-GHG health and environmental impacts associated with criteria pollutants and air toxics.

Based on modeling analysis performed by the EPA, reductions in CO_2 and other GHG emissions associated with this final rule will affect future climate change. Since GHGs are well-mixed in the atmosphere and have long atmospheric lifetimes, changes in GHG emissions will affect atmospheric concentrations of greenhouse gases and future climate for decades to millennia, depending on the gas. This section provides estimates of the projected change in atmospheric CO_2 concentrations based on the emission reductions estimated for this final rule, compared to the reference case. In addition, this section analyzes the response to the changes in GHG concentrations of the following climate-related variables: global mean temperature, sea level rise, and ocean pH. See Chapter 4 in this RIA for the estimated net reductions in global emissions over time by GHG.

There are also health and environmental impacts associated with the non-GHG emissions projected to change as a result of the final standards. To adequately assess these impacts, we conducted full-scale photochemical air quality modeling to project changes in atmospheric concentrations of $PM_{2.5}$, ozone and air toxics in the year 2030.

Based on the magnitude of the emissions changes predicted to result from the final vehicle standards (as shown in Chapter 4), we project that our modeling indicates that there will be very small changes in ambient ozone and $PM_{2.5}$ concentrations across most of the country. However, there will be small decreases in ambient concentrations in some areas of the country and small increases in ambient concentrations in other areas. The nationwide population-weighted average change for ozone is an increase of 0.001 ppb and the nationwide population-weighted average change for $PM_{2.5}$ is a decrease of 0.007 $\mu g/m^3$.

The final rule reduces the net human health risk posed by non-GHG related pollutants. In monetized terms, the present value of PM- and ozone-related impacts associated with the Calendar Year analysis equals between $3.1 and $9.2 billion in benefits, depending on the assumed discount rate (7 percent and 3 percent, respectively). The present value of PM2.5-related benefits associated with the lifetimes of 2017-2025 model year light-duty vehicles (the Model Year analysis) ranges between $4.3 and $5.5 billion dollars, depending on the assumed discount rate (7% and 3%, respectively).

Chapter 7: Other Economic and Social Impacts, This Chapter presents a summary of the total costs, total benefits, and net benefits expected under the final rule as well as an expanded description of the agency's approach to the monetization of GHG emission reductions and benefits from less frequent refueling. Table 2 presents a summary of all economic impacts on an annual basis and as present values in 2012 for the years 2017 through 2050 at both 3% and 7% discount rates. Additional tables in Chapter 7 present the total value of each category of costs and benefits from this rule over the lifetime of MY 2017-2025 vehicles as well as in select calendar years through 2050. We note that several of the cost and benefit categories we would typically discuss in an RIA are considered joint economic assumptions common to EPA and NHTSA and are discussed in more detail in EPA and NHTSA's Joint TSD Chapter 4. For the reader's reference, Chapter 7 includes a summary table with a number of the economic values discussed in the Joint TSD, including the value of improving U.S. energy security by reducing imported oil, discount rates, the magnitude of the VMT rebound effect, and the value of accidents, noise, and congestion associated with additional vehicle use due to the rebound effect.

Table 2 Undiscounted Annual Monetized Net Benefits & Net Benefits of the Final Program Discounted Back to 2012 at 3% and 7% Discount Rates (Millions, 2010$)

	2017	2020	2030	2040	2050	NPV, 3%[a]	NPV, 7%[a]
Technology Costs	$2,470	$9,190	$35,900	$41,000	$46,500	$561,000	$247,000
Fuel Savings	$651	$7,430	$86,400	$155,000	$212,000	$1,600,000	$607,000
Total Annual Benefits at each assumed SCC value[b]							
5% (avg SCC)	$97	$1,120	$15,300	$28,500	$31,300	$257,000	$118,000
3% (avg SCC)	$138	$1,590	$21,200	$40,000	$47,200	$395,000	$256,000
2.5% (avg SCC)	$171	$1,960	$25,600	$48,400	$58,100	$515,000	$376,000
3% (95th %ile)	$250	$2,890	$38,500	$74,800	$96,900	$743,000	$604,000
Monetized Net Benefits at each assumed SCC value[c]							
5% (avg SCC)	-$1,690	-$316	$68,000	$146,000	$201,000	$1,290,000	$478,000
3% (avg SCC)	-$1,650	$153	$73,900	$158,000	$217,000	$1,430,000	$616,000
2.5% (avg SCC)	-$1,610	$524	$78,300	$166,000	$228,000	$1,550,000	$736,000
3% (95th %ile)	-$1,530	$1,460	$91,200	$192,000	$267,000	$1,780,000	$964,000

Notes:
[a] Net present value of reduced CO_2 emissions is calculated differently than other benefits. The same discount rate used to discount the value of damages from future emissions (SCC at 5, 3, 2.5 percent) is used to calculate net present value of SCC for internal consistency. Refer to the SCC TSD for more detail. Annual costs shown are undiscounted values.
[b] RIA Chapter 7.1 notes that SCC increases over time. For the years 2017-2050, the SCC estimates range as follows: for Average SCC at 5%: $6-$16; for Average SCC at 3%: $26-$47; for Average SCC at 2.5%: $41-$68; and for 95th percentile SCC at 3%: $79-$142. RIA Chapter 7.1 also presents these SCC estimates.
[c] Net Benefits equal Fuel Savings minus Technology Costs plus Benefits.

Chapter 8: Vehicle Sales and Employment Impacts, Chapter 8 provides background on analyses of the impacts of this rule on vehicle sales and employment in the auto industry and closely related sectors. Employment effects due to the rule depend in part on the state of the economy when the rule becomes effective. The auto industry (the directly regulated sector) is expected to require additional labor, due both to increased vehicle production and increased production of fuel-saving technologies. Effects on other sectors vary: though the rule is likely to increase employment at dealerships (due to the estimated increased sales) and parts suppliers, and through consumers' ability to use money not spent on fuel for other purposes, employment is expected to be reduced in fuel production and supply sectors. These analyses provide a fuller picture of the impacts of this rule.

Chapter 9: Small Business Flexibility Analysis, Chapter 9 includes EPA's analysis of the small business impacts due to EPA's final rulemaking. EPA is exempting domestic and foreign businesses that meet small business size definitions established by the Small Business Administration.

Chapter 10: **Alternate Analysis Using 2010 MY Baseline**, Results Using the 2010 Baseline Fleet. In this chapter, EPA presents an alternate analysis using the 2010 based fleet as the input to the Omega model.

8 Vehicle Sales and Employment Impacts

8.1 Vehicle Sales Impacts

8.1.1 How Vehicle Sales Impacts were Estimated for this Rule

Predicting the effects of this rule on vehicle sales entails comparing two competing effects. On the one hand, as a result of this rule, the vehicles will become more expensive, which would, by itself, discourage sales. On the other hand, the vehicles will have improved fuel economy and thus lower operating costs, which makes them more attractive to consumers. As discussed in Preamble III.H.1.a, there are many competing hypotheses for why private markets are not providing what appear to be cost-effective energy-saving technologies, for vehicles as well as for other energy-conservation technologies. There are few empirical studies testing these hypotheses, though. The empirical literature does not provide clear evidence on how much of the value of fuel savings consumers consider at the time of vehicle purchase. It also generally does not speak to the efficiency of manufacturing and dealer pricing decisions. Thus, we do not provide quantified estimates of potential sales impacts.

In previous rulemakings, EPA and NHTSA conducted vehicle sales analyses by comparing the up-front costs of the vehicles with the present value of five years' worth of fuel savings. We assumed that the costs for the fuel-saving technologies would be passed along fully to vehicle buyers in the vehicle prices. The up-front vehicle costs were adjusted to take into account several factors that would affect consumer costs: the increased sales tax that consumers would pay, the increase in insurance premiums, the increase in loan payments that buyers would face, and a higher resale value, with all of these factors due to the higher up-front cost of the vehicle. Those calculations resulted in an adjusted increase in costs to consumers. We then assumed that consumers considered the present value of five years of fuel savings in their vehicle purchase, which is consistent with the length of a typical new light-duty vehicle loan, and is similar to the average time that a new vehicle purchaser holds onto the vehicle.[JJJJJJJJ] The present value of fuel savings was subtracted from technology costs to get a net effect on vehicle cost of ownership. We then used a short-run demand elasticity of -1 to convert a change in price into a change in quantity demanded of vehicles.[KKKKKKKK] An elasticity of -1 means that a 1% increase in price leads to a 1% reduction in quantity sold.

We do not here present a vehicle sales analysis using this approach. This rule takes effect for MY 2017-2025. In the intervening years, it is possible that the assumptions underlying this analysis, as well as market conditions, might change. Instead, Chapter 5.5

[JJJJJJJJ] In this rule, the 5-year payback assumption corresponds to an assumption that vehicle buyers take into account between 30 and 50 percent of the present value of lifetime vehicle fuel savings (with the variation depending on discount rate and model year).

[KKKKKKKK] For a durable good such as an auto, the elasticity may be smaller in the long run: though people may be able to change the timing of their purchase when price changes in the short run, they must eventually make the investment. We request comment on whether or when a long-run elasticity should be used for a rule that phases in over time, as well as how to find good estimates for the long –run elasticity.

includes a payback period analysis to estimate the number of years of fuel savings needed to recover the up-front costs of the new technologies. In other words, the payback period identifies the break-even point for new vehicle buyers. As discussed there, the payback period is 3.2 – 3.4 years for new vehicles, and even shorter for used vehicles (just over 1 year for a 5-year-old MY 2025 vehicle). That chapter also includes an assessment of the lifetime costs and benefits that accrue to a vehicle owner.

8.1.2 Consumer Vehicle Choice Modeling[LLLLLLLL]

An alternative to the vehicle sales analysis approach discussed above is the use of consumer vehicle choice models. In this section we describe some of the consumer vehicle choice models EPA has reviewed in the literature, and we describe the models' results and limitations that we have identified. The evidence from consumer vehicle choice models indicates a huge range of estimates for consumers' willingness to pay for additional fuel economy. Because consumer surplus estimates from consumer vehicle choice models depend critically on this value, we would consider any consumer surplus estimates of the effect of our rule from such models to be unreliable. In addition, the predictive ability of consumer vehicle choice models has not been tested. While vehicle choice models are based on sales of existing vehicles, vehicle models are likely to change, both independently and in response to this rule. The models may not predict well in response to these changes. Instead, we compare the value of the fuel savings associated with this rule with the increase in technology costs. EPA will continue its efforts to review the literature and (as described below) to explore the use of consumer choice modeling but, given the known limitations and uncertainties of vehicle choice models, EPA has not conducted an analysis using these models for this rule.

This rule will lead automakers to change characteristics – in particular, the fuel economy -- of the vehicles they produce. These changes will affect the cost of manufacturing the vehicle; as a result, the prices of the vehicles will also change.

In response to these changes, the number and types of vehicles sold is likely to change. When consumers buy vehicles, they consider both their personal characteristics (such as age, family composition, income, and their vehicle needs) and the characteristics of vehicles (e.g., vehicle size, fuel economy, and price). In response to the changes in vehicle characteristics, consumers will reconsider their purchases. Increases in fuel economy are likely to be attractive to consumers, but increases in price, as well as any detrimental changes in other vehicle characteristics, may be deterrents to purchase. As a result, consumers may choose a different vehicle than they would have purchased in the absence of the rule. The changes in prices and vehicle characteristics are likely to influence consumers on multiple market scales: the total number of new vehicles sold; the mix of new vehicles sold; and the effects of the sales on the used vehicle market.

[LLLLLLLL] This section is drawn heavily from Helfand, Gloria, and Ann Wolverton, "Evaluating the Consumer Response to Fuel Economy: A Review of the Literature." International Review of Environmental and Resource Economics 5 (2011): 103-146.

Consumer vehicle choice modeling (CCM) is a method used to predict what vehicles consumers will purchase based on vehicle characteristics and prices. In principle, it should produce more accurate estimates of total compliance costs compared to models that hold fleet mix constant, since it predicts changes in the fleet mix that can affect total compliance costs. It can also be used to measure changes in consumer surplus, the benefit that consumers perceive from a good over and above the purchase price. (Consumer surplus is the difference between what consumers would be willing to pay for a good, represented by the demand curve, and the amount they actually pay. For instance, if a consumer were willing to pay $30,000 for a new vehicle, but ended up paying $25,000, the $5000 difference would be called consumer surplus.)

A number of consumer vehicle choice models have been developed. They vary in the methods used, the data sources, the factors included in the models, the research questions they are designed to answer, and the results of the models related to the effects of fuel economy on consumer decisions. This section will give some background on these differences among the models.

8.1.2.1 Methods

Consumer choice models (CCMs) of vehicle purchases typically use a form of discrete choice modeling. Discrete choice models seek to explain discrete rather than continuous decisions. An example of a continuous decision is how many pounds of food a farm might grow: the pounds of food can take any numerical value. Discrete decisions can take only a limited set of values. The decision to purchase a vehicle, for instance, can only take two values, yes or no. Vehicle purchases are typically modeled as discrete choices, where the choice is whether to purchase a specified vehicle. The result of these models is a prediction of the probability that a consumer will purchase a specified vehicle. A minor variant on discrete choice models estimates the market share (a continuous variable between 0 and 1) for each vehicle. Because the market share is, essentially, the probability that consumers will purchase a specific vehicle, these approaches are similar in process; they differ mostly in the kinds of data that they use.

The primary methods used to model vehicle choices are nested logit and mixed logit.[MMMMMMMM] In a nested logit, the model is structured in layers. For instance, the first layer may be the choice of whether to buy a new or used vehicle. Given that the person chooses a new vehicle, the second layer may be whether to buy a car or a truck. Given that the person chooses a car, the third layer may be the choice among an economy, midsize, or luxury car. Examples of nested logit models include Goldberg,[490] Greene et al.,[491] and McManus.[492]

In a mixed logit, personal characteristics of consumers play a larger role than in nested logit. While nested logit can look at the effects of a change in average consumer characteristics, mixed logit allows consideration of the effects of the distribution of consumer

[MMMMMMMM] Logit refers to a statistical analysis method used for analyzing the factors that affect discrete choices (i.e., yes/no decisions or the choice among a countable number of options).

characteristics. As a result, mixed logit can be used to examine the distributional effects on various socioeconomic groups, which nested logit is not designed to do. Examples of mixed logit models include Berry, Levinsohn, and Pakes,[493] Bento et al.,[494] and Train and Winston.[495]

While discrete choice modeling appears to be the primary method for consumer choice modeling, others (such as Kleit[496] and Austin and Dinan[497]) have used a matrix of demand elasticities to estimate the effects of changes in cost. The discrete choice models can produce such elasticities. Kleit as well as Austin and Dinan used the elasticities from an internal GM vehicle choice model.

8.1.2.2 Data Sources

The predictions of vehicle purchases from CCMs are based on consumer and vehicle characteristics. The CCMs identify the effects of changing the characteristics on the purchase decisions. These effects are typically called the parameters or coefficients of the models. For instance, the model parameters might predict that an increase in a person's income of 10% would increase the probability of her purchasing vehicle A by 5%, and decrease the probability of her purchasing vehicle B by 10%.

The parameters in CCMs can be developed either from original data sources (estimated models), or using values taken from other studies (calibrated models).

Estimated models use datasets on consumer purchase patterns, consumer characteristics, and vehicle characteristics to develop their original sets of parameters. The datasets used in these studies sometimes come from surveys of individuals' behaviors.[498] Because they draw on the behavior of individuals, they provide what is sometimes called micro-level data. Other studies, that estimate market shares instead of discrete purchase decisions, use aggregated data that can cover long time periods.[499]

Calibrated models rely on existing studies for their parameters. Researchers may draw on results from a number of estimated models, or even from research other than CCM, to choose the parameters of the models. The Fuel Economy Regulatory Analysis Model developed for the Energy Information Administration[500] and the New Vehicle Market Model developed by NERA Economic Consulting[501] are examples of calibrated models.

8.1.2.3 Factors Included in the Models

Consumer choice models vary in their complexity and levels of analysis. Some focus only on the new vehicle market;[502] others consider the choice between new vehicles and an outside good (possibly including a used vehicle);[503] others explicitly consider the relationship between the new and used vehicle markets.[504] Some models include consideration of vehicle miles traveled,[505] though most do not.

The models vary in their inclusion of both consumer and vehicle information. One model includes only vehicle price and the distribution of income in the population influencing choice;[506] others include varying numbers and kinds of vehicle and consumer attributes.

Some models include only the consumer side of the vehicle market;[507] others seek to represent both consumer and producer decisions.[508] Models that include only the consumer side are suitable for reflecting consumer choices, but they do not allow for revisions of vehicle characteristics in response to consumer preferences. Including producer behavior allows for vehicle characteristics such as price and fuel economy to be the result of market forces rather than characteristics of the existing fleet. For instance, in the context of "feebates" (subsidizing fuel-efficient cars with revenue collected by taxing fuel-inefficient vehicles), Greene et al. estimated that 95% of the increase in fuel economy was due to addition of technology rather than changes in vehicles sold.[509] Including auto maker response is a complex exercise. Auto makers are commonly considered to have market power; they can influence the prices that consumers pay to increase their profits. As a result, the price increases that consumers face may reflect strategic factors that could make them higher or lower than the technology costs. In addition, auto makers may seek to influence consumer preferences through marketing and advertising.[510] Even those vehicle choice models that include a producer model may not include much detail, due to computational limits: it is unusual for models to allow both buyers and producers to choose one vehicle characteristic, much less multiple characteristics.[511]

8.1.2.4 Research Questions for the Models

Consumer choice models have been developed to analyze many different research and policy questions. In part, these models have been developed to advance the state of economic modeling. The work of Berry, Levinsohn, and Pakes,[512] for instance, is often cited outside the motor vehicle context for its incorporation of multiple new modeling issues into its framework. In addition, because the vehicle sector is a major part of the U.S. economy and involved in many public policy discussions, research questions cover a wide gamut. These topics have included the effects of voluntary export restraints on Japanese vehicles compared to tariffs and quotas,[513] the market acceptability of alternative-fuel vehicles,[514] the effects of introduction and exit of vehicles from markets,[515] causes of the decline in market shares of U.S. automakers,[516] and the effects of gasoline taxes[517] and "feebates"[518] (subsidizing fuel-efficient cars with revenue collected by taxing fuel-inefficient vehicles).

8.1.2.5 The Effect of Fuel Economy on Consumer Decisions

Consumer vehicle choice models typically consider the effect of fuel economy on vehicle purchase decisions. Fuel economy can appear in various forms in these models.

Some models[519] incorporate fuel economy through its effects on the cost of owning a vehicle. With assumptions on the number of miles traveled per year and the cost of fuel, it is possible to estimate the fuel savings (and perhaps other operating costs) associated with a more fuel-efficient vehicle. Those savings are considered to reduce the cost of owning a vehicle: effectively, they reduce the purchase price. This approach relies on the assumption that, when purchasing vehicles, consumers can estimate the fuel savings that they expect to receive from a more fuel-efficient vehicle and consider the savings equivalent to a reduction in purchase price. The vehicle sales method described in Chapter 8.1.1 uses a variant on this approach, in which it is assumed that consumers consider some fraction of future fuel savings. Turrentine and Kurani[520] question this assumption; they find, in fact, that consumers do not make this calculation when they purchase a vehicle. The question remains, then, how or whether consumers take fuel economy into account when they purchase their vehicles.

Most estimated consumer choice models, instead of making assumptions about how consumers incorporate fuel economy into their decisions, use data on consumer behavior to identify that effect. In some models, miles per gallon is one of the vehicle characteristics included to explain purchase decisions. Other models use fuel consumption per mile, the inverse of miles per gallon, as a measure.[521] Since consumers pay for gallons of fuel, then this measure can assess fuel savings relatively directly.[522] Yet other models multiply fuel consumption per mile by the cost of fuel to get the cost of driving a mile,[523] or they divide fuel economy by fuel cost to get miles per dollar.[524] It is worth noting that these last two measures assume that consumers respond the same way to an increase in fuel economy as they do to a decrease in the price of fuel when each has the same effect on cost per mile driven.[NNNNNNNN] On the one hand, while this assumption does not rely on as complex a calculation as the present value of fuel savings that Turrentine and Kurani examined, it suggests a calculating consumer. On the other hand, using a form of cost per mile is a way to recognize the role of fuel prices in consumers' purchase of fuel economy: recent research[525] presents results that higher fuel prices play a major role in that decision.

Greene and Liu,[526] in a paper published in 1988, reviewed 10 papers using consumer vehicle choice models and estimated for each one how much consumers would be willing to pay at time of purchase to reduce vehicle operating costs by $1 per year. They found that people were willing to pay between $0.74 and $25.97 for a $1 decrease in annual operating costs for a vehicle. This is clearly a very wide range: while the lowest estimate suggests that people are not willing to pay $1 once to get $1 per year reduced costs of operating their vehicles, the maximum suggests a willingness to pay 35 times as high. For comparison, the present value of saving $1 per year for 15 years at a 3% discount rate is $11.94, while a 7% discount rate produces a present value of $8.78. While this study is quite old, it suggests that, at least as of that time, consumer vehicle choice models produced widely varying estimates of the value of reduced vehicle operating costs.

A newer literature review from David Greene[527] suggests continued lack of convergence on the value of increased fuel economy to consumers. Of 27 studies, willingness to pay for fuel economy as a percent of the expected value of fuel savings varied from highly positive to highly negative. Significant numbers of studies found that consumers overvalued fuel economy, undervalued fuel economy, or roughly valued fuel economy correctly relative to fuel savings. Part of the difficulty may be, as these papers note, that fuel economy may be correlated (either positively or negatively) with other vehicle attributes, such as size, power, or quality, not all of which may be included in the analyses; as a result, "fuel economy" may in fact represent several characteristics at the same time. Indeed, Gramlich[528] includes both

[NNNNNNNN] Likewise, these measures assume consumers respond the same way to increases and decreases in cost per mile of driving, as well as if those increases and decreases are large shocks rather than small, gradual changes. The issue of potential asymmetric consumer response to increased fuel efficiency compared to other types of changes to the cost of driving also arises and is discussed in the context of the VMT rebound effect (see Section III.H.4 of the Preamble and Chapter 4.2.5 of the TSD).

fuel cost (dollars per mile) and miles per gallon in his analysis, with the argument that miles per gallon measures other undesirable quality attributes, while fuel cost picks up the consumer's demand for improved fuel economy. Greene finds that, while some of the variation may be explainable due to issues in some of the studies, the variation shows up in studies that appear to be well conducted. As a result, further work needs to be conducted before it is possible to identify the role of fuel economy in consumer purchase decisions.

Some studies[529] argue that automakers could increase profits by increasing fuel economy because the amount that consumers are willing to pay for increased fuel economy outweighs the costs of that improvement. Other studies[530] have found that increasing fuel economy standards imposes welfare losses on consumers and producers, because consumers should already be buying as much fuel economy as they want. In the course of reaching this result, though, at least one of these studies[531] notes that its baseline model implies that consumers are willing to buy more fuel economy than producers have provided; they have to adjust their model to eliminate these "negative-cost" fuel economy improvements.

The models do not appear to yield very consistent results on the role of fuel economy in consumer and producer decisions.

8.1.2.6 Why Market Outcomes May Not Reflect Full Appreciation for Fuel Economy that Pays for Itself

A detailed and wide ranging literature attempts to explain why market outcomes for energy-using products appear to reflect under-investment in energy saving technologies that – at least using a present value calculation based on engineering estimates – appear to pay for themselves. Existing research does not provide a definitive answer to this question. Potential explanations are bounded by two scenarios. On the one hand, purely private benefits of fuel economy (fuel savings, time savings, increases in driving time) must be accompanied by private losses of the same magnitude. However, if there is no such private loss, or if it is small or insignificant, then there is a market or behavioral failure.

This disconnect between net present value estimates of energy-conserving cost savings and what consumers actually spend on energy conservation is often referred to as the Energy Paradox,[532] since consumers appear to undervalue a wide range of investments in energy conservation. There are many possible explanations for the paradox discussed in the literature.[533] Some explanations point to costs or aspects of consumer decision-making unaccounted for in a simple present value calculation, while others point to potential behavioral or market failures. There is little empirical literature to help the analyst determine which combination of hypothesis offers the most credible explanation. Some possibilities include:

- Consumers might be "myopic" and hence undervalue future fuel savings in their purchasing decisions.
- Consumers might lack the information necessary to estimate the value of future fuel savings, or not have a full understanding of this information even when it is presented.

- Consumers may be accounting for uncertainty in future fuel savings when comparing upfront cost to future returns.
- Consumers may consider fuel economy after other vehicle attributes and, as such, not optimize the level of this attribute (instead "satisficing" – that is, selecting a vehicle that is acceptable rather than optimal -- or selecting vehicles that have some sufficient amount of fuel economy).
- Consumers might be especially averse to the short-term losses associated with the higher prices of energy efficient products relative to the future fuel savings (the behavioral phenomenon of "loss aversion").
- Consumers might associate higher fuel economy with inexpensive, less well designed vehicles.
- When buying vehicles, consumers may focus on visible attributes that convey status, such as size, and pay less attention to attributes such as fuel economy that do not visibly convey status.
- Even if consumers have relevant knowledge, selecting a vehicle is a highly complex undertaking, involving many vehicle characteristics. In the face of such a complicated choice, consumers may use simplified decision rules.
- In the case of vehicle fuel efficiency, and perhaps as a result of one or more of the foregoing factors, consumers may have relatively few choices to purchase vehicles with greater fuel economy once other characteristics, such as vehicle class, are chosen.[oooooooo]

The extent to which fuel economy is optimized relative to other, potentially more salient vehicle attributes (such as engine horsepower and seating capacity) in market outcomes for new vehicles remains an important area of uncertainty. There are significant challenges involved in effectively interpreting and anticipating consumer preferences for various vehicle attributes and amenities. There are significant lead times to market, potential return to scale limits on the range of options provided for a given attribute or amenity, market transaction frictional factors, and other factors inherent to the nature of these costly durable goods which may contribute to imperfect satisfaction of market demand for fuel economy among a highly heterogeneous customer base. Both sides of the market would be expected to attempt to maximize the utility they gain from these transactions; they presumably rely heavily in their calculations on the uncertain benefits of savings from fuel economy improvements, and yet market outcomes may still appear to reflect potential foregone opportunities to increase utility. We remain interested in these market dynamics, their

[oooooooo] For instance, in MY 2010, the range of fuel economy (combined city and highway) available among all listed 6-cylinder minivans was 18 to 20 miles per gallon. With a manual-transmission 4-cylinder minivan, it is possible to get 24 mpg. See http://www.fueleconomy.gov, which is jointly maintained by the U.S. Department of Energy and the EPA.

underlying causes, and their potential significance for assessing the potential incremental effects of pollution control standards.

8.1.2.7 Electric Vehicles and Other New Vehicles

Modeling the introduction of new vehicles can be a greater challenge than modeling the existing vehicle market, because the modeler does not have data on how many of the new vehicles consumers buy. Nevertheless, it can be possible to estimate the effects of new vehicle introduction by identifying characteristics for the new vehicles and using those in a vehicle choice model. For instance, as discussed above, the models can estimate effects on the vehicle market when vehicles change their fuel economy or price. If the model incorporates other vehicle attributes important to the new vehicles, such as size, performance, or range, then the effect of the introduction can be modeled by applying the parameters for those features to the new vehicle characteristics.

As discussed above, some models rely on vehicle price as the primary or only explanatory variable. Even in these models, it is possible, with some additional information, to consider the effects of new vehicle introduction. The first step is to find a vehicle similar on as many dimensions as possible to the new vehicle. For instance, if the change is to create an electric vehicle (EV) version of an existing model, then the existing model serves as the base vehicle. Next, it is necessary to measure the changes in vehicle attributes of interest to potential vehicle buyers. For an EV, changes in vehicle driving range and cost of fueling may be two such attributes. The next requirement is information on the value to consumers of the attributes that change between the new and the base vehicle. Multiplying the value for that attribute by the change in the attribute provides an estimate of the benefit or cost associated with changing that characteristic. That amount can then be added to or subtracted from the vehicle purchase price to give an adjusted purchase price reflecting the changed characteristic. This procedure is just an extension of the approach, discussed above, used to incorporate fuel economy improvements into vehicle choice models, by calculating future fuel savings and subtracting them (either in whole or a fraction) from vehicle purchase price.

Incorporating new vehicles into a vehicle choice model, then, requires estimates of the changes in key attributes from conventional vehicles, and estimates of the value, also called the willingness to pay (WTP), that consumers put on those attributes.

Electric vehicles (EVs) will have a number of changes in vehicle characteristics from any baseline model. EVs are likely to have a smaller driving range between refuelings than conventional vehicles, due to the large battery capacity needed to increase range. The ability to recharge at home may be a convenient, desirable feature for people who have garages with electric hookups, but not for people who park on the street. If an infrastructure develops for recharging vehicles with the convenience approaching that of buying gasoline, range or home recharging may become less of a barrier to purchase. The reduced tailpipe emissions and reduced noise may be attractive features to some consumers.[PPPPPPPP] They may have different

[PPPPPPPP] For instance, Hidrue et al. (Hidrue, Michael K., George R. Parsons, Willett Kempton, and Meryl P. Gardner. "Willingness to Pay for Electric Vehicles and their Attributes." Resource and Energy Economics performance or storage capacity. If sufficient data were available, the changes in these attributes, combined with WTP for each of the attributes, could be used to adjust the purchase price of the baseline vehicle to estimate consumers' WTP for the electric version of a vehicle. Greene (2001), for instance, used this approach for a model that simulates choice, not only for EVs, but also for other alternative-fuel vehicles.[534] In that model, he considers only one base vehicle, a passenger car, but considers the effect on WTP of fuel cost per mile, range, acceleration, and several other vehicle attributes.

Vehicle driving range has received attention because of the current paucity of recharging infrastructure: if the driver of an EV gets low on fuel, it may be difficult to find a place to recharge. Because range appears to be a major factor in EV acceptability -- indeed, a factor in the development of plug-in hybrid-electric vehicles is responding to this concern -- it is starting to draw attention in the research community.

In several studies, researchers have used stated preference conjoint analysis to estimate the effect of vehicle range on consumer vehicle choice. In a conjoint analysis, consumers are given a choice between several vehicles with different attributes. One choice might be, for instance, between a baseline car and another car with higher range and a higher purchase price. The choices that consumers make (e.g., how much higher does the purchase price have to be for the consumer not to choose more range?) provide data that can be used to estimate the role of vehicle attributes in the consumer's choice. Stated preference analysis is sometimes considered less reliable than actual market behavior, because what people say they will do in hypothetical situations may not match what they would do in actual situations. On the other hand, stated preference methods can be used to study goods where market data do not exist, such as future market products undergoing development (marketing studies often use stated preference methods), or environmental goods. Because electric vehicles are not in widespread enough use for market studies, stated preference studies are, at this point, one of the few options to examine consumer behavior relating to these vehicles.

Table 8.1-1 summarizes results from several conjoint studies that include the effects of extending range (in the table, from 150 to 300 miles, to present standardized results). Variation of results in the table is from income or other demographic factors, not from confidence intervals. The results suggest that the value of additional range varies among consumers, and the amount of that variation is changing (perhaps shrinking) in more recent studies.

33(3) (2011): 686-705) find that some consumers are willing to pay $5100 more for vehicles with 95% lower emissions than the vehicles they otherwise aim to purchase.

Table 8.1-1 Willingness to Pay for Increasing Range Calculated from Various Studies

Study (Date)	Value of extending range from 150 to 300 miles (dollar year)	Value of additional range in 2010$[a]
Bunch et al. (1993)[b]	$7,600 (1991$)	$11,300
Kavelek (1996) for California Energy Commission[c]	$2600 - $41,900 (1993$)	$3700 - $59,400
Resource Systems Group (2009) for California Energy Commission[d]	$2900 - $7500 (2009$)	$2900 - $7600
Hess et al. (2009), using the same data as Resource Systems Group (2009)[e]	$2400 - $8500 (2009$)	$2400 - $8600
Hidrue et al. (2011)[f]	$3800 - $10,400 (2009$)	$3800 - $10,500

[a]Values adjusted to 2010$ using the Bureau of Economic Analysis GDP deflator.
[b]Bunch, David S., Mark Bradley, Thomas F. Golob, and Ryuichi Kitamura. "Demand for Clean-Fuel Vehicles in California: A Discrete-Choice Stated Preference Pilot Project." Transportation Research Part A 27A(3) (1993): 237-253. The value of range was, in their model, assumed to be the same for all people.
[c]Kavelek, Chris. "CALCARS: The California Conventional and Alternative Fuel Response Simulator." Demand Analysis Office, California Energy Commission, April 1996. The variation in values is due to willingness to pay (WTP) varying by income levels and for one-car and two-car households. The coefficient on range for one-car households was not statistically significantly different from zero (t-statistic = 1.5), but it was for 2-car households (t-statistic = 3.02). The minima and maxima presented here represent the values across both ownership and income categories.
[d]Resource Systems Groups, Inc. "Transportation Fuel Demand Forecast Household and Commercial Fleet Survey Task 8 Report: Logistic Regression Analysis and Results." Prepared for California Energy Commission, June 2009.
[e]Hess, S., T. Adler, M. Fowler and A. Bahreinian "The Use of Cross-nested Logit Models for Multi-Dimensional Choice Processes: The Case of the Demand for Alternative Fuel Vehicles," *Proceedings of the 2009 European Transport Conference*, Leiden, Netherlands, 2009. This study uses the same data as the Resource Systems Group study. The coefficient on range was not statistically significantly different from zero in these regressions: t-statistics varied from 1.29 to 1.52. The variation in values is due to willingness to pay (WTP) varying by income levels and statistical specification. The minima and maxima presented here represent the values across both income categories and specifications.
[f]Hidrue, Michael K., George R. Parsons, Willett Kempton, and Meryl P. Gardner. "Willingness to Pay for Electric Vehicles and their Attributes." Resource and Energy Economics 33(3) (2011): 686-705. The range of values is due to the model separating consumers into "gasoline vehicle-oriented" and "electric vehicle-oriented" groups. The EV-oriented group has higher WTP for additional range.

Driving range may be a major factor in consumers' decisions on EVs, but it is not the only attribute that may be important to potential buyers (e.g., as noted, Hidrue et al. find that some consumers appear willing to pay substantially for reduced tailpipe emissions). A model that does not incorporate the other factors important to consumers' decisions may not perform well in predicting vehicle purchases. In addition, as mentioned above, and as seen in Table 8.1-1, it is likely that the WTP values for attributes of EVs will change over time, particularly if EVs are used more widely, the infrastructure to fuel the vehicles becomes more accessible, and consumers develop more familiarity and understanding of the vehicles. Thus, challenges associated with predicting market shares for EVs are even more serious than those already serious challenges associated with predicting market shares for conventional vehicles.

8.1.2.8 EPA Exploration of Vehicle Choice Modeling

In order to develop greater understanding of these models, EPA is developing a vehicle choice model, although not for this rulemaking. In its current form, the model assumes that the vehicle fleet and all characteristics of each vehicle, except vehicle prices and fuel economy, stay the same. The model will predict changes in the vehicle fleet, at the individual-configuration level and at more aggregated levels, in response to changes in vehicle fuel economy and price.

The EPA model uses a nested logit structure common in the vehicle choice modeling literature, as discussed above in Chapter 8.1.2.1. "Nesting" refers to the decision-tree structure of the model, and "logit" refers to the fact that the choices are discrete (i.e., yes/no decisions about which vehicles to purchase, instead of continuous values).

The nesting involves a hierarchy of choices. In its current form, at the initial decision node, consumers choose between buying a new vehicle or not. Conditional on choosing a new vehicle, consumers then choose between passenger vehicles, cargo vehicles, and ultra-luxury vehicles. The next set of choices subdivides each of these categories into vehicle type (e.g., standard car, minivan, SUV, etc.). Next, the vehicle types are divided into classes (small, medium, and large SUVs, for instance), and then, at the bottom, are the individual vehicle configurations.

At this bottom level, vehicles that are similar to each other (such as standard subcompacts, or prestige large vehicles) end up in the same "nest." Substitution within a nest is considered much more likely than substitution across nests, because the vehicles within a nest are more similar to each other than vehicles in different nests. For instance, a person is more likely to substitute between a Chevrolet Aveo and a Toyota Yaris than between an Aveo and a pickup truck. In addition, substitution is greater at low decision nodes (such as individual configurations) than at higher decision nodes (such as the buy/no buy decision), because there are more choices at lower levels than at higher levels.

Parameters for the model (including demand elasticities and the value of fuel economy in purchase decisions) were selected based on a review of values found in the literature on vehicle choice modeling. As discussed above, a number of studies have estimated these parameters. Those estimates, combined with some theoretical requirements,[QQQQQQQQ] assist in assigning values for the parameters. The model will allow individual users to change those parameters.

The fuel economy of a vehicle is used to adjust the price of the vehicle, using a version of the procedure discussed in Chapter 8.1.2.7: the value that the consumer places on fuel economy is multiplied by the change in fuel economy and incorporated into the "effective

[QQQQQQQQ] The theory of nested logit requires that the price slopes (the change in utility as vehicle full price changes, a measure of consumer responsiveness to price changes) must be higher in absolute value for lower nests. This condition reflects the point, discussed above, that substitution is greater at lower decision notes than at higher ones.

price" of the vehicle. In practice, implementing this calculation involves calculating the change in expenditures on fuel based on schedules of VMT, vehicle survival, and fuel prices in the future consistent with those in OMEGA. As discussed in Chapter 8.1.2.5, there is no consensus value for consumers' willingness to pay for improved fuel economy: estimates vary tremendously. The model assumes that consumers will use some years of discounted fuel savings, with the modeler able to input both the number of years and the discount rate to be used in the analysis.

The vehicle choice model takes as inputs an initial fleet of vehicles (including the initial sales and fuel economy) in the absence of standards, the cost of technologies added to each vehicle to comply with standards, and the change in fuel economy. With the initial sales mix, for each vehicle, the model calculates a vehicle-specific constant that summarizes the value of all attributes of the vehicle other than price and fuel economy. This constant ensures that the model will predict changes in consumer response that would result only from changes in price and fuel economy. This constant substitutes for estimating the effects of changes in all other vehicle characteristics; the underlying assumption is that these other vehicle characteristics do not change.[RRRRRRRR] For instance, it assumes that a Ford Escape will not change in size, power, or accessories; the only changes will be to its cost and its fuel economy.

The model assumes that the increase in vehicle cost associated with increased technology is fully passed through as an increase in vehicle price, and some years of fuel savings (which the modeler may select) offset this price increase. It then calculates changes in total fleet size and in sales mix, at the individual-configuration level and at the level of vehicle class, due to the changes in fuel economy and vehicle prices. It also calculates changes in consumer surplus associated with the changes in fuel economy and vehicle prices.

The model has undergone peer review.[535] The reviewers were generally supportive of the model structure and parameters, with two major qualifications.

First, peer reviewers recommended that the model should interact closely with OMEGA, EPA's technology cost and effectiveness model, and its appropriate use may depend on that interaction. For instance, it is possible that the predicted changes in fleet mix will lead to predictions of vehicle sales for auto makers that do not meet the standards, because the mix and volume of vehicles sold changed from the initial levels. To correct this problem, it is necessary to feed the new fleet mix back into OMEGA (which calculates costs and compliance) and get a new set of output, which is then fed back into the vehicle choice model. OMEGA increases technologies, and thus costs, to improve compliance; those adjustments would then again affect vehicle demand. We expect that this iterative process would converge to a fleet mix that would meet standards. Performing this iteration requires development of an interface between the vehicle choice model and OMEGA to ensure accurate transmission of data between the models. At this time, the vehicle choice model

[RRRRRRRR] As explained in Section III.D of the preamble, as part of the technology cost analysis for the rule, the agencies have estimated the cost of maintaining all vehicle utility, with minor exceptions.

takes output from OMEGA, but the results of the modeling do not feed easily back into OMEGA. Building this interface is an expected part of our future modeling work.

Second, the peer review raised the issue of the uncertainties surrounding the model parameters and suggested the development of capacity to conduct uncertainty analysis. As discussed in Section 8.1.2.5, the role of fuel economy in consumer decisions is one source of uncertainty; the price slopes used for the different nests are also not known with certainty. EPA agrees that use of the model should involve, at the least, sensitivity analysis over key parameters, and we plan to investigate greater incorporation of uncertainty analysis in the model.

We note as well that the current model does not take EVs or other alternatively fueled vehicles into account. As discussed in Section 8.1.2.7, the values for willingness to pay for features such as range and different refueling infrastructures appear to be subject to great uncertainty. EPA's current model does not include these vehicles, because we are seeking to gain experience and confidence with the modeling where it is likely to work best before we investigate modeling where more uncertainty is involved. The incorporation of new vehicles of any kind in the modeling is another area for future work.

As discussed in Preamble Section III.H.1, EPA is not using its preliminary consumer choice model in this rulemaking because we believe it needs further development and testing before we have confidence in its use. As the peer reviewers noted, it has not yet been integrated with OMEGA, an important step for ensuring that changes in the vehicle fleet estimated by the model will result in a fleet compliant with the standards. In addition, concerns remain that vehicle choice models have rarely been validated against real-world data. In response to these concerns, we would expect any use of the model to involve, at the least, a number of sensitivity analyses to examine the robustness of results to key parameters. We will continue model development and testing to understand better the results and limitations of using the model.

8.1.2.9 Summary and Additional Considerations

Consumer vehicle choice modeling in principle could provide a great deal of useful information for regulatory analysis, helping to answer some of the central questions about relevant effects on consumer welfare. In practice, the advantages depend on the success of models in predicting changes in fleet size and mix.

First, consumer vehicle choice modeling has the potential to describe more accurately the impact of a policy, by identifying market shifts. More accurate description of the market resulting from a policy can improve other estimates of policy impacts, such as the change in total vehicle emissions or vehicle miles traveled. The predictive ability of models, though, is not proven.

Vehicle choice models can incorporate the effects on consumer decisions of changes in vehicle characteristics, if there are estimates of the value that consumers put on changes in those characteristics. These willingness-to-pay values may, however, be sensitive to the ways they are estimated, as indicated in the discussion of the value that consumers place on fuel economy in their purchase decisions. Especially for characteristics associated with advanced technology vehicles, such as EVs, the willingness-to-pay values may change over time as consumers develop more experience with the vehicles and these characteristics. Models based on current estimates may not predict well for the future.

Consumer choice modeling has the potential to improve estimates of the compliance costs of a rule. Consumers can either accept the new costs and vehicle characteristics, or they can change which vehicles they buy. Using a vehicle choice model is likely to reduce estimated compliance costs: because the model allows consumers to choose among accepting the new vehicle, buying a different vehicle, or not buying a vehicle, the model assumes that consumers have additional options, which improves their welfare relative to the assumption that consumers will not change their buying behavior.

An additional complication associated with consumer choice modeling is accurate prediction of producers' responses to the rule. While it is possible to include auto makers' decisions (for instance, on setting prices) into vehicle choices, computational limits affect the richness of these models. In addition, the pricing paths predicted by these models have not, to our knowledge, been tested against actual behavior; and auto makers may not pass along vehicle costs in the same way in the future as they have in the past. Technology costs, while an accurate measure of the opportunity cost of resources to society, may overestimate or underestimate the effect on the prices that consumers face.

Consumer choice models can be used to calculate consumer surplus impacts on vehicle purchase decisions. Because these values are based on the estimates of changes in vehicle sales and fleet mix, consumer surplus measures may not be accurate if the changes in vehicle sales and fleet mix are not well estimated.

Principles of welfare analysis can be useful for understanding the role of consumer vehicle choice models in benefit-cost analysis. In particular, except for EVs, the technology cost estimates developed in this rule take into account the costs to hold other vehicle attributes, such as size and performance, constant. In addition, the analysis assumes that the full technology costs are passed along to vehicle buyers. With these assumptions, because welfare losses are monetary estimates of how much buyers would have to be compensated to be made as well off as in the absence of the change,[SSSSSSSS] the price increase measures the loss to the buyer.[TTTTTTTT] Assuming that the full technology cost gets passed along to the

[SSSSSSSS] This approach describes the economic concept of compensating variation, a payment of money after a change that would make a consumer as well off after the change as before it. A related concept, equivalent variation, estimates the income change that would be an alternative to the change taking place. The difference between them is whether the consumer's point of reference is her welfare before the change (compensating variation) or after the change (equivalent variation). In practice, these two measures are typically very close together.

[TTTTTTTT] Indeed, it is likely to be an overestimate of the loss to the buyer, because the buyer has choices other than buying the same vehicle with a higher price; she could choose a different vehicle, or decide not to buy a new vehicle. The buyer would choose one of those options only if the alternative involves less loss than paying the higher price. Thus, the increase in price that the buyer faces would be the upper bound of loss of consumer buyer as an increase in price, the technology cost thus measures the welfare loss to the buyer. Increasing fuel economy would have to lead to other changes in the vehicles that buyers find undesirable for there to be additional losses not included in the technology costs.

Given the current limitations in modeling the role of fuel economy in vehicle purchase decisions, and limitations in modeling market responses to the new regulations, in this rule EPA holds constant the vehicle fleet size and mix in its calculations of the impacts of this rule, and compares the fuel and other savings that consumers will receive with the technology costs of the vehicles. EPA continues to explore options for including consumer and producer choice in modeling the impacts of fuel economy-related regulations. This effort includes further review of existing consumer vehicle choice models, the estimates of consumers' willingness to pay for increased fuel economy, and overall effects on consumer welfare, as well as EPA's further development of its vehicle choice model for use in the future.

8.1.3 Impact of the Rule on Affordability of Vehicles and Low-Income Households

Because this rule is expected to increase the up-front costs of vehicles, with the fuel savings that recover those costs coming in over time, questions have arisen about the effects of this rule on whether access to credit may limit consumers' ability to purchase new vehicles, on low-income households, and on the availability of low-priced vehicles. Section III.H.11.b. of the Preamble discusses these issues in the context of public comments received on the rule; here we provide some background and information on sources of data in that discussion.

When a lender is deciding whether to issue a loan to a prospective vehicle buyer, the amount of the vehicle loan and the person's income are two major factors in the loan application. If lenders in fact restrict themselves to consideration of only those two factors, then the higher up-front costs of the new vehicles subject to this rule would reduce buyers' abilities to get loans. The fuel savings would not come into play to counter-balance this cost, even though, as shown in the payback period analysis (RIA Chapter 5.5), the fuel savings exceed the increased loan payments from the first month of the loan. Thus, if lenders do not take fuel savings into account in providing loans, people who are borrowing near the limit of their abilities to borrow will either have to change what vehicles they buy, or not buy vehicles at all.

On the other hand, some evidence suggests that the loan market may evolve to take fuel savings into greater account in the lending decision. Some lenders currently give discounts for loans to purchase more fuel-efficient vehicles.[536] An internet search on the term "green auto loan" produced more than 50 lending institutions that provide reduced loan rates for more fuel-efficient vehicles.[537] Indeed, it is possible (though unknown at this time) that the auto loan market may evolve to include further consideration of fuel savings, as those savings play a significant factor in offsetting the increase in up-front costs of vehicles.

welfare, unless there are other changes to the vehicle due to the fuel economy improvements that make the vehicle less desirable to buyers.

It is possible that future trends in the auto loan market may affect future vehicle sales. It is also possible that some people who have significant debt loads may not be able to get financing for some of these new vehicles; they may have to buy different vehicles (including used vehicles) or delay purchase. For others who borrow on credit, though, as discussed in RIA Chapter 5.5, the fuel savings are expected to outweigh the increased loan costs from the time of vehicle purchase. The rule thus may make vehicles more affordable to the public, by reducing consumers' vulnerability to fuel price jumps.

The effects of this rule on low-income households depends on its impacts, not only in the new vehicle market, but also in the used vehicle market. Two sources of information on vehicle ownership by income are the 2010 Consumer Expenditure Survey (CES) conducted by the Bureau of Labor Statistics,[538] and the 2007 Survey of Consumer Finances (SCF) conducted by the Federal Reserve System.[539] The Consumer Expenditure Survey data indicate that, though the average household spent more on vehicle purchases ($2,588) than on gasoline and oil ($2,132), households in the bottom 40 percent of income spent more on fuel ($1,304) than on vehicles ($1,106); in addition, they spent more on used vehicles ($756) than on new vehicles ($330). Households in the lowest 20 percent of income spent only $127 on new vehicles, $497 on used vehicles, and $1,009 on fuel. These data suggest that the used-vehicle market is more important for low-income households than the new-vehicle market, and that they are more vulnerable to changes in fuel prices than they are to changes in vehicle prices. The Survey of Consumer Finances asks households about purchase information in a number of categories, including vehicles. For the 2007 survey, we identified the households in the survey who had bought MY 2007 or 2008 vehicles, and further looked at the income categories for those consumers. Those with income less than $35,200 (the maximum income for those in the bottom 40 percent of income in the CES) bought about 17 percent of new vehicles; those with income below $18,400 (the bottom quintile) bought fewer than 2 percent of new vehicles. These data further support the idea that low-income households are more affected by the impact of the rule on the used-vehicle market than on the new-vehicle market.

The effect of this rule on the used vehicle market will be related to its effects on new vehicle prices, the fuel efficiency of new vehicle models, the fuel efficiency of used vehicles, and the total sales of new vehicles. If the value of fuel savings resulting from improved fuel efficiency to the typical potential buyer of a new vehicle outweighs the average increase in new models' prices, sales of new vehicles could rise, and the used vehicle market may increase in volume as new vehicle buyers sell their older vehicles. In this case, low-income households are likely to benefit from the increased availability of used vehicles. However, if potential buyers value future fuel savings resulting from the increased fuel efficiency of new models at less than the increase in their average selling price, sales of new vehicles will decline, and the used vehicle market may decrease in volume as people hold onto their vehicles longer. In this case, low-income households are likely to face increased costs due to reduced availability of used vehicles. Because, as discussed in 8.1.1, we have not estimated the effects of the rule on the new vehicle market, and because we do not have a good model of the relationship between the new and used vehicle markets, we do not have estimates of the impact of this rule on the used vehicle market. However, due to the significant effect of the rule on fuel savings, especially for used vehicles (see RIA Chapter 5.5), we expect low-income households to benefit from the more rapid payback period for used vehicles, though some of this benefit may be affected by the net effect of this rule on the prices and availability of used vehicles.

The low-priced vehicle segment of the market may also deserve consideration, because it may be an entry point for first-car buyers. Vehicles in the low-priced (economy-class) segment will bear technology costs needed to meet the new standards, but it is not known how manufacturers will decide to pass on these costs across their vehicle fleets, including in the low-priced vehicle segment. If manufacturers decide to pass on the full cost of compliance in this segment, then it is possible that consumers who might barely afford new vehicles may be priced out of the new-vehicle market or may not have access to loans. As discussed above, the rule's impacts on availability of loans is unclear, because some lenders do factor fuel economy into their loans, and it is possible that this trend may expand. In addition, auto makers have some flexibility in how both technologies and price changes are applied to these vehicles; auto makers have ways to keep some vehicles in the low-priced vehicle segment if they so choose. Though the rule is expected to increase the prices of these vehicles, the degrees of price increase and the impacts of the price increases, especially when combined with the fuel savings that will accompany these changes, are much less clear.

In summary, we recognize that this rule may have impacts on consumers' access to loans for new vehicles, on low-income households, and on the market for low-priced vehicles; less clear are the directions of these effects. Lenders who only consider consumers' debt-to-income ratios may reduce consumers' abilities to purchase more expensive vehicles, but some lenders already take the fuel efficiency of vehicles into account. Low-income households will benefit from reduced fuel costs; we do not estimate the direction of effects of this rule on used vehicle prices, which are more relevant for low-income households than effects on new vehicles. The effects of this rule on low-priced vehicles depends on how manufacturers add technologies and price vehicles in this segment; they have flexibility to keep some vehicles in this segment if they so wish.

8.2 Employment Impacts

8.2.1 Introduction

Although analysis of employment impacts is not part of a cost-benefit analysis (except to the extent that labor costs contribute to costs), employment impacts of federal rules are of particular concern in the current economic climate of sizeable unemployment. When President Obama requested that the agencies develop this program, he sought a program that would "strengthen the [auto] industry and enhance job creation in the United States."[540,UUUUUUUU] The recently issued Executive Order 13563, "Improving Regulation and Regulatory Review" (January 18, 2011), states, "Our regulatory system must protect public health, welfare, safety, and our <u>environment</u> while promoting economic growth, innovation,

[UUUUUUUU] The May 21, 2010 Presidential Memorandum also requested that EPA and NHTSA, in developing the technical assessment to inform the rulemaking process (which was issued by the agencies and CARB on September 30, 2010), include, among other things, the "impacts on jobs and the automotive manufacturing base in the United States."

competitiveness, and job creation" (emphasis added). EPA is accordingly providing partial estimates of the effects of this rule on domestic employment in the auto manufacturing and parts sectors, while qualitatively discussing how it may affect employment in other sectors more generally.

This rule is expected to affect employment in the United States through the regulated sector – the auto manufacturing industry – and through several related sectors, specifically, industries that supply the auto manufacturing industry (e.g., vehicle parts), auto dealers, the fuel refining and supply sectors, and the general retail sector. According to the U.S. Bureau of Labor Statistics, in 2010, about 677,000 people in the U.S. were employed in Motor Vehicle and Parts Manufacturing Sector (NAICS 3361, 3362, and 3363). About 129,000 people in the U.S. were employed in the Automobile and Light Truck Manufacturing Sector (NAICS 33611) in December 2010; this is the directly regulated sector, since it encompasses the auto manufacturers that are responsible for complying with the standards.[541] Changes in light duty vehicle sales, discussed in Chapter 8.1.1, could affect employment for auto dealers. The employment effects of this rule are expected to expand beyond the regulated sector. Though some of the parts used to achieve the standards are likely to be built by auto manufacturers themselves, the auto parts manufacturing sector also plays a significant role in providing those parts, and will also be affected by changes in vehicle sales. As discussed in Chapter 5.4 of this RIA, this rule is expected to reduce the amount of fuel these vehicles use, and thus affect the petroleum refinery and supply industries. Finally, since the net reduction in cost associated with this rule is expected to lead to lower household expenditures on fuel net of vehicle costs, consumers then will have additional discretionary income that can be spent on other goods and services.

When the economy is at full employment, an environmental regulation is unlikely to have much impact on net overall U.S. employment; instead, labor would primarily be shifted from one sector to another. These shifts in employment impose an opportunity cost on society, approximated by the wages of the employees, as regulation diverts workers from other activities in the economy. In this situation, any effects on net employment are likely to be transitory as workers change jobs (e.g., some workers may need to be retrained or require time to search for new jobs, while shortages in some sectors or regions could bid up wages to attract workers).

On the other hand, if a regulation comes into effect during a period of high unemployment, a change in labor demand due to regulation may affect net overall U.S. employment because the labor market is not in equilibrium. In such a period, both positive and negative employment effects are possible.[vvvvvvvv] Schmalansee and Stavins point out that net positive employment effects are possible in the near term when the economy is at less than full employment due to the potential hiring of idle labor resources by the regulated sector to meet new requirements (e.g., to install new equipment) and new economic activity in sectors related to the regulated sector.[542] In the longer run, the net effect on employment is more difficult to predict and will depend on the way in which the related industries respond to

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[vvvvvvvv] Masur and Posner, available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1920441 the regulatory requirements. As Schmalansee and Stavins note, it is possible that the magnitude of the effect on employment could vary over time, region, and sector, and positive effects on employment in some regions or sectors could be offset by negative effects in other regions or sectors. For this reason, they urge caution in reporting partial employment effects since it can "paint an inaccurate picture of net employment impacts if not placed in the broader economic context."

It is assumed that the official unemployment rate will have declined to 5.3 percent by the time by the time this rule takes effect and so the effect of the regulation on labor will be to shift workers from one sector to another.[wwwwwwww] Those shifts in employment impose an opportunity cost on society, approximated by the wages of the employees, as regulation diverts workers from other activities in the economy. In this situation, as discussed above, any effects on net employment are likely to be transitory. It is also possible that the state of the economy will be such that positive or negative employment effects will occur.

A number of different approaches have been used in published literature to conduct employment analysis. This section describes some of the common methods, as well as some of their limitations.

8.2.2 Approaches to Quantitative Employment Analysis

Measuring the employment impacts of a policy depend on a number of inputs and assumptions. For instance, as discussed, assumptions about the overall state of unemployment in the economy play a major role in measured job impacts. The inputs to the models commonly are the changes in quantities or expenditures in the affected sectors; model results may vary in different studies depending on the assumptions about the levels of those inputs, and which sectors receive those changes. Which sectors are included in the study can also affect the results. For instance, a study of this program that looks only at employment impacts in the refinery sector may find negative effects, because consumers will purchase less gasoline; a study that looks only at the auto parts sector, on the other hand, may find positive impacts, because the program will require redesigned or additional parts for vehicles. In both instances, these would only be partial perspectives on the overall change in national employment due to Federal regulation.

8.2.2.1 Conceptual Framework for Employment Impacts in the Regulated Sector

One study by Morgenstern, Pizer, and Shih[543] provides a retrospective look at the impacts of regulation in employment in the regulated sectors by estimating the effects on employment of spending on pollution abatement for four highly polluting/regulated U.S. industries (pulp and paper, plastics, steel, and petroleum refining) using data for six years between 1979 and 1991. The paper provides a theoretical framework that can be useful for examining the impacts of a regulatory change on the regulated sector in the medium to longer

[wwwwwwww] Office of Management and Budget, "Fiscal Year 2012 Mid-Session Review: Budget of the U.S. Government." http://www.whitehouse.gov/sites/default/files/omb/budget/fy2012/assets/12msr.pdf , p. 10.

term. In particular, it identifies three separate ways that employment levels may change in the regulated industry in response to a new (or more stringent) regulation.

- *Demand effect*: higher production costs due to the regulation will lead to higher market prices; higher prices in turn reduce demand for the good, reducing the demand for labor to make that good. In the authors' words, the "extent of this effect depends on the cost increase passed on to consumers as well as the demand elasticity of industry output."

- *Cost effect*: as costs go up, plants add more capital and labor (holding other factors constant), with potentially positive effects on employment. In the authors' words, as "production costs rise, more inputs, including labor, are used to produce the same amount of output."

- *Factor shift effect*: post-regulation production technologies may be more or less labor-intensive (i.e., more/less labor is required per dollar of output). In the authors' words, "environmental activities may be more labor intensive than conventional production," meaning that "the amount of labor per dollar of output will rise," though it is also possible that "cleaner operations could involve automation and less employment, for example."

According to the authors, the "demand effect" is expected to have a negative effect on employment,[XXXXXXXX] the "cost effect" to have a positive effect on employment, and the "factor shift effect" to have an ambiguous effect on employment. Without more information with respect to the magnitudes of these competing effects, it is not possible to predict the total effect environmental regulation will have on employment levels in a regulated sector.

The authors conclude that increased abatement expenditures generally have not caused a significant change in employment in those sectors. More specifically, their results show that, on average across the industries studied, each additional $1 million spent on pollution abatement results in a (statistically insignificant) net increase of 1.5 jobs.

This approach to employment analysis has the advantage of carefully controlling for many possibly confounding effects in order to separate the effect of changes in regulatory costs on employment. It was, however, conducted for only four sectors. It could also be very difficult to update the study for other sectors, because one of the databases on which it relies, the Pollution Abatement Cost and Expenditure survey, has been conducted infrequently since 1994, with the last survey conducted in 2005. The empirical estimates provided by Morgenstern et al. are not relevant to the case of fuel economy standards, which are very different from the pollution control standards on industrial facilities that were considered in

[XXXXXXXX] As will be discussed below, the demand effect in this rule is potentially an exception to this rule. While the vehicles become more expensive, they also produce reduced fuel expenditures; the reduced fuel costs provide a countervailing impact on vehicle sales. As discussed in Preamble Section III.H.1, this possibility that vehicles may become more attractive to consumers after the program poses a conundrum: why have interactions between vehicle buyers and producers not provided these benefits without government intervention?

that study. In addition, it does not examine the effects of regulation on employment in sectors related to but outside of the regulated sector. Nevertheless, the theory that Morgenstern et al. developed continues to be useful in this context.

The following discussion of additional methodologies draws from Berck and Hoffmann's review of employment models.[544]

8.2.2.2 Computable General Equilibrium (CGE) Models

Computable general equilibrium (CGE) models are often used to assess the impacts of policy. These models include a stylized representation of supply and demand curves for all major markets in the economy. The labor market is commonly included. CGE models are very useful for looking at interaction effects of markets: "they allow for substitution among inputs in production and goods in consumption." Thus, if one market experiences a change, such as a new regulation, then the effects can be observed in all other markets. As a result, they can measure the employment changes in the economy due to a regulation. Because they usually assume equilibrium in all markets, though, they typically lack involuntary unemployment. If the total amount of labor changes, it is due to people voluntarily entering or leaving the workforce. As a result, these models may not be appropriate for measuring effects of a policy on unemployment, because of the assumption that there is no involuntary unemployment. In addition, because of the assumptions of equilibrium in all markets and forward-looking consumers and firms, they are designed for examining the long-run effects of a policy but may offer little insight into its short-run effects.

8.2.2.3 Input-Output (IO) Models

Input-output models represent the economy through a matrix of coefficients that describe the connections between supplying and consuming sectors. In that sense, like CGE models, they describe the interconnections of the economy. These interconnections look at how changes in one sector ripple through the rest of the economy. For instance, a requirement for additional technology for vehicles requires additional steel, which requires more workers in both the auto and steel sectors; the additional workers in those sectors then have more money to spend, which leads to more employment in retail sectors. These are known as "multiplier" effects, because an initial impact in one sector gets multiplied through the economy. Unlike CGE models, input-output models have fixed, linear relationships among the sectors (e.g., substitution among inputs or goods is not allowed), and quantity supplied need not equal quantity demanded. In particular, these models do not allow for price changes – an increase in the demand for labor or capital does not result in a change in its price to help reallocate it to its best use. As a result, these models cannot capture opportunity costs from using resources in one area of the economy over another. The multipliers take an initial impact and can increase it substantially.

IO models are commonly used for regional analysis of projects. In a regional analysis, the markets are commonly considered small enough that wages and prices are determined outside the region, and any excess supply or demand is due to exports and imports (or, in the case of labor, emigration or immigration). For national-level employment analysis, the use of input-output models requires the assumption that workers flow into or out of the labor market perfectly freely. Wages do not adjust; instead, people join into or depart from the labor pool as production requires them. For other markets as well, there is no substitution of less expensive inputs for more expensive ones. As a result, IO models provide an upper bound on employment impacts. As Berck and Hoffmann note, "For the same reason, they can be thought of as simulating very short-run adjustment," in contrast to the CGE's implicit assumption of long-run adjustment. Changes in production processes, introductions of new technologies, or learning over time due to new regulatory requirements are also generally not captured by IO models, as they are calibrated to already established relationships between inputs and outputs.

8.2.2.4 Hybrid Models

As Berck and Hoffmann note, input-output models and CGE models "represent a continuum of closely related models." Though not separately discussed by Berck and Hoffmann, some hybrid models combine some of the features of CGE models (e.g., prices that can change) with input-output relationships. For instance, a hybrid model may include the ability to examine disequilibrium phenomena, such as labor being at less than full employment. Hybrid models depend on assumptions about how adjustments in the economy occur. CGE models characterize equilibria but say little about the pathway between them, while IO models assume that adjustments are largely constrained by previously defined relationships; the effectiveness of hybrid models depends on their success in overcoming the limitations of each of these approaches. Hybrid models could potentially be used to model labor market impacts of various vehicle policy options although a number of judgments need to be made about the appropriate assumptions underlying the model as well the empirical basis for the modeling results.

8.2.2.5 Single Sectors

It is possible to conduct a bottom-up analysis of the partial effect of regulation on employment in a single sector by estimating the change in output or expenditures in a sector and multiplying it by an estimate of the number of workers per unit of output or expenditures, under the assumption that labor demand is proportional to output or expenditures. As Berck and Hoffmann note, though, "Compliance with regulations may create additional jobs that are not accounted for." While such an analysis can approximate the effects in that one sector in a simple way, it also may miss important connections to related sectors.

8.2.2.6 Ex-Post Econometric Studies

A number of ex-post econometric analyses examine the net effect of regulation on employment in regulated sectors. Morgenstern, Pizer, and Shih (2002), discussed above, and Berman and Bui (2001) are two notable examples that rely on highly disaggregated establishment-level time series data to estimate longer-run employment effects.[545] While often a sophisticated treatment of the issues analyzed, these studies commonly analyze specific scenarios or sectors in the past; care needs to be taken in extrapolating their results to other scenarios and to the future. For instance, neither of these two studies examines the auto industry and are therefore of limited applicability in this context.

8.2.2.7 Summary

All methods of estimating employment impacts of a regulation have advantages and limitations. CGE models may be most appropriate for long-term impacts, but the usual assumption of equilibrium in the employment market means that it is not useful for looking at changes in overall employment: overall levels are likely to be premised on full employment. IO models, on the other hand, may be most appropriate for small-scale, short-term effects, because they assume fixed relationships across sectors and do not require market equilibria. Hybrid models, which combine some features of CGEs with IO models, depend upon key assumptions and economic relationships that are built into them. Single-sector models are simple and straightforward, but they are often based on the assumptions that labor demand is proportional to output, and that other sectors are not affected. Finally, econometric models have been developed to evaluate the longer-run net effects of regulation on sector employment, though these are ex-post analyses commonly of specific sectors or situations, and the results may not have direct bearing for the regulation being reviewed.

8.2.3 Employment Analysis of This Rule

As mentioned above, this program is expected to affect employment in the regulated sector (auto manufacturing) and in other sectors directly affected by the rule: auto parts suppliers, auto dealers, and the fuel supply market (which will face reduced petroleum production due to reduced fuel demand but which may see additional demand for electricity or other fuels). Changes in consumer expenditures due to higher vehicle costs and lower fuel expenses will also affect employment. In addition, as the discussion above suggests, each of these sectors could potentially have ripple effects in the rest of the economy. These ripple effects depend much more heavily on the state of the macroeconomy than do the direct effects. At the national level, employment may increase in one industry or region and decrease in another, with the net effect being smaller than either individual-sector effect. EPA does not attempt to quantify the net effects of the regulation on overall national employment.

The discussion that follows provides a partial, bottom-up quantitative estimate of the effects of this rule on the regulated sector (i.e., the auto industry; for reasons discussed below, we include some quantitative assessment of effects on suppliers to the auto industry although suppliers are not regulated directly). It also includes qualitative discussion of the effects of the rule on other sectors. Focusing quantification of employment impacts on the regulated sector has some advantages over quantifying all impacts. First, the analysis relies on data generated as part of the rulemaking process, which focuses on the regulated sector; as a result, what is presented here is based on internally consistent assumptions and estimates made in this rule. Second, as discussed above, net effects on employment in the economy as a whole depend heavily on the overall state of the economy when this rule has its effects. Focusing on the regulated sector provides insight into employment effects in that sector without having to make assumptions about the state of the economy when this rule has its impacts. We include a qualitative discussion of employment effects on other sectors to provide a broader perspective on the impacts of this rule.

As noted above, in a full-employment economy, any changes in employment will result from people changing jobs or voluntarily entering or exiting the workforce. In a full-employment economy, employment impacts of this rule will change employment in specific sectors, but it will have small, if any, effect on aggregate employment. This rule would take effect in model years 2017 through 2025; by then, the current high unemployment may be moderated or ended. For that reason, this analysis does not include multiplier effects, but instead focuses on employment impacts in the most directly affected industries. Those sectors are likely to face the most concentrated employment impacts.

8.2.3.1 Employment Impacts in the Auto Industry

Following the Morgenstern et al. conceptual framework for the impacts of regulation on employment in the regulated sector, we consider three effects for the auto sector: the demand effect, the cost effect, and the factor shift effect. However, we are only able to offer quantitative estimates for the cost effect. We note that these estimates, based on extrapolations from current data, become more uncertain as time goes on.

8.2.3.1.1 The Demand Effect

The demand effect depends on the effects of this rule on vehicle sales. If vehicle sales increase, then more people will be required to assemble vehicles and their components. If vehicle sales decrease, employment associated with these activities will unambiguously decrease. Unlike in Morgenstern et al.'s study, where the demand effect decreased employment, there are countervailing effects in the vehicle market due to the fuel savings resulting from this program. On one hand, this rule will increase vehicle costs; by itself, this effect would reduce vehicle sales. On the other hand, this rule will reduce the fuel costs of operating the vehicle; by itself, this effect would increase vehicle sales, especially if potential buyers have an expectation of higher fuel prices. The sign of demand effect will depend on which of these effects dominates. Because, as described in Chapter 8.1, we have not quantified the impact on sales for this rule, we do not quantify the demand effect.

8.2.3.2 The Cost Effect

The demand effect, discussed above, measures employment changes due to new vehicle sales only. The cost effect measures employment impacts due to the development, manufacturing, and installation by auto suppliers and manufacturers of the new or additional technologies needed for vehicles to comply with the standards.

One way to estimate the cost effect, given the cost estimates for complying with the rule, is to use the ratio of workers to each $1 million of expenditures in that sector. The use of these ratios has both advantages and limitations. It is often possible to estimate these ratios for quite specific sectors of the economy: for instance, it is possible to estimate the average number of workers in the light-duty vehicle manufacturing sector per $1 million spent in the sector, rather than use the ratio from another, more aggregated sector, such as motor vehicle manufacturing. As a result, it is not necessary to extrapolate employment ratios from possibly unrelated sectors. On the other hand, these estimates are averages for the sectors, covering all the activities in those sectors; they may not be representative of the labor required when expenditures are required on specific activities, as the factor shift effect (discussed below) indicates. For instance, the ratio for the motor vehicle manufacturing sector represents the ratio for all vehicle manufacturing, not just for fuel efficiency improvements. In addition, these estimates do not include changes in sectors that supply these sectors, such as steel or electronics producers. They thus may best be viewed as the effects on employment in the auto sector due to the changes in expenditures in that sector, rather than as an assessment of all employment changes due to these changes in expenditures.

Some of the costs of this rule will be spent directly in the auto manufacturing sector, but some of the costs will be spent in the auto parts manufacturing sector. Because we do not have information on the proportion of expenditures in each sector, we separately present the ratios for both the auto manufacturing sector and the auto parts manufacturing sector. These are not additive, but should instead be considered as a range of estimates for the cost effect, depending on which sector adds technologies to the vehicles to comply with the regulation.

We use several sources for estimates of employment per $1 million expenditures. The U.S. Bureau of Labor Statistics (BLS) provides its Employment Requirements Matrix (ERM),[546] which provides direct estimates of the employment per $1 million in sales of goods in 202 sectors. The estimates used here, updated from the NPRM, are from 2010 (adjusted to 2010$). Not all expenditures are for domestically produced vehicles, however. To estimate the proportion of domestic expenditures affected by the rule, we use data from Ward's Automotive Group for total car and truck production in the U.S. compared to total car and truck sales in the U.S.[547] For the period 2001-2010, the proportion is 66.7%. We thus weight sales by this factor to get an estimate of the effect on employment in the motor vehicle manufacturing sector due to this rule.

The Annual Survey of Manufactures[548] (ASM) provides another source of estimates based on a sample of 50,000 establishments out of a universe of 346,000 manufacturing establishments. It includes more sectoral detail than the BLS ERM: for instance, while the ERM includes the Motor Vehicle Manufacturing sector, the ASM has detail at the 6-digit NAICS code level (e.g., automobile manufacturing vs. light truck and utility vehicle manufacturing). While the ERM provides direct estimates of employees/$1 million in expenditures, the ASM separately provides number of employees and value of shipments; the direct employment estimates here are the ratio of those values. The data in the ASM are updated annually, except for years when the full Economic Census occurs. The tables presented here use data from 2010 (also updated from the NPRM). As with the ERM, we adjust for the ratio of domestic production to domestic sales. The values reported are for Motor Vehicle Manufacturing (NAICS 3361), Automobile and Light Duty Motor Vehicle Manufacturing (NAICS 33611), and Motor Vehicle Parts Manufacturing (NAICS 3363).

The Economic Census includes all large companies and a sample of smaller ones. The ASM is a subset of the Economic Census; though the Census itself is more complete, it is conducted only every 5 years, while the ASM is annual. The values presented here use data from 2007 (adjusted to 2010$), with the domestic production-to-sales adjustment. The values reported are for Motor Vehicle Manufacturing (NAICS 3361), Automobile and Light Duty Motor Vehicle Manufacturing (NAICS 33611), and Motor Vehicle Parts Manufacturing (NAICS 3363).

Table 8.2-2 provides the values, either given (BLS) or calculated (ASM, Economic Census) for employment per $1 million of expenditures, all based on 2010 dollars, though the underlying data come from different years (which may account for some of the differences). The different data sources provide similar magnitudes for the estimates for the sectors. Parts manufacturing appears to be more labor-intensive than vehicle manufacturing; light-duty vehicle manufacturing appears to be slightly less labor-intensive than motor vehicle manufacturing as a whole.

Table 8.2-2 Employment per $1 Million Expenditures (2010$) in the Motor Vehicle Manufacturing Sector*

Source	Sector	Ratio of workers per $1 million expenditures	Ratio of workers per $1 million expenditures, adjusted for domestic vs. foreign production
BLS ERM	Motor Vehicle Mfg	0.770	0.514
ASM	Motor Vehicle Mfg	0.655	0.437
ASM	Light Duty Vehicle Mfg	0.609	0.406
Economic Census	Motor Vehicle Mfg	0.665	0.443
Economic Census	Light Duty Vehicle Mfg	0.602	0.402
BLS ERM	Motor Vehicle Parts Mfg	2.614	1.743
ASM	Motor Vehicle Parts Mfg	2.309	1.540
Economic Census	Motor Vehicle Parts Mfg	2.712	1.809

BLS ERM refers to the U.S. Bureau of Labor Statistics' Employment Requirement Matrix. ASM refers to the U.S. Census Bureau's Annual Survey of Manufactures. Economic Census refers to the U.S. Census Bureau's Economic Census.

Over time, the amount of labor needed in the auto industry has changed: automation and improved production methods have led to significant productivity increases. The BLS ERM, for instance, provided estimates that, in 1993, 1.64 workers in the Motor Vehicle Manufacturing sector were needed per $1 million of 2005$, but only 0.86 workers by 2010 (in 2005$). Because the ERM is available annually for 1993-2010, we used these data to estimate productivity improvements over time. We regressed logged ERM values on year for both the Motor Vehicle Manufacturing and Motor Vehicle Parts Manufacturing sectors. We used this approach because the coefficient describing the relationship between time and productivity is a direct measure of the percent change in productivity per year. The results suggest a 3.9 percent per year productivity improvement in the Motor Vehicle Manufacturing

Sector, and a 3.8 percent per year improvement in the Motor Vehicle Parts Manufacturing Sector. We then used the equation resulting from the regression to project the ERM through 2025. In the results presented below, these projected values (adjusted to 2010$) were used directly for the BLS ERM estimates. For the ASM, we used the ratio of the projected value in the future to the projected value in 2010 (the base year for the ASM); for the Economic Census estimates, we used the ratio of the projected value in the future to the projected value in 2007 (the base year for that estimate). This is a simple way to examine the relationship between labor required and expenditure.

Table 8.2-3 shows the cost estimates developed for this rule, discussed in Chapter 5. The maximum value in Table 8.2-2 for employment impacts per $1 million expenditures (after accounting for the share of domestic production) is 1.809 in 2010 if all the additional costs are in the parts sector; the minimum value is 0.402 in 2010, if all the additional costs are in the light-duty vehicle manufacturing sector: that is, the range of employment impacts is between 0.4 and 2 additional jobs per $1 million expenditures in the sector in 2010. The results in Table 8.2-3 include the productivity adjustment described above.

While we estimate employment impacts, measured in job-years, beginning with the first year of the standard (2017), some of these employment gains may occur earlier as auto manufacturers and parts suppliers hire staff in anticipation of compliance with the standard. A job-year is a way to calculate the amount of work needed to complete a specific task. For example, a job-year is one year of work for one person.

Table 8.2-3 Employment per $1 Million in the Motor Vehicle Manufacturing Sector, in job-years

Year	Costs (before adjustment for domestic proportion of production) ($Millions)	Minimum employment effect (if all expenditures are in the parts sector)	Maximum employment effect (if all expenditures are in the light duty vehicle mfg sector)
2017	$ 2,435	700	3,200
2018	$ 4,848	1,300	6,200
2019	$ 6,818	1,700	8,400
2020	$ 8,858	2,100	10,500
2021	$ 12,400	2,900	14,200
2022	$ 18,323	4,100	20,200
2023	$ 23,734	5,100	25,200
2024	$ 29,101	6,000	29,700
2025	$ 31,678	6,300	31,100
Total		30,300	148,800

We note that the cost effect depends only on technology costs, not vehicle sales. It is therefore not sensitive to assumptions about how consumers consider fuel savings at the time of vehicle purchase.

8.2.3.2.1 The Factor Shift Effect

The factor shift effect looks at the effects on employment due to changes in labor intensity associated with a regulation. As noted above, the estimates of the cost effect assume constant labor per $1 million in expenditures, though the new technologies may be either more or less labor-intensive than the existing ones. An estimate of the factor shift effect would either increase or decrease the estimate used for the cost effect.

We are not quantifying the factor shift effect here, for lack of data on the labor intensity of all the possible technologies that manufacturers could use to comply with the standards. For a subset of the technologies, though, EPA-sponsored research (discussed in Chapter 3.2.1.1 of the Joint TSD) which compared new technologies to existing ones at the level of individual components provides some insights into the factor shift effect.

The comparison involved tearing down the selected technologies to their individual components and looking at the differences in materials and labor needs in moving from the conventional to the new technologies. For instance, the analysis compared all the parts and labor associated with an 8-speed automatic transmission to those needed for a 6-speed automatic transmission.

Because labor cost was one of the sources of differences between the technologies, it is possible, for those technologies, to see whether labor needs increase or decrease with the switch to technologies that might contribute to compliance with the standards. An increase in labor cost for the new technology indicates an increase in the labor needed for the new technology compared to the baseline technology. For instance, an 8-speed transmission requires $15.11 more in labor costs than a 6-speed transmission (as accounted for in EPA's cost estimates for the rule). Dividing the labor cost by a wage per hour estimate provides an estimate of the additional hours (and thus the additional labor) needed for the new technology compared to the baseline technology. As with labor cost, an increase in labor hours per technology indicates greater employment needs for the new technologies. For this conversion, a weighted average wage rate (90 percent of the average wage in the Motor Vehicle Parts Manufacturing sector, and 10 percent of the average wage in the Motor Vehicle Manufacturing Sector) of $46.36/hour in 2015, using 2008 dollars (the unit of analysis for the FEV study). For the change from a 6-speed to an 8-speed transmission, we thus estimate an additional 0.33 hours of labor per transmission.

Table 8.2-4 shows the changes in labor hours in moving from baseline to new fuel-saving technologies for technologies in the FEV study. It indicates that, in switching from the baseline to the new technologies, labor use per technology increased: the fuel-saving technologies use more labor than the baseline technologies. For a subset of the technologies likely to be used to meet the standards in this rule, then, the factor shift effect increases labor demand, at least in the short run; in the long run, as with all technologies, the cost structure is likely to change due to learning, economies of scale, etc. The technologies examined in this research are, however, only a subset of the technologies that auto makers may use to comply with the standards in this program. As a result, these results cannot be considered definitive evidence that the factor shift effect increases employment for this rule. We therefore do not quantify the factor shift effect for this rule.

Table 8.2-4 Estimated Change in Labor for Selected Compliance Technologies

Technology	FEV Case Study	Vehicle Class	Labor Costs	Total Costs	Hours/ Technology
Downsized Turbo GDI 4	0101	Compact C	$72.58	$537.70	1.57
Downsized Turbo GDI V6	0102	Mid/Large C	$25.76	$87.38	0.56
Downsized Turbo GDI V6	0104	SUV/Trucks	$84.19	$789.53	1.82
Electric A/C compressor	0602		$4.68	$167.54	0.10
Power split hybrid	0502	Mid/Large C	$395.85	$3,435.01	8.54
6- to 8-speed transmission	0803	Mid/Large C	$15.11	$61.84	0.33

8.2.3.2.2 Summary of Employment Effects in the Auto Sector

While we are not able to quantify the demand or factor shift effects, the cost effect results show that the employment effects of the increased spending in the regulated sector (and, possibly, the parts sector) are expected to be positive and on the order of a few thousand in the initial years of the program. As noted above, motor vehicle and parts manufacturing sectors employed about 677,000 people in 2010, with automobile and light truck manufacturing accounting for about 129,000 of that total.

8.2.4 Effects on Employment for Auto Dealers

The effects of the standards on employment for auto dealers depend principally on the effects of the standards on light duty vehicle sales: increases in sales are likely to contribute to employment at dealerships, while reductions in sales are likely to have the opposite effect. In addition, auto dealers may be affected by changes in maintenance and service costs. Increases in those costs are likely to increase labor demand in dealerships, and reductions are likely to decrease labor demand.

Although this rule predicts very small penetration of plug-in hybrid and electric vehicles, the uncertainty on consumer acceptance of such technology vehicles is even greater. As discussed in Chapter 8.1.2.7, consumers may find some characteristics of electric vehicles and plug-in hybrid electric vehicles, such as the ability to fuel with electricity rather than gasoline, attractive; they may find other characteristics, such as the limited range for electric vehicles, undesirable. As a result, some consumers will find that EVs will meet their needs, but other buyers will choose more conventional vehicles. Auto dealers may play a major role in explaining the merits and disadvantages of these new technologies to vehicle buyers. There may be a temporary need for increased employment to train sales staff in the new technologies as the new technologies become available.

8.2.5 Effects on Employment in the Auto Parts Sector

As discussed in the context of employment in the auto industry, some vehicle parts are made in-house by auto manufacturers; others are made by independent suppliers who are not directly regulated, but who will be affected by the standards as well. The additional expenditures on technologies are expected to have a positive effect on employment in the parts sector as well as the manufacturing sector; the breakdown in employment between the two sectors is difficult to predict. The effects on the parts sector also depend on the effects of the standards on vehicle sales and on the labor intensity of the new technologies, qualitatively in the same ways as for the auto manufacturing sector.

8.2.6 Effects on Employment for Fuel Suppliers

In addition to the effects on the auto manufacturing and parts sectors, these rules will result in changes in fuel use that lower GHG emissions. Fuel saving, principally reductions in liquid fuels such as gasoline and diesel, will affect employment in the fuel suppliers industry sectors throughout the supply chain, from refineries to gasoline stations. To the extent that the standards result in increased use of electricity or other new fuels, employment effects will result from providing these fuels and developing the infrastructure to supply them to consumers.

Expected petroleum fuel consumption reductions can be found in RIA Chapter 5.4. While this reduced consumption represents fuel savings for purchasers of fuel, it represents a loss in value of output for the petroleum refinery industry, fuel distributors, and gasoline stations. The loss of expenditures to petroleum fuel suppliers throughout the petroleum fuel supply chain, from the petroleum refiners to the gasoline stations, is likely to result in reduced employment in these sectors.

This rule is also expected to lead to increases in electricity consumption by vehicles, as discussed in RIA Chapter 5.4. This new fuel may require additional infrastructure, such as electricity charging locations. Providing this infrastructure, as well as infrastructure for other alternative fuels (such as CNG), will require some increased employment. In addition, the generation of electricity is likely to require some additional labor. We have insufficient information at this time to predict whether the increases in labor associated with increased infrastructure provision and generation for electricity will be greater or less than the employment reductions associated with reduced demand for petroleum fuels.

8.2.7 Effects on Employment due to Impacts on Consumer Expenditures

As a result of these standards, consumers will pay a higher up-front cost for the vehicles, but they will recover those costs in a fairly short payback period (see Preamble Section III.H.5 and Chapter 5.5 of this RIA); indeed, people who finance their vehicles are expected to find that their fuel savings per month exceed the increase in the loan cost (though this depends on the particular loan rate a consumer receives). As a result, consumers will have additional money to spend on other goods and services, though, for those who do not finance their vehicles, it will occur after the initial payback period. These increased expenditures will support employment in those sectors where consumers spend their savings.

These increased expenditures will occur in 2017 and beyond. If the economy returns to full employment by that time, any change in consumer expenditures would primarily represent a shift in employment among sectors. If, on the other hand, the economy still has substantial unemployment, these expenditures would contribute to employment through increased consumer demand.

8.2.8 Summary

The primary employment effects of this rule are expected to be found throughout several key sectors: auto manufacturers, auto dealers, auto parts manufacturing, fuel production and supply, and consumers. These standards initially take effect in model year 2017, a time period sufficiently far in the future that the current sustained high unemployment at the national level may be moderated or ended. In an economy with full employment, the primary employment effect of a rulemaking is likely to be to move employment from one sector to another, rather than to increase or decrease employment. For that reason, we focus our partial quantitative analysis on employment in the regulated sector, to examine the impacts on that sector directly. We discuss the likely direction of other impacts in the regulated sector as well as in other directly related sectors, but we do not quantify those impacts, because they are more difficult to quantify with reasonable accuracy, particularly so far into the future.

For the regulated sector, the cost effect is expected to increase employment by 700 – 3,200 job-years in 2017, depending on the share of that employment that is in the auto manufacturing sector compared to the auto parts manufacturing sector. As mentioned above, some of these job gains may occur earlier as auto manufacturers and parts suppliers hire staff to prepare to comply with the standard. The demand effect depends on changes in vehicle sales, which are not quantified for this rule. Though we do not have estimates of the factor shift effect for all potential compliance technologies, the evidence which we do have for some technologies suggests that many of the technologies will have increased labor needs.

Effects in other sectors that are predicated on vehicle sales are also ambiguous. Changes in vehicle sales are expected to affect labor needs in auto dealerships and in parts manufacturing. Increased expenditures for auto parts are expected to require increased labor to build parts, though this effect also depends on any changes in the labor intensity of production; as noted, the subset of potential compliance technologies for which data are available show increased labor requirements. Reduced petroleum fuel production implies less employment in the petroleum sectors, although there could be increases in employment related to providing infrastructure for alternative fuels such as electricity and CNG. Finally, consumer spending is expected to affect employment through changes in expenditures in general retail sectors; net fuel savings by consumers are expected to increase demand (and therefore employment) in other sectors.

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EXHIBIT 19

Regulatory Impact Analysis of the Proposed Revisions to the National Ambient Air Quality Standards for Ground-Level Ozone

EPA-452/P-14-006
November 2014

Regulatory Impact Analysis of the Proposed Revisions to the National Ambient Air Quality Standards for Ground-Level Ozone

U.S. Environmental Protection Agency
Office of Air and Radiation
Office of Air Quality Planning and Standards
Research Triangle Park, NC 27711

EXECUTIVE SUMMARY

Overview

In setting primary national ambient air quality standards (NAAQS), the EPA's responsibility under the law is to establish standards that protect public health. The Clean Air Act (the Act) requires the EPA, for each criteria pollutant, to set a standard that protects public health with "an adequate margin of safety." As interpreted by the Agency and the courts, the Act requires the EPA to base this decision on health considerations only; economic factors cannot be considered. The prohibition against considering cost in the setting of the primary air quality standards does not mean that costs, benefits or other economic considerations are unimportant. The Agency believes that consideration of costs and benefits is an essential decision-making tool for the efficient implementation of these standards. The impacts of costs, benefits, and efficiency are considered by the States when they make decisions regarding what timelines, strategies, and policies are appropriate for their circumstances.

The EPA is proposing to revise the level of the ozone NAAQS to within a range of 65 ppb to 70 ppb and is soliciting comment on alternative standard levels below 65 ppb, as low as 60 ppb. The EPA is also proposing to revise the level of the secondary standard to within the range of 65 ppb to 70 ppb to provide increased protection against vegetation-related effects on public welfare.[1] The EPA performed an illustrative analysis of the potential costs, human health benefits, and welfare co-benefits of nationally attaining primary alternative ozone standard levels and did not estimate any incremental costs and benefits associated with attaining a revised secondary standard. Per Executive Order 12866 and the guidelines of OMB Circular A-4, this Regulatory Impact Analysis (RIA) presents the analyses of the following alternative standard levels -- 70 ppb, 65 ppb, and 60 ppb. The cost and benefit estimates below are calculated incremental to a 2025 baseline that incorporates air quality improvements achieved through the projected implementation of existing regulations and full attainment of the existing ozone

[1] As an initial matter, the EPA is proposing that ambient ozone concentrations in terms of a three-year average W126 index value within the range from 13 parts per million-hours (ppm-hours) to 17 ppm-hours would provide the requisite protection against known or anticipated adverse effects to the public welfare, which data analyses indicate would provide air quality in terms of three-year average W126 index values of a range at or below 13 ppm-hours to 17 ppm-hours. Data analyses also indicate that actions taken to attain a standard in the range of 65 ppb to 70 ppb would also improve air quality as measured by the W126 metric.

NAAQS (75 ppb). The 2025 baseline reflects, among other existing regulations, the Mercury and Air Toxics Standard, the Clean Air Interstate Rule, the Tier 3 Motor Vehicle Emission and Fuel Standards, and adjustments for the Clean Power Plan, all of which will help many areas move toward attainment of the existing ozone standard (see Chapter 3, Section 3.1.3 for additional information).

In this RIA we present the primary costs and benefits estimates for 2025. We assume that potential nonattainment areas everywhere in the U.S., excluding California, will be designated such that they are required to reach attainment by 2025, and we developed our projected baselines for emissions, air quality, and populations for 2025.

The EPA will likely finalize designations for a revised ozone NAAQS in late 2017. Depending on the precise timing of the effective date of those designations, nonattainment areas classified as Marginal will likely have to attain in either late 2020 or early 2021. Nonattainment areas classified as Moderate will likely have to attain in either late 2023 or early 2024. If a Moderate nonattainment area qualifies for two 1-year extensions, the area may have as late as 2026 to attain. Lastly, Serious nonattainment areas will likely have to attain in late 2026 or early 2027. We selected 2025 as the primary year of analysis because most areas of the U.S. will likely be required to meet a revised ozone standard by 2025 and because it provided a good representation of the remaining air quality concerns that Moderate nonattainment areas would face; states with areas classified as Moderate and higher are required to develop attainment demonstration plans for those nonattainment areas.

In estimating the incremental costs and benefits of potential alternative standards, we recognize that there are several areas that are not required to meet the existing ozone standard by 2025. The Clean Air Act allows areas with more significant air quality problems to take additional time to reach the existing standard. Several areas in California are not required to meet the existing standard by 2025 and may not be required to meet a revised standard until sometime between 2032 and 2037.[2] We were not able to project emissions and air quality

[2] The EPA will likely finalize designations for a revised ozone NAAQS in late 2017. Depending on the precise timing of the effective date of those designations, nonattainment areas classified as Severe 15 will likely have to

beyond 2025 for California, however, we adjusted baseline air quality to reflect mobile source emissions reductions for California that would occur between 2025 and 2030; these emissions reductions were the result of mobile source regulations expected to be fully implemented by 2030. While there is uncertainty about the precise timing of emissions reductions and related costs for California, we assume costs occur through the end of 2037 and beginning of 2038. In addition, we model benefits for California using projected population demographics for 2038.

Because of the different timing for incurring costs and accruing benefits and for ease of discussion throughout the analyses, we refer to the different time periods for potential attainment as 2025 and post-2025 to reflect that (1) we did not project emissions and air quality for any year other than 2025; (2) for California, emissions controls and associated costs are assumed to occur through the end of 2037 and beginning of 2038; and (3) for California benefits are modeled using population demographics in 2038. It is not straightforward to discount the post-2025 results for California to compare with or add to the 2025 results for the rest of the U.S. While we estimate benefits using 2038 information, we do not have good information on precisely when the costs of controls will be incurred. Because of these differences in timing related to California attaining a revised standard, the separate costs and benefits estimates for post-2025 should not be added to the primary estimates for 2025.

ES.1 Overview of Analytical Approach

This RIA consists of multiple analyses including an assessment of the nature and sources of ambient ozone (Chapter 2 – Defining the Air Quality Problem); estimates of current and future emissions of relevant precursors that contribute to the problem; air quality analyses of baseline and alternative control strategies (Chapter 3 – Air Quality Modeling and Analysis); development of illustrative control strategies to attain the primary alternative standard levels (Chapter 4 – Control Strategies and Emissions Reductions); estimates of the incremental benefits of attaining the primary alternative standard levels (Chapter 5 – Human Health Benefits); a qualitative discussion of the welfare co-benefits of attaining the primary alternative standard levels (Chapter 6 – Welfare Co-Benefits of the Primary Standard); estimates of the incremental

attain sometime between late 2032 and early 2033 and nonattainment areas classified as Extreme will likely have to attain by December 31, 2037.

costs of attaining the primary alternative standard levels (Chapter 7 – Engineering Cost Analysis and Economic Impacts); a comparison and discussion of the benefits and costs (Chapter 8 – Comparison of Costs and Benefits); an analysis of the impacts of the relevant statutory and executive orders (Chapter 9 – Statutory and Executive Order Impact Analysis); and a discussion of the theoretical framework used to analyze regulation-induced employment impacts, as well as information on employment related to installation of NOx controls on coal and gas-fired electric generating units, industrial boilers, and cement kilns (Chapter 10 – Qualitative Discussion of Employment Impacts of Air Quality).

Because States are ultimately responsible for implementing strategies to meet revised standards, this RIA provides insights and analysis of a limited number of illustrative control strategies that states might adopt to meet a revised standard. The goal of this RIA is to provide estimates of the costs and benefits of the illustrative attainment strategies to the meet each alternative standard level. The flowchart below (Figure ES-1) outlines the analytical steps taken to illustrate attainment with the potential alternative standard levels, and the following discussion, by primary flowchart section, describes the steps taken.

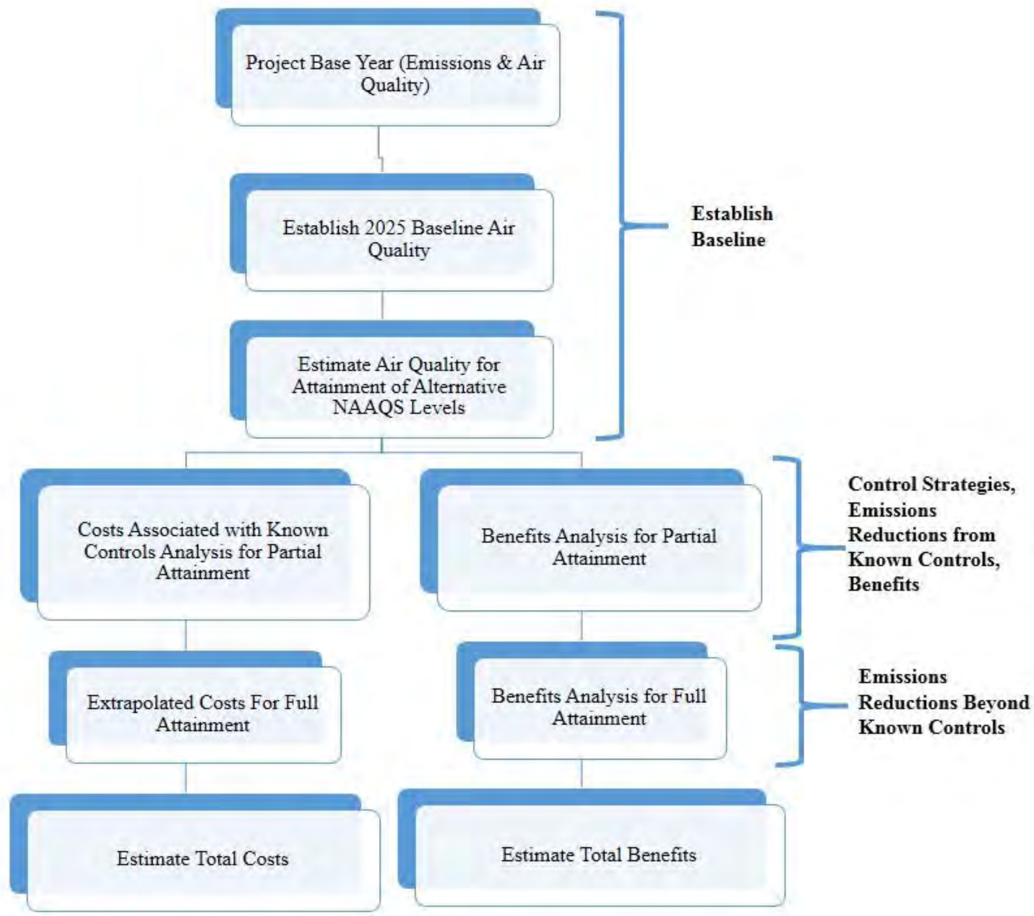

Figure ES-1. Analytical Flowchart for Primary Standards Analyses

ES.1.1 Establishing the Baseline

The future year base case reflects emissions projected from 2011 to 2025 and incorporates current state and federal programs, including the Tier 3 Motor Vehicle Emission and Fuel Standards (U.S. EPA, 2014a) (see Chapter 3, Section 3.1.3 for a discussion of the rules included in the base case). The base case does not include control programs specifically for the purpose of attaining the existing ozone standard (75 ppb). The baseline builds on the future year base case and reflects the additional emissions reductions needed to reach attainment of the current ozone standard (75 ppb), as well as adjustments for the Clean Power Plan (U.S. EPA, 2014b).

We performed a national scale air quality modeling analysis to estimate ozone concentrations for the future base case year of 2025. To accomplish this, we modeled multiple emissions cases for 2025, including the 2025 base case and twelve 2025 emissions sensitivity simulations. The twelve emissions sensitivity simulations were used to develop ozone sensitivity factors (ppb/ton) from the modeled response of ozone to changes in NOx and VOC emissions from various sources and locations. These ozone sensitivity factors were then used to determine the amount of emissions reductions needed to reach the 2025 baseline and evaluate potential alternative standard levels of 70, 65, and 60 ppb incremental to the baseline. We used the estimated emissions reductions needed to reach each of these standard levels to analyze the costs and benefits of alternative standard levels.

ES.1.2 Control Strategies and Emissions Reductions

The EPA analyzed illustrative control strategies that areas across the U.S. might employ to attain alternative revised primary ozone standard levels of 70, 65, and 60 ppb. The EPA analyzed the impact that additional emissions control technologies and measures, across numerous sectors, would have on predicted ambient ozone concentrations incremental to the baseline. These control measures, also referred to as known controls, are based on information available at the time of this analysis and include primarily end-of-pipe control technologies. In addition, to attain some of the alternative primary standard levels analyzed, some areas needed additional emissions reductions beyond the known controls, and we refer to these as unknown controls (see Chapter 7, Section 7.2 for additional information).

Using average ozone response factors, we estimated the portion of the emissions reductions required to meet the baseline, including any additional emissions reductions beyond known controls. We then estimated the emissions reductions incremental to the baseline that were needed to meet the alternative standard levels of 70, 65, and 60 ppb. Costs of controls incremental to (i.e., over and above) the baseline emissions reductions are attributed to the costs of meeting the alternative standard levels. These emissions reductions can come from both specific known controls, as well as unknown controls. The baseline shows that by 2025, while ozone air quality would be significantly better than today under current requirements, depending on the alternative standard level analyzed, several areas in the Eastern, Central, and Western U.S. would need to develop and adopt additional controls to attain alternative standard levels (see Chapter 4, Section 4.3).

ES.1.2.1 Emissions Reductions from Known Controls in 2025

Figure ES-2 shows the counties projected to exceed the alternative standard levels analyzed for 2025 for areas other than California. For the 70 ppb alternative standard level, emissions reductions were required for monitors in the Central and Northeast regions. For the 65 and 60 ppb alternative standard levels, emissions reductions were applied in all regions with projected baseline design values (DVs) above these levels.[3] For the 60 ppb alternative standard level, additional VOC emissions reductions were identified in Chicago because some sites in that area experienced NO_x disbenefits, meaning that the regional NO_x emissions reductions resulted in ozone increases from below 60 ppb to above 60 ppb. Tables ES-1 through ES-3 show the emissions reductions from known controls for the alternative standard levels analyzed.

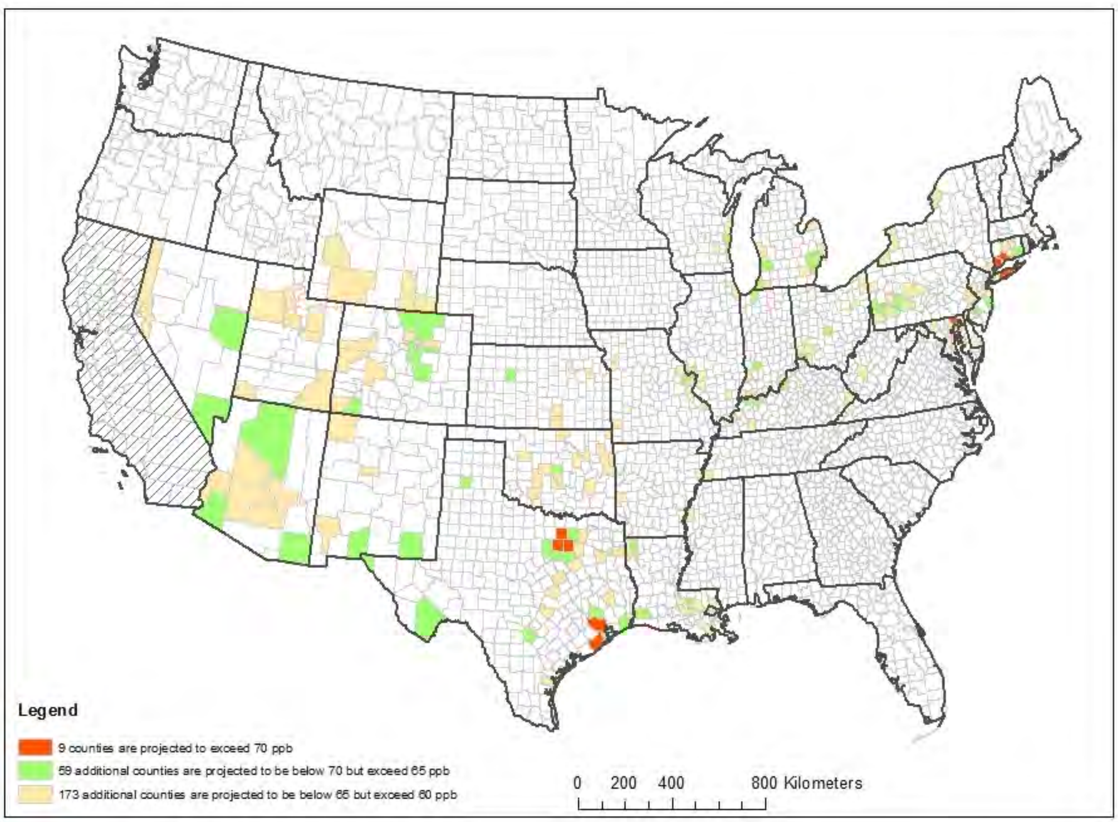

Figure ES-2. Projected Ozone Design Values in the 2025 Baseline Scenario

[3] A design value is a statistic that describes the air quality status of a given area relative to the level of the NAAQS. Design values are typically used to classify nonattainment areas, assess progress toward meeting the NAAQS, and develop control strategies.

Table ES-1. Summary of Emission Reductions by Sector for Known Controls for 70 ppb Proposed Alternative Standard Level for 2025, except California (1,000 tons/year)[a]

Geographic Area	Emissions Sector	NO_x	VOC
East	EGU	25	-
	Non-EGU Point	210	0.98
	Nonpoint	260	54
	Nonroad	5	-
	Total	**490**	**55**
West	EGU	-	-
	Non-EGU Point	-	-
	Nonpoint	-	-
	Nonroad	-	-
	Total	**-**	**-**

[a] Estimates are rounded to two significant figures.

Table ES-2. Summary of Emission Reductions by Sector for Known Controls for 65 ppb Proposed Alternative Standard Level for 2025 - except California (1,000 tons/year)[a]

Geographic Area	Emissions Sector	NO_x	VOC
East	EGU	170	-
	Non-EGU Point	410	3.6
	Nonpoint	420	95
	Nonroad	12	-
	Total	**1,000**	**99**
West	EGU	36	-
	Non-EGU Point	38	0.47
	Nonpoint	37	6.6
	Nonroad	1.3	-
	Total	**110**	**7**

[a] Estimates are rounded to two significant figures.

Table ES-3. Summary of Emission Reductions by Sector for Known Controls for 60 ppb Alternative Standard Level for 2025 - except California (1,000 tons/year)[a]

Geographic Area	Emissions Sector	NO_x	VOC
East	EGU	170	-
	Non-EGU Point	410	4.2
	Nonpoint	420	99
	Nonroad	12	-
	Total	**1,000**	**100**
West	EGU	62	-
	Non-EGU Point	48	0.47
	Nonpoint	39	6.6
	Nonroad	1.3	-
	Total	**150**	**7**

[a] Estimates are rounded to two significant figures.

ES.1.2.2 Emissions Reductions beyond Known Controls in 2025

There were several areas where known controls did not achieve enough emissions reductions to attain the proposed alternative standard levels of 70 and 65 as well as the more stringent alternative standard level of 60 ppb. To complete the analysis, the EPA then estimated the additional emissions reductions beyond known controls needed to reach attainment (i.e., unknown controls). Table ES-4 shows the emissions reductions needed from unknown controls in 2025 for the U.S., except California, for the alternative standard levels analyzed.

Table ES-4. Summary of Emissions Reductions by Alternative Standard for Unknown Controls for 2025 - except California (1,000 tons/year)[a]

	Region	NO_x	VOC
Proposed Alternative Standard Levels			
70 ppb	**East**	**150**	**-**
	West	**-**	**-**
65 ppb	**East**	**750**	**-**
	West	**-**	**-**
Alternative Standard Level			
60 ppb	East	1,900	41
	West	350	-

ES.1.2.3 Emissions Reductions beyond Known Controls for Post-2025

Figure ES-3 shows the counties projected to exceed the alternative standard levels analyzed for the post-2025 analysis for California. For the California post-2025 alternative standard level analyses, all known controls were applied in the baseline, so incremental emissions reductions are from unknown controls. Table ES-5 shows the emissions reductions needed from unknown controls for post-2025 for California for the alternative standard levels analyzed.

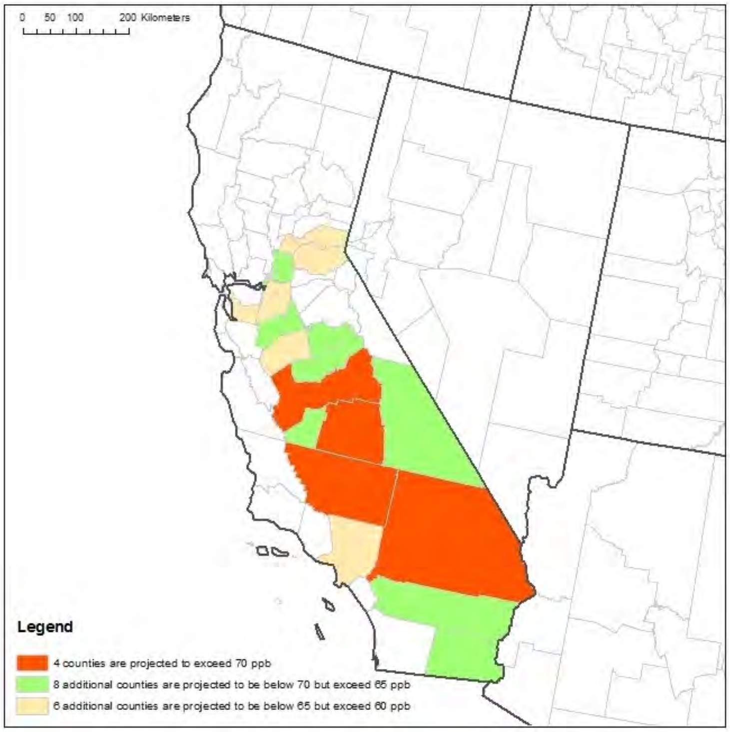

Figure ES-3. Projected Ozone Design Values in the post-2025 Baseline Scenario

Table ES-5. Summary of Emissions Reductions by Alternative Standard Level for Unknown Controls for post-2025 - California (1,000 tons/year)[a]

	Region	NO_x	VOC
Proposed Alternative Standard Levels			
70 ppb	**CA**	**53**	**-**
65 ppb	**CA**	**110**	**-**
Alternative Standard Level			
60 ppb	CA	140	-

[a] Estimates are rounded to two significant figures.

ES.1.3 Human Health Benefits

To estimate benefits, we follow a "damage-function" approach in calculating total benefits of the modeled changes in environmental quality. This approach estimates changes in individual health endpoints (specific effects that can be associated with changes in air quality) and assigns values to those changes assuming independence of the values for those individual endpoints. Total benefits are calculated as the sum of the values for all non-overlapping health endpoints. The "damage-function" approach is the standard method for assessing costs and benefits of environmental quality programs and has been used in several recent published analyses (Levy et al., 2009; Fann et al., 2012a; Tagaris et al., 2009).

To assess economic values in a damage-function framework, the changes in environmental quality must be translated into effects on people or on the things that people value. In some cases, the changes in environmental quality can be directly valued, as is the case for changes in visibility. In other cases, such as for changes in ozone and PM, an impact analysis must first be conducted to convert air quality changes into effects that can be assigned dollar values. For the purposes of this RIA, the health impacts analysis is limited to those health effects that are directly linked to ambient levels of air pollution and specifically to those linked to ozone and $PM_{2.5}$.

Benefits estimates for ozone were generated using the damage function approach outlined above wherein potential changes in ambient ozone levels (associated with future attainment of alternative standard levels) were explicitly modeled and then translated into reductions in the incidence of specific health endpoints. In generating ozone benefits estimates for the two attainment timeframes considered in the RIA (2025 and post-2025), we used three distinct benefits simulations including one completed for 2025 and two completed for 2038. The way in which these three benefits simulations were used to generate estimates for the two timeframes is detailed in Chapter 5, Section 5.4.3.

In contrast to ozone, we used a benefit-per-ton approach in modeling $PM_{2.5}$ co-benefits. With this approach, we use the results of previous benefits analysis simulations focusing on $PM_{2.5}$ to derive benefits-per-ton estimates for NOx.[4] We then combine these dollar-per-ton estimates with projected reductions in NOx associated with meeting a given alternative standard level to project cobenefits associated with $PM_{2.5}$. We acknowledge increased uncertainty associated with the dollar-per-ton approach for $PM_{2.5}$, relative to explicitly modeling benefits using gridded $PM_{2.5}$ surfaces specific to the baseline and alternative standard levels (see Appendix 5A, Table 5A-1 for additional discussion).

In addition to ozone and $PM_{2.5}$ benefits, implementing emissions controls to reach some of the alternative ozone standard levels would reduce other ambient pollutants. However, because the methods used in this analysis to simulate attainment do not account for changes in ambient

[4] In addition to dollar-per-ton estimates for NOx, we also used incidence-per-ton values (also for NOx) for specific health endpoints to generate incidence reduction estimates associated with the dollar benefits.

concentrations of other pollutants, we were not able to quantify the co-benefits of reduced exposure to these pollutants. In addition, due to data and methodology limitations, we were unable to estimate some anticipated health benefits associated with exposure to ozone and $PM_{2.5}$.

ES.1.4 Welfare Co-Benefits of the Primary Standard

Section 109 of the Clean Air Act defines welfare effects to include any non-health effects, including direct economic damages in the form of lost productivity of crops and trees, indirect damages through alteration of ecosystem functions, indirect economic damages through the loss in value of recreational experiences or the existence value of important resources, and direct damages to property, either through impacts on material structures or by soiling of surfaces (42 U.S.C. 7409). Ozone can affect ecological systems, leading to changes in the ecological community and influencing the diversity, health, and vigor of individual species (U.S. EPA, 2013). Ozone causes discernible injury to a wide array of vegetation (U.S. EPA, 2013). In terms of forest productivity and ecosystem diversity, ozone may be the pollutant with the greatest potential for region-scale forest impacts (U.S. EPA, 2013). Studies have demonstrated repeatedly that ozone concentrations observed in polluted areas can have substantial impacts on plant function (De Steiguer et al,. 1990; Pye, 1988).

In this RIA, we are able to quantify only a small portion of the welfare impacts associated with reductions in ozone concentrations to meet alternative ozone standards. Using a model of commercial agriculture and forest markets, we are able to analyze the effects on consumers and producers of forest and agricultural products of changes in the W126 index resulting from meeting alternative standards within the proposed range of 70 to 65 ppb, as well as a lower standard level of 60 ppb. We also assess the effects of those changes in commercial agricultural and forest yields on carbon sequestration and storage. This analysis provides limited quantitative information on the welfare co-benefits of meeting these alternative standards, focused only on one subset of ecosystem services. Commercial and non-commercial forests provide a number of additional services, including medicinal uses, non-commercial food and fiber production, arts and crafts uses, habitat, recreational uses, and cultural uses for Native American tribes. A more complete discussion of these additional ecosystem services is provided in the final Welfare Risk and Exposure Assessment for Ozone (U.S. EPA, 2014c).

ES.2 Results of Benefit-Cost Analysis

Below in Table ES-6, we present the primary costs and benefits estimates for 2025 for all areas except California. In addition, Tables 5-1 and 5-23 in Chapter 5 provide a breakdown of ozone-only and $PM_{2.5}$-only benefits, as well as total benefits at 3 percent. We anticipate that benefits and costs will likely begin occurring earlier, as states begin implementing control measures to show progress towards attainment. In these tables, ranges within the total benefits rows reflect variability in the studies upon which the estimates associated with premature mortality were derived. $PM_{2.5}$ co-benefits account for approximately two-thirds to three-quarters of the estimated benefits, depending on the standard analyzed and on the choice of ozone and PM mortality functions used. In addition for 2025, Table ES-7 presents the numbers of premature deaths avoided for the alternative standard levels analyzed, as well as the other health effects avoided. Table ES-8 provides information on the costs by geographic region for the U.S., except California in 2025, and Table ES-9 provides a regional breakdown of benefits for 2025.

In the RIA we provide estimates of costs of emissions reductions to attain the proposed standards in three regions -- California, the rest of the western U.S., and the eastern U.S. In addition, we provide estimates of the benefits that accrue to each of these three regions resulting from (i) control strategies applied within the region, (ii) reductions in transport of ozone associated with emissions reductions in other regions, and (iii) the control strategies for which the regional cost estimates are generated. These benefits are not directly comparable to the costs of control strategies in a region because the benefits include benefits not associated with those control strategies.

The net benefits of emissions reductions strategies in a specific region would be the benefits of the emissions reductions occurring both within and outside of the region minus the costs of the emissions reductions. Because the air quality modeling is done the national level, we do not estimate separately the nationwide benefits associated with the emissions reductions occurring in any specific region.[5] As a result, we are only able to provide net benefits estimates at the national level. The difference between the costs for a specific region and the benefits

[5] For California, we provide separate estimates of the costs and nationwide estimates of benefits, so it is appropriate to calculate net benefits. As such, we provide net benefits for the post-2025 California analysis.

accruing to that region is not an estimate of net benefits of the emissions reductions in that region.

Table ES-6. Total Annual Costs and Benefits[a] for U.S., except California in 2025 (billions of 2011$, 7% Discount Rate)[b]

	Proposed Alternative Standard Levels		Alternative Standard Level
	70 ppb	**65 ppb**	60 ppb
Total Costs (7%)	**$3.9**	**$15**	$39
Total Health Benefits (7%)[c]	**$6.4 to $13.0**	**$19 to $38**	$34 to $70
Net Benefits (7%)	**$2.5 to $9.1**	**$4 to $23**	($5) to $31

[a] Benefits are nationwide benefits of attainment everywhere except California.
[b] EPA believes that providing comparisons of social costs and social benefits at 3 and 7 percent is appropriate. Estimating multiple years of costs and benefits is not possible for this RIA due to data and resource limitations. As a result, we provide a snapshot of costs and benefits in 2025, using the best available information to approximate social costs and social benefits recognizing uncertainties and limitations in those estimates.
[c] The benefits range reflects the LOW and UPPER core estimates of short-term ozone and long-term PM mortality.

EPA believes that providing comparisons of social costs and social benefits at 3 and 7 percent is appropriate. Ideally, streams of social costs and social benefits over time would be estimated and the net present values of each would be compared to determine net benefits of the illustrative attainment strategies. The three different uses of discounting in the RIA – (i) construction of annualized engineering costs, (ii) adjusting the value of mortality risk for lags in mortality risk decreases, and (iii) adjusting the cost of illness for non-fatal heart attacks to adjust for lags in follow up costs -- are all appropriate. Our estimates of net benefits are the approximations of the net value (in 2025) of benefits attributable to emissions reductions needed to attain just for the year 2025.

Table ES-7. Summary of Total Number of Annual Ozone and PM-Related Premature Mortalities and Premature Morbidity: 2025 National Benefits [a]

	Proposed Alternative Standard Levels (95th percentile confidence intervals)[b]		Alternative Standard Level (95th percentile confidence intervals)
	70 ppb	**65 ppb**	60 ppb
Short-term exposure-related premature deaths avoided (all ages) (Ozone – 2 studies)	200 to 340 (97 to 300) (180 to 490)	630 to 1,000 (310 to 940) (560 to 1,500)	1,100 to 1,900 (560 to 1,700) (1,000 to 2,800)
Long-term exposure-related premature deaths avoided (age 30+) (PM – 2 studies)	O_3: 680 (230 to 1,100) $PM_{2.5}$: 510 to 1,100[c]	O_3: 2,100 (710 to 3,500) $PM_{2.5}$: 1,400 to 3,300[c]	O_3: 3,900 (1,300 to 6,400) $PM_{2.5}$: 2,600 to 6,000[c]
Other health effects avoided[d]			
Non-fatal heart attacks (age 18-99) (5 studies) [PM]	64 to 600	180 to 1,700	330 to 3,100

	Proposed Alternative Standard Levels (95th percentile confidence intervals)[b]		Alternative Standard Level (95th percentile confidence intervals)
	70 ppb	**65 ppb**	60 ppb
Respiratory hospital admissions (age 0-99)[O3, PM]	510	1,500	2,900
Cardiovascular hospital admissions (age 18-99)[PM]	180	530	950
Asthma emergency department visits (age 0-99)[O3, PM]	1,400	4,300	8,000
Acute bronchitis (age 8-12)[PM]	790	2,300	4,100
Asthma exacerbation (age 6-18)[O3, PM]	320,000	960,000	1,800,000
Lost work days (age 18-65)[PM]	65,000	180,000	340,000
Minor restricted activity days (age 18-65)[O3, PM]	1,300,000	4,000,000	7,300,000
Upper & lower respiratory symptoms (children 7-14)[PM]	24,000	70,000	130,000
School loss days (age 5-17)[O3]	330,000	1,000,000	1,900,000

[a] Nationwide benefits of attainment everywhere except California.
[b] We present a confidence interval in parentheses for each study on short-term or long-term ozone-related mortality.
[c] These estimates were generated using benefit-per-ton estimates and confidence intervals are not available. In general, the 95th percentile confidence interval for the health impact function alone ranges from ± 30 percent for mortality incidence based on Krewski et al. (2009) and ± 46 percent based on Lepeule et al. (2012).
[d] See Table 5-19 in Chapter 5 for detailed information on confidence intervals related to ozone-related morbidity incidence estimates. The $PM_{2.5}$ morbidity incidence estimates were generated using benefit-per-ton estimates and confidence intervals are not available.

Table ES-8. Summary of Total Control Costs (Known and Extrapolated) by Alternative Level for 2025 - U.S., except California (billions of 2011$, 7% Discount Rate)[a]

Alternative Level	**Geographic Area**	**Total Control Costs (Known and Extrapolated)**
70 ppb	East	3.9
	West	-
	Total	**$3.9**
65 ppb	East	15
	West	0.40
	Total	**$15**
60 ppb	East	33
	West	5.8
	Total	**$39**

[a] All values are rounded to two significant figures. Extrapolated costs are based on the average-cost methodology.

Table ES-9. Regional Breakdown of Monetized Ozone-Specific Benefits Results for the 2025 Scenario (nationwide benefits of attaining each alternative standard everywhere in the U.S. except California) – Full Attainment [a]

Region	Proposed and Alterative Standards		
	70 ppb	**65 ppb**	**60 ppb**
East [b]	99%	96%	92%
California	0%	0%	0%
Rest of West	1%	4%	7%

[a] Because we use benefit-per-ton estimates to calculate the $PM_{2.5}$ co-benefits, a regional breakdown for the co-benefits is not available. Therefore, this table only reflects the ozone benefits.
[b] Includes Texas and those states to the north and east. Several recent rules such as Tier 3 will have substantially reduced ozone concentrations by 2025 in the East, thus few additional controls would be needed to reach 70 ppb.

To understand possible additional costs and benefits of fully attaining in California in a post-2025 timeframe, we provide separate results for California in Table ES-10. In addition, Tables 5-2 and 5-30 in Chapter 5 provide a breakdown of ozone-only and $PM_{2.5}$-only benefits, as well as total benefits at 3 percent. Relative to the primary cost and benefits estimates, the California cost estimates are between 5 and 20 percent and the benefits estimates are between 8 and 15 percent of the national estimates. Because of the differences in the timing of achieving needed emissions reductions, incurring costs, and accruing benefits for California, the separate costs and benefits estimates for post-2025 should not be added to the primary estimates for 2025. For the post-2025 timeframe, Table ES-11 presents the numbers of premature deaths avoided for the alternative standard levels analyzed, as well as the other health effects avoided. Table ES-12 provides information on the costs for California for post-2025, and Table ES-13 provides a regional breakdown of benefits for post-2025.

The EPA presents separate costs and benefits results for California because forcing attainment in an earlier year than would be required under the Clean Air Act would likely lead to an overstatement of costs because California might benefit from some existing federal or state programs that would be implemented between 2025 and the ultimate attainment years; because additional new technologies may become available between 2025 and the attainment years; and because the cost of existing technologies might fall over time. As such, we use the best available data to estimate costs and benefits for California in a post-2025 timeframe, but because of data limitations and additional uncertainty associated with not projecting emissions and air quality beyond 2025, we recognize that the estimates of costs and benefits for California in a post-2025 timeframe are likely to be relatively more uncertain than the national attainment estimates for 2025.

Table ES-10. Total Annual Costs and Benefits[a] of Control Strategies Applied in California, post-2025 (billions of 2011$, 7% Discount Rate)[b]

	Proposed Alternative Standard Levels		Alternative Standard Level
	70 ppb	**65 ppb**	60 ppb
Total Costs (7%)	$0.80	$1.6	$2.2
Total Health Benefits (7%)[c]	$1.1 to $2	$2.2 to $4.1	$3.2 to $5.9
Net Benefits (7%)	$0.3 to $1.2	$0.60 to $2.5	$1 to $3.7

[a] Benefits are nationwide benefits of attainment in California.
[b] EPA believes that providing comparisons of social costs and social benefits at 3 and 7 percent is appropriate. Estimating multiple years of costs and benefits is not possible for this RIA due to data and resource limitations. As a result, we provide a snapshot of costs and benefits in 2025, using the best available information to approximate social costs and social benefits recognizing uncertainties and limitations in those estimates.
[c] The benefits range reflects the LOW and UPPER core estimates of short-term ozone and long-term PM mortality.

Table ES-11. Summary of Total Number of Annual Ozone and PM-Related Premature Mortalities and Premature Morbidity: Post-2025[a]

	Proposed Alternative Standard Levels (95th percentile confidence intervals)[b]		Alternative Standard Level (95th percentile confidence intervals)
	70 ppb	**65 ppb**	60 ppb
Short-term exposure-related premature deaths avoided (all ages) (Ozone – 2 studies)	65 to 110 (31 to 97) (57 to 160)	140 to 230 (68 to 210) (120 to 340)	210 to 350 (100 to 320) (190 to 510)
Long-term exposure-related premature deaths avoided (age 30+) (PM – 2 studies)	O_3: 260 (88 to 430) $PM_{2.5}$: 45 to 100[c]	O_3: 560 (190 to 930) $PM_{2.5}$: 89 to 200[c]	O_3: 840 (290 to 1,400) $PM_{2.5}$: 120 to 280[c]
Other health effects avoided[d]			
Non-fatal heart attacks (age 18-99) (5 studies) [PM]	6 to 54	11 to 110	16 to 140
Respiratory hospital admissions (age 0-99)[O3, PM]	130	290	430
Cardiovascular hospital admissions (age 18-99) [PM]	16	32	45
Asthma emergency department visits (age 0-99) [O3, PM]	340	740	1,100
Acute bronchitis (age 8-12) [PM]	67	130	180
Asthma exacerbation (age 6-18) [O3, PM]	99,000	210,000	320,000
Lost work days (age 18-65) [PM]	5,500	11,000	15,000
Minor restricted activity days (age 18-65) [O3, PM]	320,000	690,000	1,000,000
Upper & lower respiratory symptoms (children 7-14) [PM]	2,100	4,100	5,600
School loss days (age 5-17) [O3]	110,000	230,000	350,000

[a] Nationwide benefits of attainment in California.
[b] We present a confidence interval in parentheses for each study on short-term or long-term ozone-related mortality.

[c] These estimates were generated using benefit-per-ton estimates and confidence intervals are not available. In general, the 95th percentile confidence interval for the health impact function alone ranges from + 30 percent for mortality incidence based on Krewski et al. (2009) and + 46 percent based on Lepeule et al. (2012).
[d] See Table 5-26 in Chapter 5 for detailed information on confidence intervals related to ozone-related morbidity incidence estimates. The PM2.5 morbidity incidence estimates were generated using benefit-per-ton estimates and confidence intervals are not available.

Table ES-12. Summary of Total Control Costs (Known and Extrapolated) by Alternative Level for post-2025 - California (billions of 2011$, 7% Discount Rate)[a]

Alternative Level	Geographic Area	Total Control Costs (Known and Extrapolated)
70 ppb	California	$0.80
65 ppb	California	$1.6
60 ppb	California	$2.2

[a] All values are rounded to two significant figures. Extrapolated costs are based on the average-cost methodology.

Table ES-13. Regional Breakdown of Monetized Ozone-Specific Benefits Results for the post-2025 Scenario (nationwide benefits of attaining each alternative standard just in California) – Full Attainment[a]

Region	Proposed and Alterative Standards		
	70 ppb	**65 ppb**	**60 ppb**
East	0%	0%	0%
California	93%	94%	94%
Rest of West	6%	6%	6%

[a] Because we use benefit-per-ton estimates to calculate the $PM_{2.5}$ co-benefits, a regional breakdown for the co-benefits is not available. Therefore, this table only reflects the ozone benefits.

Despite uncertainties inherent in any complex, quantitative analysis, the overall underlying analytical methods used in this RIA have been peer-reviewed. For a detailed discussion on uncertainty associated with developing illustrative control strategies to attain the alternative standard levels, see Chapter 4, Section 4.4. For a description of the key assumptions and uncertainties related to the modeling of ozone benefits, see Chapter 5, Section 5.7.3, and for an additional qualitative discussion of sources of uncertainty associated with both the modeling of ozone-related benefits and $PM_{2.5}$-related co-benefits, see Appendix 5A. For a discussion of the limitations and uncertainties in the engineering cost analyses, see Chapter 7, Section 7.7. For a discussion about generally framing uncertainty, see Chapter 8, Section 8.3.

ES.3 References

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CHAPTER 10: QUALITATIVE DISCUSSION OF EMPLOYMENT IMPACTS OF AIR QUALITY

Overview

Executive Order 13563 directs federal agencies to consider regulatory impacts on job creation and employment: "our regulatory system must protect public health, welfare, safety, and our environment while promoting economic growth, innovation, competitiveness, and job creation. It must be based on the best available science". Although benefit-cost analyses do not typically include a separate analysis of regulation-induced employment impacts,[144] during periods of sustained high unemployment, such impacts are of particular concern and questions may arise about their existence and magnitude. This chapter discusses some, but not all, possible types of labor impacts that may result from measures to decrease NOx emissions.

Section 10.1 describes the theoretical framework used to analyze regulation-induced employment impacts, discussing how economic theory alone cannot predict whether such impacts are positive or negative. Section 10.2 presents an overview of the peer-reviewed literature relevant to evaluating the effect of environmental regulation on employment. Section 10.3 discusses employment related to installation of NOx controls on coal and gas-fired electric generating units, industrial boilers, and cement kilns.

10.1 Economic Theory and Employment

Regulatory employment impacts are difficult to disentangle from other economic changes affecting employment decisions over time and across regions and industries. Labor market responses to regulation are complex. They depend on labor demand and supply elasticities and possible labor market imperfections (e.g., wage stickiness, long-term unemployment, etc). The unit of measurement (e.g., number of jobs, types of job hours worked, and earnings) may affect observability of that response. Net employment impacts are composed of a mix of potential declines and gains in different areas of the economy (the directly regulated sector, upstream and

[144] Labor expenses do, however, contribute toward total costs in the EPA's standard benefit-cost analyses.

downstream sectors, etc.) over time. In light of these difficulties, economic theory provides a constructive framework for analysis.

Microeconomic theory describes how firms adjust input use in response to changes in economic conditions.[145] Labor is one of many inputs to production, along with capital, energy, and materials. In competitive markets, firms choose inputs and outputs to maximize profit as a function of market prices and technological constraints.[146,147]

Berman and Bui (2001) and Morgenstern, Pizer, and Shih (2002), adapt this model to analyze how environmental regulations affect labor demand.[148] They model environmental regulation as effectively requiring certain factors of production, such as pollution abatement capital, at levels that firms would not otherwise choose.

Berman and Bui (2001, pp. 274-75) model two components that drive changes in firm-level labor demand: output effects and substitution effects.[149] Regulation affects the profit-maximizing quantity of output by changing the marginal cost of production. If regulation causes marginal cost to increase, it will place upward pressure on output prices, leading to a decrease in demand, and resulting in a decrease in production. The output effect describes how, holding labor intensity constant, a decrease in production causes a decrease in labor demand. As noted by Berman and Bui, although many assume that regulation increases marginal cost, it need not be the case. A regulation could induce a firm to upgrade to less polluting and more efficient equipment that lowers marginal production costs. In such a case, output could increase for facilities that do not exit the industry. For example, improving the heat rate of a utility boiler increases fuel efficiency, lowering marginal production costs, and thereby potentially increasing

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[145] See Layard and Walters (1978), a standard microeconomic theory textbook, for a discussion, in Chapter 9.

[146] See Hamermesh (1993), Ch. 2, for a derivation of the firm's labor demand function from cost-minimization.

[147] In this framework, labor demand is a function of quantity of output and prices (of both outputs and inputs).

[148] Berman and Bui (2001) and Morgenstern, Pizer, and Shih (2002) use a cost-minimization framework, which is a special case of profit-maximization with fixed output quantities.

[149] The authors also discuss a third component, the impact of regulation on factor prices, but conclude that this effect is unlikely to be important for large competitive factor markets, such as labor and capital. Morgenstern, Pizer and Shih (2002) use a very similar model, but they break the employment effect into three parts: 1) a demand effect; 2) a cost effect; and 3) a factor-shift effect.

the boiler's generation. An unregulated profit-maximizing firm may not have chosen to install such an efficiency-improving technology if the investment cost were too high.

The substitution effect describes how, holding output constant, regulation affects labor-intensity of production. Although stricter environmental regulation may increase use of pollution control equipment and energy to operate that equipment, the impact on labor demand is ambiguous. Equipment inspection requirements, specialized waste handling, or pollution technologies that alter the production process may affect the number of workers necessary to produce a unit of output. Berman and Bui (2001) model the substitution effect as the effect of regulation on pollution control equipment and expenditures required by the regulation and the corresponding change in labor-intensity of production.

In summary, as output and substitution effects may be positive or negative, theory cannot predict the direction of the net effect of regulation on labor demand at the level of the regulated firm. Operating within the bounds of standard economic theory, however, empirical estimation of net employment effects on regulated firms is possible when data and methods of sufficient detail and quality are available. The literature, however, illustrates difficulties with empirical estimation. For example, studies sometimes rely on confidential plant-level employment data from the U.S. Census Bureau, possibly combined with pollution abatement expenditure data that are too dated to be reliably informative. In addition, the most commonly used empirical methods do not permit estimation of net national effects.

The conceptual framework described thus far focused on regulatory effects on plant-level decisions within a regulated industry. Employment impacts at an individual plant do not necessarily represent impacts for the sector as a whole. The approach must be modified when applied at the industry level.

At the industry-level, labor demand is more responsive if: (1) the price elasticity of demand for the product is high, (2) other factors of production can be easily substituted for labor, (3) the supply of other factors is highly elastic, or (4) labor costs are a large share of total production costs.[150] For example, if all firms in an industry are faced with the same regulatory compliance costs and product demand is inelastic, then industry output may not change much, and output of individual firms may change slightly.[151] In this case the output effect may be small, while the substitution effect depends on input substitutability. Suppose, for example, that new equipment for heat rate improvements requires labor to install and operate. In this case the substitution effect may be positive, and with a small output effect, the total effect may be positive. As with potential effects for an individual firm, theory cannot determine the sign or magnitude of industry-level regulatory effects on labor demand. Determining these signs and magnitudes requires additional sector-specific empirical study. For environmental rules, much of the data needed for these empirical studies are not publicly available, would require significant time and resources in order to access confidential U.S. Census data for research, and also would not be necessary for other components of a typical RIA.

In addition to changes to labor demand in the regulated industry, net employment impacts encompass changes in other related sectors. For example, the proposed guidelines may increase demand for pollution control equipment and services. This increased demand may increase revenue and employment in the firms supporting this technology. At the same time, the regulated industry is purchasing the equipment and these costs may impact labor demand at regulated firms. Therefore, it is important to consider the net effect of compliance actions on employment across multiple sectors or industries.

If the U.S. economy is at full employment, even a large-scale environmental regulation is unlikely to have a noticeable impact on aggregate net national employment.[152] Instead, labor would primarily be reallocated from one productive use to another (e.g., from producing electricity or steel to producing high efficiency equipment), and net national employment effects

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[150] See Ehrenberg & Smith, p. 108.

[151] This discussion draws from Berman and Bui (2001), pp. 293.

[152] Full employment is a conceptual target for the economy where everyone who wants to work and is available to do so at prevailing wages is actively employed. The unemployment rate at full employment is not zero.

from environmental regulation would be small and transitory (e.g., as workers move from one job to another).[153]

Affected sectors may experience transitory effects as workers change jobs. Some workers may retrain or relocate in anticipation of new requirements or require time to search for new jobs, while shortages in some sectors or regions could bid up wages to attract workers. These adjustment costs can lead to local labor disruptions. Although the net change in the national workforce is expected to be small, localized reductions in employment may adversely impact individuals and communities just as localized increases may have positive impacts.

If the economy is operating at less than full employment, economic theory does not clearly indicate the direction or magnitude of the net impact of environmental regulation on employment; it could cause either a short-run net increase or short-run net decrease (Schmalansee and Stavins, 2011). An important research question is how to accommodate unemployment as a structural feature in economic models. This feature may be important in assessing large-scale regulatory impacts on employment (Smith 2012).

Environmental regulation may also affect labor supply. In particular, pollution and other environmental risks may impact labor productivity or employees' ability to work.[154] While the theoretical framework for analyzing labor supply effects is analogous to that for labor demand, it is more difficult to study empirically. There is a small emerging literature, described in the next section that uses detailed labor and environmental data to assess these impacts.

To summarize, economic theory provides a framework for analyzing the impacts of environmental regulation on employment. The net employment effect incorporates expected employment changes (both positive and negative) in the regulated sector and elsewhere. Labor demand impacts for regulated firms, and also for the regulated industry, can be decomposed into output and substitution effects which may be either negative or positive. Estimation of net employment effects for regulated sectors is possible when data of sufficient detail and quality are

[153] Arrow et. al. 1996; see discussion on bottom of p. 8. In practice, distributional impacts on individual workers can be important, as discussed in later paragraphs of this section.

[154] E.g. Graff Zivin and Neidell (2012).

available. Finally, economic theory suggests that labor supply effects are also possible. In the next section, we discuss the empirical literature.

10.2 Current State of Knowledge Based on the Peer-Reviewed Literature

The labor economics literature contains an extensive body of peer-reviewed empirical work analyzing various aspects of labor demand, relying on the theoretical framework discussed in the preceding section.[155] This work focuses primarily on effects of employment policies such as labor taxes and minimum wages.[156] In contrast, the peer-reviewed empirical literature specifically estimating employment effects of environmental regulations is more limited.

Empirical studies, such as Berman and Bui (2001), suggest that net employment impacts were not statistically different from zero in the regulated sector. Other research suggests that more highly regulated counties may generate fewer jobs than less regulated ones (Greenstone 2002). Environmental regulations may affect sectors that support pollution reduction earlier than the regulated industry. Rules are usually announced well in advance of their effective dates and then typically provide a period of time for firms to invest in technologies and process changes to meet the new requirements. When a regulation is promulgated, the initial response of firms is often to order pollution control equipment and services to enable compliance when the regulation becomes effective. Estimates of short-term increases in demand for specialized labor within the environmental protection sector have been prepared for several EPA regulations in the past, including the Mercury and Air Toxics Standards (MATS).[157] Overall, the peer-reviewed literature does not contain evidence that environmental regulation has a large impact on net employment (either negative or positive) in the long run across the whole economy.

10.2.1 Regulated Sectors

Berman and Bui (2001) examine how an increase in local air quality regulation affects manufacturing employment in the South Coast Air Quality Management District (SCAQMD), which includes Los Angeles and its suburbs. From 1979 to 1992 the SCAQMD enacted some of

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155 Again, see Hamermesh (1993) for a detailed treatment.

156 See Ehrenberg & Smith (2000), Chapter 4: "Employment Effects: Empirical Estimates" for a concise overview.

157 U.S. EPA (2011b).

the country's most stringent air quality regulations. Using SCAQMD's local air quality regulations, Berman and Bui identify the effect of environmental regulations on net employment in regulated manufacturing industries relative to other plants in the same 4-digit SIC industries but in regions not subject to local regulations.[158] The authors find that "while regulations do impose large costs, they have a limited effect on employment" (Berman and Bui, 2001, p. 269). Their conclusion is that local air quality regulation "probably increased labor demand slightly" but that "the employment effects of both compliance and increased stringency are fairly precisely estimated zeros, even when exit and dissuaded entry effects are included" (Berman and Bui, 2001, p. 269).[159]

A small literature examines impacts of environmental regulations on manufacturing employment. Kahn and Mansur (2013) study environmental regulatory impacts on geographic distribution of manufacturing employment, controlling for electricity prices and labor regulation (right to work laws). Their methodology identifies employment impacts by focusing on neighboring counties with different ozone regulations. They find limited evidence that environmental regulations may cause employment to be lower within "county-border-pairs." This result suggests that regulation may cause an effective relocation of labor across a county border, but since one county's loss may be another's gain, such shifts cannot be transformed into an estimate of a national net effect on employment. Moreover this result is sensitive to model specification choices.

10.2.2 Labor Supply Impacts

The empirical literature on environmental regulatory employment impacts focuses primarily on labor demand. However, there is a nascent literature focusing on regulation-induced effects on labor supply.[160] Although this literature is limited by empirical challenges, researchers have found that air quality improvements lead to reductions in lost work days (e.g., Ostro 1987). Limited evidence suggests worker productivity may also improve when pollution is reduced.

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158 Berman and Bui include over 40 4-digit SIC industries in their sample. They do not estimate the number of jobs created in the environmental protection sector.

159 Including the employment effect of existing plants and plants dissuaded from opening will increase the estimated impact of regulation on employment.

160 For a recent review see Graff-Zivin and Neidell (2013).

Graff Zivin and Neidell (2012) used detailed worker-level productivity data from 2009 and 2010, paired with local ozone air quality monitoring data for one large California farm growing multiple crops, with a piece-rate payment structure. Their quasi-experimental structure identifies an effect of daily variation in monitored ozone levels on productivity. They find "ozone levels well below federal air quality standards have a significant impact on productivity: a 10 parts per billion (ppb) decreases in ozone concentrations increases worker productivity by 5.5 percent." (Graff Zivin and Neidell, 2012, p. 3654).[161]

This section has outlined the challenges associated with estimating regulatory effects on both labor demand and supply for specific sectors. These challenges make it difficult to estimate net national employment estimates that would appropriately capture the way in which costs, compliance spending, and environmental benefits propagate through the economy. Quantitative estimates are further complicated by the fact that macroeconomic models often have little sectoral detail and usually assume that the economy is at full employment. The EPA is currently seeking input from an independent expert panel on modeling economy-wide regulatory impacts, including employment effects.[162]

10.3 Employment Related to Installation and Maintenance of NOx Control Equipment

This section discusses employment related to installation of NOx controls on coal and gas-fired electric generating units, industrial boilers, and cement kilns, which are among the highest NOx-emitting source categories in EPA's emissions inventory (see chapter 3 for more detail on emissions). Sections 10.3.1 and 10.3.2 below contain estimates of the number of direct short-term and long-term jobs that would be created by addition of NOx controls at these three categories of emissions sources, for various size units. Because the apportionment of emissions control across emissions sources in this RIA analysis is illustrative and not necessarily representative of the controls that will be required in individual state SIPs, EPA did not estimate

[161] The EPA is not quantifying productivity impacts of reduced pollution in this rulemaking using this study. In light of this recent research, however, the EPA is considering how best to incorporate possible productivity effects in the future.

[162] For further information see: <https://www.federalregister.gov/articles/2014/02/05/2014-02471/draft-supporting-materials-for-the-science-advisory-board-panel-on-the-role-of-economy-wide-modeling>.

short-term or long-term employment that would result from addition of NOx controls at these three source categories at the national level.

10.3.1 Employment Resulting from Addition of NOx Controls at EGUs

Coal-fired EGUs are likely to apply additional NOx controls in response to State Implementation Plans (SIPs) approved pursuant to a revised ozone standard. While many EGUs have already installed and operate various NOx control devices, there are additional existing coal-fired EGUs that could decrease NOx emissions by installing or upgrading their NOx reducing systems. While all existing coal-fired EGUs already have low NOx burners, there are EGUs that could have a selective catalytic reduction (SCR) system installed, or could improve their NOx emissions by replacing an existing selective non-catalytic reduction (SNCR) system with an SCR system. The EPA identified 145 existing coal-fired EGUs, with a total of 51.0 GW of capacity, that (1) are in areas anticipated to need additional NOx reductions under an alternative ozone standard of 65 ppb , and (b) do not already have an SCR emission control system. (For an alternative ozone standard of 70 ppb, there are 15 EGUs so identified, with a total of 7.4 GW of capacity.) While there are currently SNCR systems in use that could be upgraded to an SCR system, the EPA's 2025 baseline analysis[163] estimates that the remaining SNCR systems will already be upgraded by 2025 in response to existing emission control programs.

The EPA used a bottom up engineering analysis using data on labor productivity, engineering estimates of the types of labor needed to manufacture, construct and operate SCRs on EGUs. The EPA's labor estimates include not only labor directly involved with installing SCRs on EGUs and on-site labor used to operate the SCRs once they become operational, but also include the labor requirements in selected major upstream sectors directly involved manufacturing the materials used in SCR systems (steel), as well as the chemicals used to operate an SCR system (ammonia and the catalyst used to in the construction and operation of SCR systems, including such as steel, concrete, or chemicals used to manufacture NOx controls.

[163] The 2025 baseline used in this illustrative analysis incorporates the "state only" implementation option used in the proposed carbon pollution guidelines for existing power plants and emission standards for modified and reconstructed power plants (a.k.a. the proposed Clean Power Plan, June, 2013).

This section presents an illustrative analysis of the direct labor needs to install and operate SCRs at 3 common sizes of coal-fired EGUs: 300 MW, 500 MW and 1000 MW. As discussed below, the illustrative analysis is for a "model plant" of each size, using consistent assumptions about the plant's operation that impact the material and labor needs of an representative plant such as the capacity factor, heat rate, and type of coal. The analysis does not include an estimate of the aggregate total of the labor needed for installing and running SCRs in any particular level of the revised ozone standard, nor does it reflect plant-specific variations in labor needs due to regional differences in prices and labor availability, existing control technology at the plant, etc.

The analysis draws on information from four primary sources:

- Documentation for EPA Base Case v.5.13 Using the Integrated Planning Model. November, 2013
- "ENGINEERING AND ECONOMIC FACTORS AFFECTING THE INSTALLATION OF CONTROL TECHNOLOGIES: An Update". By James E. Staudt, Andover Technology Partners. December, 2011.
- "Regulatory Impact Analysis (RIA) for the final Transport Rule". June 2011
- "Regulatory Impact Analysis for the Proposed Carbon Pollution Guidelines for Existing Power Plants and Emission Standards for Modified and Reconstructed Power Plants". June 2013

10.3.1.1 Existing EGUs Without SCR Systems

The EPA identified 145 existing coal-fired EGU units that are estimated to continue to be in operation in 2025 in the baseline that are located in areas considered likely to be affected by State Implementation Plans developed for a 65 ppb alternative ozone standard. The size distribution of the 145 units is shown in Figure 10-1. The 145 units have a total generating capacity of 51.0 GW and are anticipated to generate 282,000 GWh of electricity in 2025. With the current level of NOx controls installed (or anticipated to be installed by 2025 to meet existing environmental regulations), these 145 units are estimated to emit 290.7 tons of NOx in 2025.

The following key assumptions are used to estimate the amount of labor needed to install and operate individual SCR systems of various sizes.

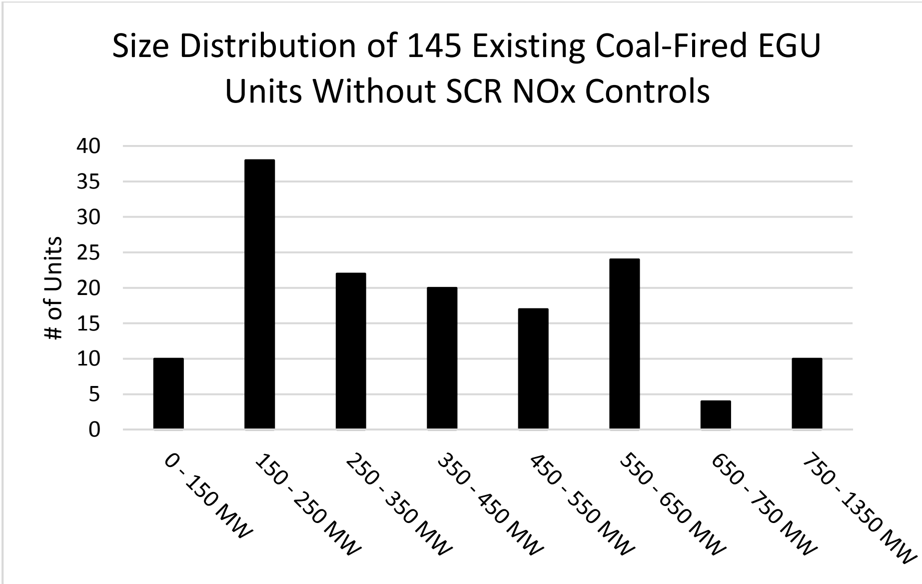

Figure 10-1. Size Distribution of 145 Existing Coal-Fired EGU Units without SCR NOx Controls

10.3.1.2 Labor Estimates for Installing and Operating Individual SCR Systems

All labor estimates in this illustrative analysis are in terms of person-years (i.e., full time equivalents, or FTEs).

The labor involved with manufacturing and installing the SCRs is a one-time labor need, and occurs over a 2 to 3 year construction period; the estimated FTEs during the construction phase are presented as the cumulative amount of labor over the multi-year period. The construction phase labor includes both labor directly involved with installing the SCR on site (including boiler makers, general labor and engineering).

There are three types of annual labor estimated to operate an SCR, and will be needed each year the EGU is in operation. The largest category is on-site labor at the EGU. The estimated amounts of direct labor involved with installing SCR systems is shown in Table 10-1.

Table 10-1. Summary of Direct Labor Impacts for SCR Installation at EGUs

	Plant Size		
	300 MW	**500 MW**	**1000 MW**
Construction Phase (One time, Total Labor over 2-3 Year Period)			
Direct Construction-related Employment	158.7	264.4	528.8
Operation Phase (Annual Operations)			

	Plant Size		
Operation and Maintenance	1.9	2.8	4.6

The key assumptions used in the labor analysis are presented in Table 10-2.

Table 10-2. Key Assumptions in Labor Analysis for EGUs

Assumptions	Key Factor	Source	300 MW	500 MW	1000 MW
Capital Investment to Install SCR	Utility-owned Capital Recovery Rate for Environmental Retrofits (12.1%)	IPM 5/13 Base Case Documentation	$86.1 million	$133 million	$244 million
Result: FTEs to Install an SCR	**1,100 hours/MW**	**Staudt, 2011**	**158.65**	**264.42**	**528.85**
Labor Cost (fixed O&M) per Year		IPM analysis of CPP baseline	$218,000	$310,500	$513,000
Result: FTEs per Year	8.9 FTEs per $1 million of Fixed O&M	CSAPR RIA	1.95	2.76	4.57
Result: Total FTES to Operate an SCR Annually			**1.95**	**2.76**	**4.57**

10.3.2 Assessment of Employment Impacts for Individual Industrial, Commercial, and Institutional (ICI) Boilers and Cement Kilns

Facilities other than electric power generators are likely to apply NOx controls in response to State Implementation Plans (SIPs) approved pursuant to a revised ozone standard. In addition to EGUs, the EPA estimated the amount and types of direct labor that might be used to apply and operate NOX controls for ICI boilers and for cement kilns. As with EGUs, the EPA used a bottom up engineering analysis using data on labor productivity, engineering estimates of the types of labor needed to manufacture, construct and operate NOx controls on ICI boilers and cement kilns. No estimates were made for labor requirements in upstream sectors such as steel, concrete, or chemicals used to manufacture or search as inputs to NOx controls. In addition, the numbers presented in this section are only indicative of the relative number and types of labor that might be used at these two categories of plants, without calculating an estimate of the labor that would be required by them in the aggregate (SC&A, 2014).

10.3.2.1 ICI Boilers

There are a number of control technologies available to reduce NOx emissions from ICI boilers. The EPA anticipates that the most commonly applied control technology for ICI boilers that could require NOx reductions as part of an ozone SIP will be selective catalytic reduction (SCR). The analysis calculates s labor requirements to fabricate, install, and operate different sizes of SCR for coal, oil and natural gas ICI boilers. Estimated total labor costs are a function of total capital costs and boiler size in EPA's Coal Utility Environmental Cost (CUECost) model. Total SCR capital costs of ICI boilers was estimated using the EPA's Control Strategy tool (CoST) model. Labor is estimated to be about 50% of the total capital costs of an SCR. (SC&A, 2014).

Just over 24% of total capital costs are for labor used in SCR fabrication. This percentage was multiplied by the total capital cost, and the resulting dollar amount was converted into full time equivalents (FTE) based on the average annual salary of workers (as outlined in IEC, 2011). The annual compensation came from the Bureau of Labor Statistics (BLS). This salary number was adjusted to account for benefits also based on BLS data. The total fabrication expenditures were divided by the average fabrication labor compensation to estimate the number of full time equivalent workers in SCR fabrication.

The calculation of construction or installation labor is based on previous research on labor required for SCR installation at utility boilers. (Staudt 2011). Based on that, we estimate that 27% of SCR capital costs are spent on installation labor. We applied that percentage to the estimates of the capital costs of SCR for ICI boilers to give us the total labor expenditures, which we then converted to FTE based on average annual compensation provided by BLS.

Operation and Maintenance labor was estimated using the CUECost model. Maintenance and administrative labor for SCR is estimated to be small in relation to fabrication and construction, with the caveat that available information on which to base an estimate is sparse. According to the approach used in the CUECost model, most utility boilers require a full time worker to operate and maintain the equipment. ICI boilers are much smaller and so are likely to require less than one FTE. Table 10-3 below provides summary labor estimates for SCR at varying sized ICI boilers.

Table 10-3. Summary of Direct Labor Impacts for Individual ICI Boilers

Plant Type	Boiler Size (MMBtu/hr)	One-Time Employment Impacts[1] (Annual FTEs)	Recurring Annual Employment Impacts[2] (FTEs per year)
Coal-fired	750	19.5	1.2
	500	15.2	1.1
	400	13.6	1.0
	250	10.7	0.9
Oil-fired	250	9.8	0.9
	150	7.3	0.9
	100	5.5	0.8
	50	3.2	0.8
Natural Gas-fired	250	10.5	0.9
	150	11.0	0.9
	100	8.4	0.9
	50	6.5	0.8

1. Includes Fabrication and Installation Labor
2. Includes Operations, Maintenance, and Administrative Support

10.3.2.2 Cement Kilns

There are a number of technologies that can be used to control NOx emissions at cement kilns. The analysis focused on synthetic non-catalytic reduction (SNCR) as the most likely choice for future NOx controls at cement kilns affected by requirements in ozone SIPs. Although SNCR is not considered an appropriate technology for wet and long dry kilns, most new or recently constructed kilns will likely be preheater and precalciner kilns, and these kilns will likely operate using SNCR as a control technology.

Fabrication capital cost was estimated for an SNCR system for a mid-sized preheater and precalciner kiln (125 to 208 tons of clinker per hour). The percent of capital cost of these systems attributable to labor is 44% based on vendor supplied estimates. (Wojichowski, 2014). This labor cost was converted to FTE using BLS data. A similar methodology was used to estimate installation labor. Labor costs for SNCR installation was estimated by the vendor to be 17% of the capital cost. That was converted to FTE using BLS data. This information is summarized in Table 10-4.

Table 10-4. Estimated Direct Labor Impacts for Individual SNCR Applied to a Mid-Sized Cement Kiln (125-208 tons clinker/hr)

Kiln Type	Preheater / Precalciner
Manufacturing FTE	1.5
Installation FTE	0.9
O&M Annual Recurring FTE	13

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United States Environmental Protection Agency	Office of Air Quality Planning and Standards Health and Environmental Impacts Division Research Triangle Park, NC	Publication No. EPA-452/P-14-006 November 2014

EXHIBIT 20

United States
Environmental Protection
Agency

Regulatory Impact Analysis: Proposed Brick and Structural Clay Products NESHAP

U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards (OAQPS)
Air Economics Group
(MD-C339-01)
Research Triangle Park, NC 27711

July 2014
Docket ID No. EPA-HQ-OAR-2013-0291

EXECUTIVE SUMMARY

ES.1 Background

The U.S. Environment Protection Agency (EPA) is proposing that all major sources in Brick and Structural Clay Products Manufacturing category meet health-based standards for acid gas hazardous air pollutants; maximum achievable control technology standards for mercury, non-mercury metal hazardous air pollutants (or particulate matter surrogate), and dioxins/furans (Clay Ceramics only); and work practice standards, where applicable. The proposed rules would protect air quality and promote public health by reducing emissions of the hazardous air pollutants listed in section 112 of the Clean Air Act. As part of the regulatory process, EPA is required to perform economic analysis and the Regulatory Impact Analysis (RIA) discusses the benefits and costs of the proposed rule.

ES.2 Results

For the proposed rule, the key results of the RIA follow:

- **Engineering Cost Analysis**: EPA estimates the total annualized costs (2011$) for two compliance options:
  - Proposed Standards: $21 Million
  - Alternate Standards: $31 million
- **Benefits Analysis**: The EPA monetized human health benefits of reducing cases of morbidity and premature mortality among populations exposed to $PM_{2.5}$.
  - Proposed Standards: Using a 3% discount rate, we estimate the total monetized benefits of the proposed standards to be $52 million to $120 million. Using a 7% discount rate, we estimate the total monetized benefits to be $47 million to $110 million.
  - Alternate Standards: Using a 3% discount rate, we estimate the total monetized benefits of the alternate standards to be $78 million to $180 million. Using a 7% discount rate, we estimate the total monetized benefits to be $70 million to $160 million.

  Data, resource, and methodological limitations prevented EPA from monetizing the benefits from several important benefit categories, including benefits from reducing exposure to close to 450 tons of HAPs each year for the proposed standards and exposure to as high as 740 tons of HAPs each year for the alternate standards, as well as ecosystem effects and visibility impairment due to PM emissions. In addition to reducing emissions of PM precursors such as SO_2, this rule would reduce several non-mercury HAP metals emissions (i.e., antimony, arsenic, beryllium, cadmium, chromium, cobalt, lead, manganese, mercury, nickel, and selenium) each year.

- **Market Analysis and Closure Estimates**: Market-level impacts include the price and production adjustments for bricks. The average national price under the proposed standards increases by 1.4%, or $3.29 per 1,000 SBE, while overall domestic production falls by 1.1%, or 38 million bricks per year. These values are lower than the alternate considered: the average national price increase for the alternate standards is 2.0% and brick U.S. brick production falls by about 55 million bricks. Under the proposed standards, EPA estimated that one to two brick manufacturing facilities are at significant risk of closure. Under the alternate standards EPA estimated that two to six brick manufacturing facilities are at significant risk of closure.

- **Social Cost Analysis**: Under the proposed standards, the economic model suggests that industries are able to pass on $11.4 million (2011$) of the rule's costs to U.S. households in the form of higher prices. Existing U.S. industries' surplus falls by $9.1 million, and the total U.S. economic surplus loss is $20.6 million. Under the alternate standards, total U.S. economic surplus loss is about $10 million higher ($30.5 million).

- **Comparison of Benefits and Costs**: The estimated monetized human health benefits outweigh the social costs.

  - Proposed Standards: The net benefits are $31 million to $99 million at a 3% discount rate for the benefits and $26 million to $89 billion at a 7% discount rate.

  - Alternate Standards: The net benefits are $47 million to $149 million at a 3% discount rate for the benefits and $39 million to $129 billion at a 7% discount rate.

- **Initial Regulatory Flexibility Analysis**: EPA was particularly concerned about the proposed rule's potential impacts to small entities, because 36 of 44 firms owning BSCP facilities have fewer than 750 employees and thus meet the Small Business Administration's (SBA's) criterion for a small business in this industry. EPA thus conducted a screening analysis of the potential impacts by computing the ratio of control costs to firm sales revenues (i.e., a sales test). Based on the results of the screening analysis, EPA concluded that it is not able to certify that the rule will not have a Significant Impact on a Substantial Number of Small Entities (SISNOSE). As a result, EPA initiated a Small Business Advisory Review panel and undertook an Initial Regulatory Flexibility Analysis (IRFA).

ES.3 Organization of this Report

The remainder of this report details the methodology and the results of the RIA. Section 1 provides an introduction, Section 2 presents the industry profile, Section 3 describes engineering cost analysis, Section 4 presents the benefits analysis, Section 5 presents market, employment impact, social cost, and small business impact analyses, Section 6 address statutory and Executive Order requirements, and Section 7 provides a summary of benefits and costs.

SECTION 5
ECONOMIC IMPACT ANALYSIS

EPA prepares an EIA to provide decision makers with a measure of the social costs of using resources to comply with a regulation (EPA, 2010). The social costs can then be compared with estimated social benefits (as presented in Section 4). As noted in EPA's (2010) *Guidelines for Preparing Economic Analyses*, several tools are available to estimate social costs and range from simple direct compliance cost methods to the development of a more complex market analysis that estimates market changes (e.g., price and consumption) and economic welfare changes (e.g., changes in consumer and producer surplus).

The Office of Air Quality Planning and Standards (OAQPS) adopted a market-level analysis described in the Office's resource manual (EPA, 1999a). The market approach uses a single-period static partial-equilibrium model to compare prepolicy market baselines with expected post policy outcomes in these markets. Key measures in this analysis include

- market-level effects (market prices, changes in domestic production and consumption, and international trade) and
- social costs and their distribution between producers and consumers.

We also assessed the impacts on employment in the brick industry through a qualitative discussion and a quantitative analysis that is linked to the results of the market-level analysis. Finally, we assessed how the regulatory program may influence the profitability of large and small ultimate parent companies that own affected BSCP facilities. To do this, we used a screening analysis required to comply with the Regulatory Flexibility Act (RFA) as amended by the Small Business Regulatory Enforcement Fairness Act (SBREFA).

5.1 Market Analysis

The partial-equilibrium analysis includes a market model that simulates how stakeholders (consumers and firms) might respond to the additional regulatory program costs. EPA used a perfectly competitive regional market model that accounts for the fact that brick shipments are not likely to be shipped long distances because of weight and transportation costs. In regional markets, it is more likely that only a few firms offer similar brick products and other market structures may be applicable (i.e., oligopoly). If market power exists, the use of a perfectly competitive model may understate the social costs of the proposed rule. Appendix A provides additional details about the economic model equations and parameters.

5.1.1 Market-Level Results

Market-level impacts include the price and production adjustments for bricks. As shown in Table 5-1, the average national price under the proposed standards increases by 1.4%, or $3.29 per 1,000 SBE, while overall domestic production falls by 1.1%, or 38 million bricks per year. These values are lower than the alternate approach: the average national price increase for the alternate standards is 2.0% and brick U.S. brick production falls by about 55 million bricks.

Price increases are the highest in regions with high unit compliance costs. For example, the East North Central market price increase ($8.43 per 1,000 SBE) is associated with higher per-unit compliance costs ($18.72 per 1,000 SBE). Under the proposed standards, one region does not include any facilities with incremental compliance costs (New England). As a result, there are no market-level changes. For all of the census regions, the average regional price increases between 0% and 2.8%. Regional domestic production falls between 0% and 2.2% and 0 to 14 million bricks per year. Under the alternate standards, the average regional price increases between 0% and 3.9%. Regional domestic production falls between 0% and 3.1%, or 0 to 21 million bricks per year.

5.1.2 Social Cost Estimates

Under the proposed standards, the economic model suggests that industries are able to pass on $11.4 million (2011$) of the rule's costs to U.S. households in the form of higher prices (Table 5-1). Existing U.S. industries' surplus falls by $9.1 million, and the total U.S. economic surplus loss is $20.6 million. Under the alternate standards, total U.S. economic surplus loss is $10 million higher ($30.5 million). Because higher brick prices reduce consumption, the estimated compliance costs are lower than the engineering cost estimate that does not account for price responses. However, the differences are very small (i.e., less than 0.01%).

5.2 Employment Impacts of the Proposed Rule

Executive Order 13563 directs federal agencies to consider the effect of regulations on job creation and employment. According to the Executive Order, "our regulatory system must protect public health, welfare, safety, and our environment while promoting economic growth, innovation, competitiveness, and job creation. It must be based on the best available science" (Executive Order 13563, 2011). Although standard benefit-cost analyses have not typically

Table 5-1. Estimated Market Impacts of Proposed BSCP NESHAP

Census Region	Incremental Unit Compliance Costs ($/1,000 SBE)	Market Price Change		U.S. Production Change		Change in:		
		Absolute	Percent	Absolute	Percent	Consumer Surplus	Producer Surplus	Total Surplus
Proposed Standards								
New England	$0.00	$0.00	0.0%	0	0.0%	$0.0	$0.0	$0.0
Middle Atlantic	$3.55	$1.36	0.4%	−703	−0.3%	−$0.3	−$0.2	−$0.5
East North Central	$18.72	$8.43	2.8%	−6,364	−2.2%	−$2.4	−$1.9	−$4.3
West North Central	$6.81	$3.79	1.4%	−2,000	−1.1%	−$0.7	−$0.6	−$1.2
South Atlantic	$6.17	$3.15	1.4%	−14,228	−1.1%	−$4.1	−$3.3	−$7.4
East South Central	$6.17	$3.43	1.8%	−5,727	−1.5%	−$1.3	−$1.1	−$2.4
West South Central	$5.15	$2.86	1.2%	−8,898	−1.0%	−$2.5	−$2.0	−$4.6
Mountain	$1.23	$0.34	0.1%	−86	−0.1%	$0.0	$0.0	−$0.1
Pacific	$2.35	$1.11	0.2%	−120	−0.2%	−$0.1	−$0.1	−$0.1
U.S. Average/Total	***$6.55***	***$3.29***	***1.4%***	***−38,126***	***−1.1%***	***−$11.4***	***−$9.1***	***−$20.6***

(continued)

Table 5-1. Estimated Market Impacts of Proposed BSCP NESHAP (continued)

Census Region	Incremental Unit Compliance Costs ($/1,000 SBE)	Market Price Change		U.S. Production Change		Change in:		
		Absolute	Percent	Absolute	Percent	Consumer Surplus	Producer Surplus	Total Surplus
Alternate Standards								
New England	$0.00	$0.00	0.0%	0	0.0%	$0.0	$0.0	$0.0
Middle Atlantic	$5.39	$2.07	0.6%	−1,068	−0.5%	−$0.4	−$0.3	−$0.8
East North Central	$26.19	$11.79	3.9%	−8,901	−3.1%	−$3.3	−$2.6	−$5.9
West North Central	$10.54	$5.85	2.1%	−3,093	−1.7%	−$1.1	−$0.9	−$1.9
South Atlantic	$8.99	$4.60	2.0%	−20,743	−1.6%	−$6.0	−$4.8	−$10.7
East South Central	$9.13	$5.07	2.7%	−8,473	−2.2%	−$2.0	−$1.6	−$3.5
West South Central	$7.44	$4.13	1.8%	−12,854	−1.4%	−$3.7	−$2.9	−$6.6
Mountain	$6.05	$1.68	0.5%	−424	−0.4%	−$0.2	−$0.2	−$0.3
Pacific	$11.02	$5.21	0.9%	−563	−0.8%	−$0.4	−$0.3	−$0.7
U.S. Average/Total	***$9.74***	***$4.90***	***2.0%***	***−56,118***	***−1.6%***	***−$17.0***	***−$13.5***	***−$30.5***

included a separate analysis of regulation-induced employment impacts,[43] during periods of sustained high unemployment, employment impacts are of particular concern and questions may arise about their existence and magnitude. This chapter provides a conceptual framework for considering the potential influence of environmental regulation on employment in the U.S. economy and discusses the limited empirical literature that is available. The chapter then discusses the potential employment impacts in the BSCP industry, as well as the environmental protection sector (e.g., for construction, manufacture, installation and operation of needed pollution control equipment). Section 5.2.1 describes the economic theory used for analyzing regulation-induced employment impacts, discussing how standard neoclassical theory alone does not point to a definitive net effect of regulation on labor demand for regulated firms. Section 5.2.2 presents an overview of the peer-reviewed literature relevant to evaluating the effect of environmental regulation on employment. Section 5.2.3 discusses macroeconomic net employment effects. EPA is currently in the process of seeking input from an independent expert panel on economy-wide impacts, including employment effects. Section 5.2.4 addresses the particular influence of this proposed rule on employment. Finally, Section 5.2.5 offers several conclusions.

5.2.1 Theory

The effects of environmental regulation on employment are difficult to disentangle from other economic changes and business decisions that affect employment, over time and across regions and industries. Labor markets respond to regulation in complex ways. That response depends on the elasticities of demand and supply for labor and the degree of labor market imperfections (e.g., wage stickiness, long-term unemployment). The unit of measurement (e.g., number of jobs, types of job hours worked, or earnings) may affect observability of that response. Net employment impacts are composed of a mix of potential declines and gains in different areas of the economy (i.e., the directly regulated sector, upstream and downstream sectors, and the pollution abatement sector) and over time. In light of these difficulties, economic theory provides a constructive framework for approaching these assessments and for better understanding the inherent complexities in such assessments. In this section, we briefly describe theory relevant to the impact of regulation on labor demand at the regulated firm, in the regulated industry, and in the environmental protection sector and highlight the importance of considering potential effects of regulation on labor supply, a topic addressed further in a subsequent section.

[43]Labor expenses do, however, contribute toward total costs in EPA's standard benefit-cost analyses.

Neoclassical microeconomic theory describes how profit-maximizing firms adjust their use of productive inputs in response to changes in their economic conditions.[44] In this framework, labor is one of many inputs to production, along with capital, energy, and materials. In competitive output markets, profit-maximizing firms take prices as given and choose quantities of inputs and outputs to maximize profit. Factor demand at the firm, then, is determined by input and output prices.[45,46]

Berman and Bui (2001) and Morgenstern, Pizer, and Shih (2002) have specifically tailored one version of the standard neoclassical model to analyze how environmental regulations affect labor demand decisions.[47] Environmental regulation is modeled as effectively requiring certain factors of production, such as pollution abatement capital investment, that would not be freely chosen by profit-maximizing/cost-minimizing firms.

In Berman and Bui's (2001, p. 274–75) theoretical model, the change in a firm's labor demand arising from a change in regulation is decomposed into two main components: output and substitution effects.[48] For the output effect, by affecting the marginal cost of production, regulation affects the profit-maximizing quantity of output. The output effect describes how, if labor intensity of production is held constant, a decrease in output generally leads to a decrease in labor demand. However, as noted by Berman and Bui, although it is often assumed that regulation increases marginal cost, and thereby reduces output, it need not be the case. A regulation could induce a firm to upgrade to less polluting and more efficient equipment that lowers marginal production costs, for example. In such a case, output could theoretically increase.

The substitution effect describes how, holding output constant, regulation affects the labor intensity of production. Although increased environmental regulation generally results in higher utilization of production factors such as pollution control equipment and energy to operate that equipment, the resulting impact on labor demand is ambiguous. For example, equipment inspection requirements, specialized waste handling, or pollution technologies that alter the production process may affect the number of workers necessary to produce a unit of output.

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[44]See Layard and Walters (1978), a standard microeconomic theory textbook, for a discussion.
[45]See Hamermesh (1993), Chapter 2, for a derivation of the firm's labor demand function from cost-minimization.
[46]In this framework, labor demand is a function of quantity of output and prices (of both outputs and inputs).
[47]Berman and Bui (2001) and Morgenstern, Pizer, and Shih (2002) used a cost-minimization framework, which is a special case of profit-maximization with fixed output quantities.
[48]The authors also discuss a third component, the impact of regulation on factor prices but conclude that this effect is unlikely to be important for large competitive factor markets, such as labor and capital. Morgenstern, Pizer, and Shih (2002) used a very similar model, but they break the employment effect into three parts: 1) the demand effect, 2) the cost effect, and 3) the factor-shift effect.

Berman and Bui (2001) modeled the substitution effect as the effect of regulation on "quasi-fixed" pollution control equipment and expenditures that are required by the regulation and the corresponding change in labor intensity of production. Within the production theory framework, when levels of a given set of inputs are fixed by external constraints such as regulatory requirements, rather than allowing the firm to freely choose all inputs under cost-minimization alone, these inputs are described as "quasi-fixed." For example, materials would be a "quasi-fixed" factor if there were specific requirements for landfill liner construction, but the footprint of the landfill was flexible. Brown and Christensen (1981) developed a partial static equilibrium model of production with quasi-fixed factors, which Berman and Bui (2001) extended to analyze environmental regulations with technology-based standards.

In summary, because the output and substitution effects may be both positive, both negative, or some combination, standard neoclassical theory alone does not point to a definitive net effect of regulation on labor demand at regulated firms. Operating within the bounds of standard neoclassical theory, however, rough estimation of net employment effects is possible with empirical study, specific to the regulated firms, when data and methods of sufficient detail and quality are available. The available literature illustrates some of the difficulties for empirical estimation: studies sometimes rely on confidential plant-level employment data from the U.S. Census Bureau, possibly combined with pollution abatement expenditure data that are too dated to be reliably informative. In addition, the most commonly used empirical methods in the literature do not permit the estimation of net effects. These studies will be discussed at greater length later in this chapter.

The above describes a conceptual framework for analyzing potential employment effects at a particular firm within a regulated industry. It is important to emphasize that employment impacts at a particular firm will not necessarily represent impacts for the overall industry; therefore, the theoretic approach requires some adjustment when applied at the industry level.

As stated, the responsiveness of industry labor demand depends on how the output and substitution effects interact.[49] At the industry level, labor demand will be more responsive when (1) the price elasticity of demand for the product is high, (2) other factors of production can be easily substituted for labor, (3) the supply of other factors is highly elastic, or (4) labor costs are a large share of the total costs of production.[50] So, for example, if all firms in the industry are faced with the same compliance costs of regulation and product demand is inelastic, then

[49] On Marshall's laws of derived demand, see Ehrenberg and Smith (2000), Chapter 4.
[50] See Ehrenberg and Smith (2000), p. 108.

industry output may not change much at all, and output of individual firms may only be slightly changed.[51] In this case, the output effect may be small, while the substitution effect will still depend on the degree of substitutability or complementarity between factors of production. Continuing the example, if new pollution control equipment requires labor to install and operate, labor is more of a complement than a substitute. In this case, the substitution effect may be positive, and if the output effect is small or zero, the total effect may then be positive. As with the potential effects for an individual firm, theory alone is unable to determine the sign or magnitude of industry-level regulatory effects on labor. Determining these signs and magnitudes requires additional sector-specific empirical study. To conduct such targeted research would require estimates of product demand elasticity; production factor substitutability; supply elasticity of production factors; and the share of total costs contributed by wages, by industry, and perhaps even by facility. For environmental rules, many of these data items are not publicly available, would require significant time and resources to access confidential U.S. Census data for research, and also would not be necessary for other components of a typical RIA.

In addition to changes to labor demand in the regulated industry, net employment impacts encompass changes within the environmental protection sector and, potentially, in other related sectors, as well. Environmental regulations often create increased demand for pollution control equipment and services needed for compliance. This increased demand may increase revenue and employment in the environmental protection industry. At the same time, the regulated industry is purchasing the equipment, and these costs may affect labor demand at regulated firms. Therefore, it is important to consider the net effect of compliance actions on employment across multiple sectors or industries.

On the one hand, if the U.S. economy is at full employment, even a large-scale environmental regulation is unlikely to have a noticeable impact on aggregate net employment.[52] Instead, labor would primarily be reallocated from one productive use to another (e.g., from producing electricity or steel to producing pollution abatement equipment). Theory supports the argument that, in the case of full employment, the net national employment effects from environmental regulation are likely to be small and transitory (e.g., as workers move from one job to another).[53] On the other hand, if the economy is operating at less than full employment, economic theory does not clearly indicate the direction or magnitude of the net impact of

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[51]This discussion draws from Berman and Bui (2001), p. 293.
[52]Full employment is a conceptual target for the economy where everyone who wants to work and is available to do so at prevailing wages is actively employed.
[53]Arrow et al. (1996); see discussion on bottom of p. 8. In practice, distributional impacts on individual workers can be important, as discussed in later paragraphs of this section.

environmental regulation on employment; it could cause either a short-run net increase or short-run net decrease (Schmalansee and Stavins, 2011). An important fundamental research question is how to accommodate unemployment as a structural feature in economic models. This feature may be important in evaluating the impact of large-scale regulation on employment (Smith, 2012).

Affected sectors may experience transitory effects as workers change jobs. Some workers may need to retrain or relocate in anticipation of the new requirements or require time to search for new jobs, while shortages in some sectors or regions could bid up wages to attract workers. It is important to recognize that these adjustment costs can entail local labor disruptions, and although the net change in the national workforce is expected to be small, localized reductions in employment can still have negative impacts on individuals and communities just as localized increases can have positive impacts.

Although the current discussion focuses on labor demand effects, environmental regulation may also affect labor supply. In particular, pollution and other environmental risks may affect labor productivity[54] or employees' ability to work. Although there is an accompanying, and parallel, theoretical approach to examining impacts on labor supply, similar to labor demand, it is even more difficult and complex to study labor supply empirically. There is a small, nascent empirical literature using more detailed labor and environmental data and quasi-experimental techniques that is starting to find traction on this question. These are described in Section 5.2.6.

To summarize the discussion in this section, economic theory provides a framework for analyzing the impacts of environmental regulation on employment. The net employment effect incorporates expected employment changes (both positive and negative) in the regulated sector, the environmental protection sector, and other relevant sectors. Using economic theory, labor demand impacts for regulated firms, and also for the regulated industry, can be decomposed into output and substitution effects. With these potentially competing forces, under standard neoclassical theory estimation of net employment effects is possible with empirical study specific to the regulated firms and firms in the environmental protection sector and other relevant sectors when data and methods of sufficient detail and quality are available. Finally, economic theory suggests that labor supply effects are also possible. In the next section, we discuss the available empirical literature.

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[54]For example, Graff Zivin and Neidell (2012).

5.2.2 Current State of Knowledge Based on the Peer-Reviewed Literature

In the labor economics literature, an extensive body of peer-reviewed empirical work analyzes various aspects of labor demand, relying on the above theoretical framework.[55] This work focuses primarily on the effects of employment policies, for example, labor taxes and minimum wage.[56] In contrast, the peer-reviewed empirical literature specifically estimating employment effects of environmental regulations is very limited. In this section, we present an overview of the latter. As discussed in the preceding section on theory, determining the direction of employment effects in regulated industries is challenging because of the complexity of the output and substitution effects. Complying with a new or more stringent regulation may require additional inputs, including labor, and may alter the relative proportions of labor and capital used by regulated firms (and firms in other relevant industries) in their production processes.

Several empirical studies, including Berman and Bui (2001) and Morgenstern et al. (2002), suggest that net employment impacts may be zero or slightly positive but small even in the regulated sector. Other research suggests that more highly regulated counties may generate fewer jobs than less regulated ones (Greenstone, 2002; Walker, 2011). However, because these latter studies compare more regulated to less regulated counties, they overstate the net national impact of regulation to the extent that regulation causes plants to locate in one area of the country rather than another. List et al. (2003) found some evidence that this type of geographic relocation may be occurring. Overall, the peer-reviewed literature does not contain evidence that environmental regulation has a large impact on net employment (either negative or positive) in the long run across the whole economy.

Environmental regulations seem likely to affect the environmental protection sector earlier than the regulated industry. Rules are usually announced well in advance of their effective dates and then typically provide a period of time for firms to invest in technologies and process changes to meet the new requirements. When a regulation is promulgated, the initial response of firms is often to order pollution control equipment and services to enable compliance when the regulation becomes effective. This can produce a short-term increase in labor demand for specialized workers within the environmental protection sector, particularly workers involved in the design, construction, testing, installation, and operation of the new pollution control equipment required by the regulation (see Schmalansee and Stavins, 2011; Bezdek, Wendling, and Diperna, 2008). Estimates of short-term increases in demand for specialized labor within the

[55] Again, see Hamermesh (1993) for a detailed treatment.
[56] See Ehrenberg and Smith (2000), Chapter 4: "Employment Effects: Empirical Estimates" for a concise overview.

environmental protection sector have been prepared for several EPA regulations in the past, including the Mercury and Air Toxics Standards (MATS) (U.S. EPA, 2011b).

5.2.3 Regulated Sector

Determining the direction of net employment effects of regulation on industry is challenging. Two papers that present a formal theoretic model of the underlying profit-maximizing/cost-minimizing problem of the firm are Berman and Bui (2001) and Morgenstern, Pizer, and Shih (2002) mentioned above.

Berman and Bui (2001) developed an innovative approach to estimate the effect on employment of environmental regulations in California. Their model empirically examines how an increase in local air quality regulation affects manufacturing employment in the South Coast Air Quality Management District (SCAQMD), which incorporates Los Angeles and its suburbs. During the time frame of their study, 1979 to 1992, the SCAQMD enacted some of the country's most stringent air quality regulations. Using SCAQMD's local air quality regulations, Berman and Bui identified the effect of environmental regulations on net employment in the regulated industries.[57] In particular, they compared changes in employment in affected plants to those in other plants in the same 4-digit Standard Industrial Classification (SIC) industries but in regions not subject to the local regulations.[58] The authors found that "while regulations do impose large costs, they have a limited effect on employment" (Berman and Bui, 2001, p. 269). Their conclusion is that local air quality regulation "probably increased labor demand slightly" but that "the employment effects of both compliance and increased stringency are fairly precisely estimated zeros, even when exit and dissuaded entry effects are included" (Berman and Bui, 2001, p. 269).[59] In their view, the limited effects likely arose because 1) the regulations applied disproportionately to capital-intensive plants with relatively little employment, 2) the plants sold to local markets where competitors were subject to the same regulations (so that sales were relatively unaffected), and 3) abatement inputs served as complements to employment.

Morgenstern, Pizer, and Shih (2002) developed a similar structural approach to Berman and Bui's, but their empirical application used pollution abatement expenditures from 1979 to 1991 at the plant level, including air, water, and solid waste, to estimate net employment effects in four highly regulated sectors (pulp and paper, plastics, steel, and petroleum refining). Thus, in

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[57]Note, like Morgenstern, Pizer, and Shih (2002), this study does not estimate the number of jobs created in the environmental protection sector.

[58]Berman and Bui include over 40 4-digit SIC industries in their sample.

[59]Including the employment effect of exiting plants and plants dissuaded from opening will increase the estimated impact of regulation on employment. This employment effect is not included in Morgenstern et al. (2002) .

contrast to Berman and Bui (2001), this study identified employment effects by examining differences in abatement expenditures rather than geographical differences in stringency. They conclude that increased abatement expenditures generally have *not* caused a significant change in net employment in those sectors.

5.2.4 Environmental Protection Sector

The long-term effects of a regulation on the environmental protection sector, which provides goods and services that help protect the environment to the regulated sector, are difficult to assess. Employment in the industry supplying pollution control equipment or services is likely to increase with the increased demand from the regulated industry for increased pollution control.[60]

A report by the U.S. International Trade Commission (2013) shows that domestic environmental services revenues grew by 41% between 2000 and 2010. According to U.S. Department of Commerce (2010) data, by 2008, there were 119,000 environmental technology (ET) firms generating approximately $300 billion in revenues domestically, producing $43.8 billion in exports, and supporting nearly 1.7 million jobs in the United States. Air pollution control accounted for 18% of the domestic ET market and 16% of exports. Small and medium-size companies represent 99% of private ET firms, producing 20% of total revenue (OEEI, 2010).

5.2.5 Labor Supply Impacts

As described above, the small empirical literature on employment effects of environmental regulations focuses primarily on labor demand impacts. However, there is a nascent literature focusing on regulation-induced effects on labor supply, though this literature remains very limited because of empirical challenges. This new research uses innovative methods and new data and indicates that there may be observable impacts of environmental regulation on labor supply, even at pollution levels below mandated regulatory thresholds. Many researchers have found that work-loss days and sick days, as well as mortality, are reduced when air pollution is reduced (EPA, 2011a). EPA's study of the benefits and costs of implementing the clean air regulations used these studies to predict how increased labor availability would increase the labor supply and improve productivity and the economy (EPA, 2011a).Another literature estimates how worker productivity improves at the work site when pollution is reduced. Graff Zivin and Neidell (2013) reviewed this literature, focusing on how health and human capital may be affected by environmental quality, particularly air pollution. In previous research, Graff Zivin

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[60]See Bezdek, Wendling, and Diperna (2008) , for example, and U.S. Department of Commerce (2010).

and Neidell (2012) used detailed worker-level productivity data from 2009 and 2010, paired with local ozone air quality monitoring data for one large California farm growing multiple crops, with a piece-rate payment structure. Their quasi-experimental structure identified an effect of daily variation in monitored ozone levels on productivity. They found “that ozone levels well below federal air quality standards have a significant impact on productivity: a 10 parts per billion (ppb) decrease in ozone concentrations increases worker productivity by 5.5 percent.” (Graff Zivin and Neidell, 2012, p. 3654). Such studies are a compelling start to exploring this new area of research, considering the benefits of improved air quality on productivity, alongside the existing literature exploring the labor demand effects of environmental regulations.

5.2.6 Macroeconomic Net Employment Effects

The preceding sections have outlined the challenges associated with estimating net employment effects in the regulated sector and in the environmental protection sector and labor supply impacts. These challenges make it very difficult to accurately produce net employment estimates for the whole economy that would appropriately capture the way in which costs, compliance spending, and environmental benefits propagate through the macro-economy. Quantitative estimates are further complicated by the fact that macroeconomic models often have very little sectoral detail and usually assume that the economy is at full employment. EPA is currently in the process of seeking input from an independent expert panel on modeling economy-wide impacts, including employment effects.

5.2.7 Information Specific to this Regulation

In 2011, the ASM reported that 218 establishments (174 in NAICS 327121 and 44 in NAICS 327123) employed 8,000 people with a total annual payroll of about $300 million (U.S. Census Bureau, 2013a, b). Approximately 12 million production labor hours were used to produce BSCP in 2011.

For this analysis, EPA quantified a subset of possible types of employment effects associated with the regulation:

- additional labor requirements (full-time equivalents [FTEs]) associated with meeting the new regulation
- employment effect of facilities that may exit the BSCP industry

As shown in Table 5-2, EPA estimates that the regulation will require an additional 133,000 labor hours per year to operate control devices, or approximately a 1.1% increase. This is equivalent to about 64 additional FTEs. The total estimated cost of these additional labor requirements is $3.12 million per year.

Table 5-2. Estimated Additional Labor Requirements

	Total Annual Labor Cost ($ million) Required to Operate Control Devices	Total Annual Labor Hours Required to Operate Control Devices
Proposed Standards	$3.12	133,000
Alternate Standards	$5.00	214,000

In Section 5.3, EPA estimates that the regulation may lead to one to two affected facilities exiting the BSCP industry. According the U.S. Census Bureau (2013b), the average number of employees per facility in 2011 was 37 (8,000/218 = 37). As a result, we estimate 37 to 74 employees may need to retrain or relocate in anticipation of the new requirements or require time to search for new jobs.

5.2.8 Conclusion

Although EPA has quantified two types of employment effects in this RIA, deriving estimates of how this regulation will affect *net* employment is a difficult task, requiring consideration of labor demand in both the regulated and environmental protection sectors. Economic theory predicts that the total effect of an environmental regulation on labor demand in regulated sectors is not necessarily positive or negative. Peer-reviewed econometric studies that use a structural approach, applicable to overall net effects in the regulated sectors, converge on the finding that such effects, whether positive or negative, have been small and have not affected employment in the national economy in a significant way. Effects on labor demand in the environmental protection sector seem likely to be positive. Finally, new evidence suggests that environmental regulation may improve labor supply and productivity.

5.3 Impacts on Small Entities

As mentioned above, EPA was particularly concerned about the proposed rule's potential impacts to small entities, because 36 of 44 firms owning BSCP facilities have fewer than 750 employees and thus meet the Small Business Administration's (SBA's) criterion for a small business in this industry. EPA thus conducted a screening analysis of the potential impacts by computing the ratio of control costs to firm sales revenues (i.e., a sales test). Based on the results of the screening analysis, EPA concluded that it is not able to certify that the rule will not have a Significant Impact on a Substantial Number of Small Entities (SISNOSE). As a result, EPA initiated a Small Business Advisory Review panel and undertook an Initial Regulatory Flexibility Analysis (IRFA).

5.3.1 Small Business Impact Screening Analysis

As discussed in Section 2, EPA has identified 44 ultimate parent companies with facilities that will need new or modified control devices to meet new emission standards. Affected parent companies fall under the Clay Building Material and Refractories Manufacturing (NAICS 327120) industry and the SBA (2013) defines a small business as having fewer than 750 employees. There are 36 parent companies that are small businesses.

EPA assessed how the regulatory program may influence the profitability of ultimate parent companies by comparing pollution control costs to total sales (i.e., a "sales" test or cost-to-sales ratios [CSR]). To do this, we divided an ultimate parent company's (i) total annualized compliance costs by its reported revenue:

$$\text{Sales Test}_i = \frac{Total\ Annualized\ Compliance\ Cost_i}{Total\ Revenue_i} \tag{5.1}$$

As shown in Table 5-3, 40 of the 44 ultimate parent companies had sales data available that enabled EPA to compute a sales test. The table shows that 73% of all businesses and 75% of small businesses affected by the proposed standards have CSRs of under 1%.

EPA estimated the range of the number of ultimate parent companies that may close rather than comply with the regulation. The lower and upper bounds of the range were determined as follows:

- Lower bound: All ultimate parent companies with CSR > 10%.
- Upper bound: All ultimate parent companies with CSR > 10%, 50% of ultimate parent companies with CSRs between 5% and 10%, and 25% of ultimate parent companies with CSRs between 3% and 5%.

Under the proposed standards, EPA estimated that one to two brick manufacturing facilities are at significant risk of closure. Under the alternate standards, two to six brick manufacturing facilities are at significant risk of closure.

Table 5-3. Small Business Impact Screening Assessment Results and Closure Estimates

	Capital Cost (Million $)	Annual Cost (Million $)	Ultimate Parent Companies with Cost-to-Sales Ratios (CSRs)[a] Less than 1%	1% to 3%	3% to 5%	5% to 10%	Greater than 10%	Estimated[b] Closures	Estimated Number of Facilities Closed
All Businesses (n=40)									
Proposed Standards	$58	$21	73%	15%	5%	5%	3%	3–6%	1–2
Alternate Standards	$94	$31	45%	25%	15%	10%	5%	5–14%	2–6
Small Businesses (n=32)									
Proposed Standards	$11	$5	75%	16%	3%	3%	3%	3–5%	1–2
Alternate Standards	$34	$11	47%	22%	16%	9%	6%	6–15%	2–5

[a] The screening assessment was conducted for 40 of the 44 ultimate parent companies with annual sales data available. For small businesses, 32 of the 36 small entities had annual sales data available.

[b] EPA estimated a lower and upper bound as follows: Lower bound: All ultimate parent companies with CSR > 10%.; Upper bound: All ultimate parent companies with CSR > 10%, 50% of ultimate parent companies with CSRs between 5% and 10%, and 25% of ultimate parent companies with CSRs between 3% and 5%.

As shown in Table 5-3, 32 of the 36 small ultimate parent companies had sales data available that enabled EPA to compute a sales test. Under the proposed standards, EPA estimated that one to two brick manufacturing facilities are at significant risk of closure. Under the alternate standards, two to five small brick manufacturing facilities are at significant risk of closure. All of the facilities at risk of closure were one facility companies.

EPA has been informed that firms may have difficulty obtaining longer-term financing needed to buy the control equipment and make process changes needed to comply with the proposed standards. Firms may not have cash on hand or the ability to convert assets into cash in order to make these purchases; as a result, firms would have to consider other long-term financing options. Affected firms are less likely to be publicly traded and thus would be more likely to consider debt versus equity options. The additional liabilities can put firms at additional risk of closure if market conditions do not improve during the period when the rule is adopted. In addition, if creditors are concerned about existing or future market conditions in the brick industry, they may be less willing to enter a loan contract or may require higher rates of interest than the 7 percent interest rate used to annualize the capital costs associated with the rule.

EPA estimates of the range of the number of ultimate parent companies that may close rather than comply with the regulation may be an underestimate because of the difficulty in obtaining financing at a 7 percent interest rate. The estimates might be an overestimate if the industry has become more robust by 2018 when the control must be in place. The closure estimate did not include net effects on revenue due to price increases or reductions in sales attributable to the regulation.

5.3.2 Initial Regulatory Flexibility Analysis

An IRFA illustrates how EPA considers the proposed rule's small entity effects before a rule is finalized and provides information about how the objectives of the rule were achieved while minimizing significant economic impacts on small entities. We provide a summary of IRFA elements; the preamble for this rule provides additional details.

5.3.2.1 Description of the Reasons Why Action by the Agency is Being Considered

On May 16, 2003, under the authority of section 112 of the Clean Air Act, EPA promulgated national emission standards for hazardous air pollutants for brick and structural clay products manufacturing and national emission standards for hazardous air pollutants for clay ceramics manufacturing. On March 13, 2007, the U.S. Court of Appeals for the District of Columbia Circuit vacated and remanded both sets of standards. EPA is responding to the Court's vacatur and remand.

5.3.2.2 Statement of Objectives and Legal Basis of Proposed Rule

The information for this IRFA elements is contained in the preamble to the proposed rule [Docket ID No. EPA-HQ-OAR-2013-0291].

5.3.2.3 Description and Estimate of the Number of Small Entities

Small entities that EPA anticipates being affected by the standards would include the types of manufacturers listed in Section 2 of this RIA. EPA estimates that 44 U.S. companies will be affected. EPA believes that approximately 36 of these companies meet the SBA small-entity definition of having fewer than 750 employees.

5.3.2.4 Description of the Projected Reporting, Record keeping and Other Compliance requirements of the Proposed Rule

A discussion of the compliance requirements and costs is presented in Section 3 of this RIA.

5.3.2.5 Identification, to the extent practicable, of All Relevant Federal Rules Which May Duplicate, Overlap or Conflict with the Proposed Rule

EPA has determined there are no related federal rules for this source category.

5.3.2.6 Description of Significant Alternatives to the Proposed Rule

The information for this IRFA element is contained in Section 3 of this RIA and in the preamble to the proposed rule [Docket ID No. EPA-HQ-OAR-2013-0291].

EPA conducted outreach to small entities and convened a Small Business Advocacy Review (SBAR) Panel to obtain advice and recommendation of representatives of the small entities that potentially would be subject to the requirements of the BSCP proposed rule. The results of this process are discussed in *Report on EPA's Planned Proposed Rule "National Emissions Standards for Hazardous Air Pollutants Maximum Achievable Control Technology for Brick and Structural Clay Products Manufacturing*" completed on December 6, 2013.

The SBAR made several recommendations to enhance flexibility for small businesses complying with the proposed rule. The EPA adopted the panel recommendations to the extent feasible, as described below:

- The panel recommended that the EPA propose work practices for dioxin and take comment on the feasibility of work practice standards for mercury and other metals. The discussion of work practices for mercury and other metals should clearly identify any areas where the agency believes that the data do not support work practices to allow for meaningful comments and also discuss work practice alternatives with

sufficient specificity that they can be fully considered as an alternative in the final rule.
Proposed rule: The EPA is proposing work practices for dioxin/furan. Although the EPA is proposing emission limits for mercury and for non-mercury metals, the EPA is specifically requesting comment in the proposal on the feasibility of work practice standards for non-mercury metals and for mercury, including data to support development of work practice standards for non-mercury metals and mercury in lieu of numerical emission limits.

- The panel recommended that the EPA co-propose both a health-based limit and MACT limits for acid gases unless the EPA determines it lacks sufficient information to propose a numerical health-based limit.
Proposed rule: The EPA is proposing a health-based emission limit for acid gases in lieu of MACT limits.

- The panel recommended that the EPA propose separate subcategories for kilns based on size if it reduces the financial impact and that the EPA should take comment and solicit data on subcategorization based on raw materials, fuels, and other factors.
Proposed rule: The EPA evaluated the data to determine if subcategories of sources were supported, including subcategories by kiln size. As a result, the EPA is proposing emission limits for mercury in two subcategories based on kiln size (large, small). However, although the EPA has the discretion to subcategorize by kiln size, the EPA determined it was not necessary to exercise this discretion for all pollutants, including total non-mercury HAP metals. Instead, the EPA is proposing a choice of emission limits for PM or total non-mercury metals for all tunnel kilns. The ability to comply with the equivalent lb/hr total non-mercury HAP metals limit provides additional flexibility for small tunnel kilns and tunnel kilns with a low metals content in the PM emissions.

- The panel recommended that the EPA specifically request information, at proposal, on how the presence of sawdust dryers would affect emissions and control costs.
Proposed rule: The proposed rule requests comment on whether the EPA should create a subcategory for kilns fired with sawdust (with or without a sawdust dryer).

- The panel recommended that the EPA propose work practice standards for startup and shutdown.
Proposed rule: The EPA is proposing work practice standards for periods of startup and shutdown for tunnel kilns and is requesting comment on providing those work practice standards.

- The panel recommended that the EPA set the floor based on 12 percent of the entire source category if the EPA can establish that the data available to the agency represent the best-performing sources consistent with section 112 of the CAA and relevant case law.
Proposed rule: The test data for PM (the surrogate for total non-mercury metals) showed that kilns controlled with a fabric filter-based APCD (e.g., DIFF, DLS/FF) are the better performers and at least 12 percent of the kilns in the industry are

controlled with a fabric filter-based APCD. Therefore, the MACT limit is based on the top 12 percent of the kilns in the industry (i.e., the best-performing sources with a fabric filter-based APCD). However, the EPA was unable to establish that the data available to the agency represented the best-performing sources for mercury control. Therefore, the MACT limit for mercury is based upon the top 12 percent of sources for which we had test data.

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EXHIBIT 21

August 2010

Regulatory Impact Analysis: Amendments to the National Emission Standards for Hazardous Air Pollutants and New Source Performance Standards (NSPS) for the Portland Cement Manufacturing Industry

Final Report

U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards (OAQPS)
Air Benefit and Cost Group
(MD-C439-02)
Research Triangle Park, NC 27711

SECTION 1
INTRODUCTION

The U.S. Environmental Protection Agency (EPA) is finalizing amendments to the National Emission Standards for Hazardous Air Pollutants (NESHAP) from the Portland cement manufacturing industry and New Source Performance Standards (NSPS) for Portland cement plants. The final amendments to the NESHAP add or revise, as applicable, emission limits for mercury (Hg), total hydrocarbons (THC), and particulate matter (PM) from kilns located at a major or an area sources, and hydrochloric acid (HCl) from kilns and located at major sources. EPA is also adopting separate standards for these pollutants that apply during startup, shutdown, and operating modes. Finally, EPA is adopting performance specifications for use of Hg continuous emission monitors (CEMS) and updating recordkeeping and testing requirements. The final amendments to the NSPS add or revise, as applicable, emission limits for particulate matter (PM), opacity, nitrogen oxides (NO_x), and sulfur dioxide (SO_2) for facilities that commence construction, modification, or reconstruction after June 16, 2008. The final rule also includes additional testing and monitoring requirements for affected sources. As part of the regulatory process, EPA is required to develop a regulatory impact analysis (RIA). The RIA includes an economic impact analysis (EIA) and a small entity impacts analysis and documents the RIA methods and results.

1.1 Executive Summary

The key results of the RIA are as follows:

- **Options Analyzed:** EPA's analysis focuses on the results of the final NESHAP and NSPS. We also present additional information on different combinations of the regulatory programs to help stakeholders better understand the size and scope of each. These include
  - final NSPS only,
  - final NESHAP only, and
  - alternative: more stringent NSPS and final NESHAP.

The rest of this summary addresses the results of analyzing the final NESHAP and NSPS.

- **Engineering Cost Analysis:** EPA estimates that total annualized costs with the final NESHAP and NSPS will be $466 million (2005$).
- **Market Analysis:** The partial-equilibrium economic model suggests the average national price for Portland cement could be 5% higher with the NESHAP, or $4.50 per metric ton, while annual domestic production may fall by 11%, or 10 million tons

per year. Because of higher domestic prices, imports rise by 10%, or 3 million metric tons per year.

- **Industry Analysis:** Net industry operating profits fall by $241 million; EPA also identified 10 domestic plants with negative operating profits and significant utilization changes that could temporarily idle until market demand conditions improve. The plants have unit compliance costs close to $8 per ton of clinker capacity and $116 million total change in operating profits. Since these plants account for approximately 8% of domestic capacity, a decision to permanently shut down these plants would reduce domestic supply and could lead to additional projected market price increases and reductions in pollution control costs.

- **Employment Changes**: EPA uses two methods for estimating employment impacts. A simplistic, limited assessment narrowly focused on output changes in the Portland cement industry indicates that the final rule's gross impact on employment is 1,500 job losses. However, this approach inherently overstates job losses, as it is based on the assumption that employment is proportional to output, and because it ignores offsetting general equilibrium and other effects as discussed in detail in Chapter 3. A more sophisticated analytical approach that includes other types of employment effects estimates changes in net employment could range from a loss of 600 to a net gain of 1,300 jobs.

- **Social Cost Analysis:** The estimated social cost is $926 to $950 million (2005$). The range represents the estimated difference in surplus if ten facilities with low estimated post regulation capacity utilization choose to idle or close rather than operate at a low (55.5. percent) capacity utilization. The social cost estimates are significantly higher than the engineering analysis estimates, which estimated annualized costs of $466 million. This is a direct consequence of EPA's assumptions about existing market structure discussed extensively in previous cement industry rulemakings and Section 2, Appendix A, and Appendix B of this RIA. Under baseline conditions without regulation, the existing domestic cement plants are assumed to choose a production level that is less than the level produced under perfect competition. As a result, a preexisting market distortion exists in the markets covered by the final rule (i.e., the observed baseline market price is higher than the [unobserved] market price that a model of perfect competition would predict). The imposition of additional regulatory costs tends to widen the gap between price and marginal cost in these markets and contributes to additional social costs.

- **Energy Impacts:** EPA concludes that the rule when implemented will not have a significant adverse effect on the supply, distribution, or use of energy. The cement industry accounts for less than 0.4% of the U.S. total energy use. EPA estimates the additional add-on controls may increase national electrical demand by 780 million kWh per year and the natural gas use to be 1.0 million MMBTU per year for existing kilns. For new kilns, assuming that of the 16 new kilns to start up by 2013 all 16will add alkaline scrubbers and ACI systems, the electrical demand is estimated to be 199 million kWh per year. This is less than 0.1% of AEO 2010 forecasts of total electricity and natural gas consumption.

- **Small Business Analysis:** Only 4 of the over 40 cement parent companies are small entities. EPA performed a screening analysis for impacts on the 4 small entities by comparing compliance costs to average company revenues. EPA's analysis found that the ratio of compliance cost to company revenue falls below 1% for two of the four small entities (includes a Tribal government). Two small entities would have an annualized cost of between 1% and 3% of sales. No small businesses would have an annualized cost greater than 3% of sales.

- **Benefits Analysis:** In the year of full implementation (2013), EPA estimates that the total monetized benefits of the final NESHAP and NSPS are $7.4 billion to $18 billion and $6.7 billion to $16 billion, at 3% and 7% discount rates, respectively (Table 1-1). All estimates are in 2005 dollars for the year 2013. Using alternate relationships between $PM_{2.5}$ and premature mortality supplied by experts, higher and lower benefits estimates are plausible, but most of the expert-based estimates fall between these estimates. Due to data, methodology, and resource limitations, the benefits from reducing other air pollutants have not been monetized in this analysis, including reducing 4,400 tons of NO_x, 5,200 tons of organic hazardous air pollutants (HAPs), 5,900 tons of HCl, and 16,400 pounds of Hg each year. In addition, ecosystem benefits and visibility benefits have not been monetized in this analysis. These estimates include the energy disbenefits associated with increased electricity usage by the control devices.

- **Net Benefits:** In the year of full implementation (2013), EPA estimates the net benefits of the final NESHAP and NSPS are approximately $6.5 billion to $17 billion and $5.8 billion to $15 billion, at 3% and 7% discount rates, respectively. All estimates are in 2005 dollars for the year 2013.

1.2 Organization of this Report

The remainder of this report supports and details the methodology and the results of the EIA:

- Section 2 presents a profile of the affected industry.
- Section 3 describes the economic impact analysis and energy impacts.
- Section 4 describes the small business impact analysis.
- Section 5 presents the air quality modeling of emission reductions.
- Section 6 presents the benefits analysis.
- Appendix A provides an overview of the economic impact model.
- Appendix B discusses the model of the cement plant's production decision.
- Appendix C presents the social cost methodology.

Table 1-1. Summary of the Monetized Benefits, Social Costs, and Net Benefits for the Final Portland Cement NESHAP in 2013 (millions of 2005$)[a]

	3% Discount Rate			7% Discount Rate		
Final NESHAP and NSPS						
Total Monetized Benefits[b]	$7,400	to	$18,000	$6,700	to	$16,000
Total Social Costs[c]	$926	to	$950	$926	to	$950
Net Benefits	$6,500	to	$17,000	$5,800	to	$15,000
Nonmonetized Benefits[d]	4,400 tons of NO_x (includes energy disbenefits) 5,200 tons of organic HAPs 5,900 tons of HCl 16,400 pounds of mercury Health effects from HAPs, NO_2, and SO_2 exposure Ecosystem effects Visibility impairment					
Final NSPS only						
	3% Discount Rate			7% Discount Rate		
Total Monetized Benefits[b]	$510	to	$1,300	$460	to	$1,100
Total Social Costs[c]		$72			$72	
Net Benefits	$440	to	$1,200	$390	to	$1,000
Nonmonetized Benefits[d]	6,600 tons of NO_x 520 tons of HCl Health effects from HAPs, NO_2, and SO_2 exposure Ecosystem effects Visibility impairment					
Final NESHAP only						
	3% Discount Rate			7% Discount Rate		
Total Monetized Benefits[b]	$7,400	to	$18,000	$6,700	to	$16,000
Total Social Costs[c]	$904	to	$930	$904	to	$930
Net Benefits	$6,500	to	$17,000	$5,800	to	$16,000
Nonmonetized Benefits[d]	5,200 tons of organic HAPs 5,900 tons of HCl 16,400 pounds of mercury Health effects from HAPs, SO_2 exposure Ecosystem effects Visibility impairment					
Alternative: More Stringent NSPS and Final NESHAP						
	3% Discount Rate			7% Discount Rate		
Total Monetized Benefits[b]	$7,400	to	$18,000	$6,700	to	$16,000
Total Social Costs[c]	$955	to	$979	$955	to	$979
Net Benefits	$6,500	to	$17,000	$5,700	to	$15,000
Nonmonetized Benefits[d]	7,800 tons of NO_x (includes energy disbenefits) 5,200 tons of organic HAPs 5,900 tons of HCl 16,400 pounds of mercury Health effects from HAPs, NO_2, and SO_2 exposure Ecosystem effects Visibility impairment					

[a] All estimates are for the implementation year (2013) and are rounded to two significant figures.

[b] The total monetized benefits reflect the human health benefits associated with reducing exposure to $PM_{2.5}$ through reductions of directly emitted $PM_{2.5}$ and $PM_{2.5}$ precursors such as SO_2. It is important to note that the monetized benefits include many but not all health effects associated with $PM_{2.5}$ exposure. Benefits are shown as a range from Pope et al. (2002) to Laden et al. (2006). These models assume that all fine particles, regardless of their chemical composition, are equally potent in causing premature mortality because there is no clear scientific evidence that would support the development of differential effects estimates by particle type. The total monetized benefits include the energy disbenefits.

[c] The methodology used to estimate social costs for 1 year in the multimarket model using surplus changes results in the same social costs for both discount rates. Range represents the estimated difference in surplus if ten facilities with low estimated post regulation capacity utilization choose to idle or close rather than operate at a low (55.5 percent) capacity utilization.

[d] Due to data, methodology, and resource limitations, we were unable to monetize the benefits associated with these categories of benefits.

SECTION 3
ECONOMIC IMPACT ANALYSIS

EPA prepares an EIA to provide decision makers with a measure of the social costs of using resources to comply with a program (EPA, 2000). The social costs can then be compared with estimated social benefits (as presented in Section 5). As noted in EPA's (2000) *Guidelines for Preparing Economic Analyses*, several tools are available to estimate social costs and range from simple direct compliance cost methods to the development of a more complex market analysis that estimates market changes (e.g., price and consumption) and economic welfare changes (e.g., changes in consumer and producer surplus).

The Office of Air Quality Planning and Standards (OAQPS) has adopted the standard industry-level analysis described in the Office's resource manual (EPA, 1999a). This approach is consistent with previous EPA analyses of the Portland cement industry (EPA, 1998; EPA, 1999b, and 2009a) and uses a single-period static partial-equilibrium model to compare pre-policy cement market baselines with expected post-policy outcomes in these markets. The benchmark time horizon for the analysis is the intermediate run where producers have some constraints on their flexibility to adjust factors of production. This time horizon allows us to capture important transitory impacts of the program on existing producers. Key measures in this analysis include

- market-level effects (market prices, changes in domestic production and consumption, and international trade),
- industry-level effects (changes in (i.e. operating profits) and employment),
- facility-level effects (plant utilization changes), and
- social costs (changes in producer and consumer surplus).

Absent forecasts and the uncertainties of future economic baselines, the partial-equilibrium market analysis can only cover a subset of plants presumed to be operating in conditions similar to 2005. Thus, this analysis does not reflect changes in the state of the US economy which may occur by the analysis year of 2013 which could significantly influence the quantity of cement needed. As shown in the following sections, the market analysis covers $378 million of the total $466 million in regulatory program costs, or 81%; simulated post policy outcomes described throughout Section 3.2 should be interpreted in light of this modeling choice. EPA analyzed the remaining $88 million in NESHAP and NSPS regulatory program costs "outside" of the partial equilibrium market analyses using direct compliance costs methods (see Section 3.3). EPA provides complete social cost accounting in the section describing the social cost estimates (Section 3.4) and provides a discussion of its overall assessment (Section 3.5).

3.1 Regulatory Program Costs

EPA is finalizing amendments to the NESHAP from the Portland cement manufacturing industry and (NSPS for Portland cement plants. The final amendments to the NESHAP add or revise, as applicable, emission limits for Hg, THC, and PM from kilns located at a major or an area sources, and HCl from kilns and located at major sources. EPA is also adopting separate standards for these pollutants which apply during startup, shutdown, and operating modes. Finally, EPA is adopting performance specifications for use of mercury CEMS and updating recordkeeping and testing requirements. The final amendments to the NSPS add or revise, as applicable, emission limits for particulate matter (PM), opacity, nitrogen oxides (NO_x), and sulfur dioxide (SO_2) for facilities that commence construction, modification, or reconstruction after June 16, 2008. The final rule also includes additional testing and monitoring requirements for affected sources. Although EPA's analysis focuses on the final NESHAP and NSPS engineering cost estimates, EPA also presents additional information on different combinations of the regulatory programs. This information helps stakeholders better understand the size and scope of the each. These include

- final NSPS only,
- final NESHAP only, and
- alternative: more stringent NSPS and final NESHAP.

For the year 2013, EPA's engineering cost analysis estimates the total annualized costs of the final NESHAP and NSPS are $466 million (in 2005 dollars) (see Table 3-1). These costs include a variety of pollution control expenditures: equipment installation, operating and maintenance, recordkeeping, and performance-testing activities. Capital costs are annualized at a discount rate of 7% over the expected life of the control equipment which is 20 years for all devices except RTOs which are 15 years. The majority of the costs ($455 million, or 98%, are associated with the final NESHAP. The remaining costs ($11 million) are associated with the final NSPS limits for SO_2 and NO_x. Figure 3-1 illustrates the distribution of annualized compliance costs per metric ton of clinker capacity by different combinations of the regulatory programs. In Table 3-2, we report state-level summary statistics for total annualized compliance costs per metric ton of clinker capacity for the final NESHAP and NSPS to highlight any regional differences in control costs.

Table 3-1. Summary of Direct Total Annualized Compliance Costs (million, 2005$)

	Total Annualized Compliance Costs	
Description	**Final NSPS Only**	**More Stringent NSPS Only**
Total:	$40[a]	$56[a]
	Final NESHAP Only	
Partial Equilibrium Analysis (136 Kilns)	$378	
NSPS kilns (7 kilns)	$29	
Other kilns (13 kilns)	$48	
Total:	$455	
	Final NESHAP and NSPS	**Final NESHAP and More Stringent NSPS**
136 Kilns	$378	$378
20 Kilns	$88	$104
Total:	$466	$482

[a] The final NSPS only also includes the $29 million in NESHAP costs for 7 kilns. The 7 kilns will also incur an additional $11 in compliance costs to meet the final NSPS limits for SO_2 and NO_x. Alternatively, the 7 kilns would also incur an additional $27 in compliance costs to meet the stringent NSPS limits for SO_2 and NO_x.

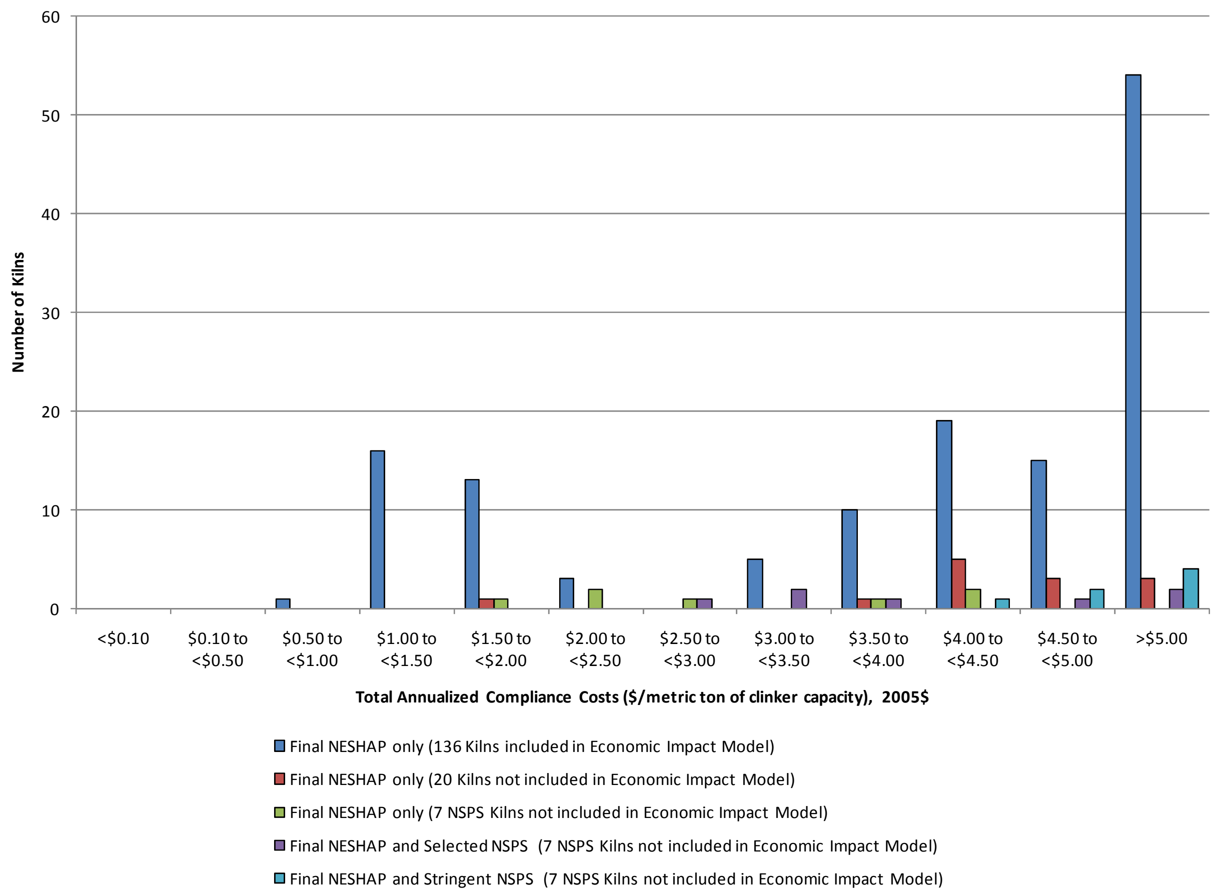

Figure 3-1. Range of Per-Ton Total Annualized Compliance Costs (2005$)

Table 3-2. Range of Per-ton Total Annualized Compliance Costs by State (2005$)

	Data		
ST	Average ($/ ton of clinker capacity)	Minimum ($/ ton of clinker capacity)	Maximum ($/ ton of clinker capacity)
AL	$3	$1	$5
AZ	$3	$1	$6
CA	$4	$3	$5
CO	$2	$1	$3
FL	$3	$1	$5
GA	$1	$1	$1
IA	$6	$4	$8
ID	$10	$9	$10
IL	$6	$1	$8
IN	$9	$5	$14
KS	$6	$6	$6
KY	$4	$4	$4
MD	$6	$3	$9
ME	$1	$1	$1
MI	$5	$4	$6
MO	$5	$4	$5
MT	$2	$2	$2
NE	$6	$5	$6
NM	$2	$2	$2
NV	$2	$2	$2
NY	$3	$1	$4
OH	$5	$5	$5
OK	$8	$4	$13
OR	$4	$4	$4
PA	$5	$2	$7
SC	$4	$4	$4
SD	$2	$1	$2
TN	$3	$1	$5
TX	$5	$1	$8
UT	$5	$1	$9
VA	$4	$4	$4
WA	$1	$1	$2
WV	$7	$6	$8
WY	$7	$5	$8
U.S.	$5	$1	$14

Note: Includes Final NESHAP only for 136 kilns included in economic impact model.

3.2 Partial-Equilibrium Analysis

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The partial-equilibrium analysis develops a cement market model that simulates how stakeholders (consumers and firms) might respond to the additional regulatory program costs. In this section, we provide an overview of the economic model used during proposal (EPA, 2009). Appendix A provides additional details about economic model updates made since proposal, model equations, and parameters.

3.2.1 Regional Structure and Baseline Data

Cement sales are often concentrated locally among a small number of firms for two reasons: high transportation costs and production economies of scale.[1] Transportation costs significantly influence where cement is ultimately sold; high transportation costs relative to unit value provide incentives to produce and sell cement locally in regional markets (USITC, 2006). To support this claim, the empirical literature has typically pointed to Census of Transportation data showing over 80% of cement shipments were made within a 200-mile radius (Jans and Rosenbaum, 1997)[2] and reported evidence of high transportation costs per dollar of product value from case studies (Ryan, 2006). Based on this literature, the Agency assumes that the U.S. Portland cement industry is divided into a number of independent regional markets with each having a single market-clearing price.

The freight-on-board (f.o.b.) price of Portland cement for each regional market is derived as the production weighted average of the state level f.o.b. prices reported by the USGS for cement (see Table 3-3). The production of Portland cement within each market is the sum of estimated individual kiln production levels (EPA, 2009) and include adjustments described in Appendix A (see Table 3-4). We obtained estimates of Portland cement imports from the USGS and mapped them to each market based on the port of entry.

3.2.2 Near-Term Cement Plant Production Decisions

A cement company acts in the best interest of its shareholders and maximizes profits. When deciding whether to make another ton of cement, the company considers the *production effect* on profits by comparing the current market price of cement and the marginal production cost; if price is above marginal production cost, producing and selling the extra ton of cement increase profit. The company continues to produce additional cement until the profit from

[1] The 2002 Economic Census reports that the national Herfindahl-Hirschman Index (HHI) for cement—North American Industry Classification System (NAICS) 32731—is 568. However, this measure is likely not representative of actual concentration that exists in regional markets.

[2] A recent USITC study of California cement markets found more than 75% of gray Portland cement shipments in the state were shipped to customers within 200 miles of the cement producer (USITC, 2006).

Table 3-3. Portland Cement Prices by Market ($/metric tons): 2005

Market	Price ($/metric ton)
Atlanta	$81
Baltimore/Philadelphia	$82
Birmingham	$83
Chicago	$67
Cincinnati	$84
Dallas	$75
Denver	$89
Detroit	$93
Florida	$91
Kansas City	$86
Los Angeles	$78
Minneapolis	$92
New York/Boston	$89
Phoenix	$83
Pittsburgh	$88
St. Louis	$84
Salt Lake City	$91
San Antonio	$82
San Francisco	$97
Seattle	$88

producing an extra ton of cement is zero (price equals marginal cost) or capacity constraints are reached. The decision rule is consistent with the assumption of pure competition.

Although perfect competition is widely accepted for modeling many industries regardless of the model time horizon (EPA, 2000), the cement industry has two characteristics that influenced EPA's modeling choice relating to market structure. First, high transportation costs and other production economics tend to limit the number of sellers (particularly over a short time horizon), so each seller has a substantial regional market share. Timely market entry is also constrained by the high capital costs that involve purchases and construction of large rotary kilns that are not readily movable or transferable to other uses.[3] Second, cement producers offer similar or identical products. American Society for Testing and Materials (ASTM) specifications tend to ensure uniform quality, and recent industry reviews (USITC, 2006) suggest that there is little or no brand loyalty that allows firms to differentiate their products.

[3] In addition, large plants are typically more economical because they can produce cement at lower unit costs; this reduces entry incentives for smaller capacity cement plants.

Table 3-4. Portland Cement Markets (10^6 metric tons): 2005

Market	U.S. Production	Imports	Total
Atlanta	5.8	2.3	8.1
Baltimore/Philadelphia	7.8	0.6	8.5
Birmingham	5.9	2.2	8.1
Chicago	4.7	0.2	4.9
Cincinnati	3.7	0.0	3.7
Dallas	8.1	2.4	10.5
Denver	3.4	0.0	3.4
Detroit	3.8	1.3	5.2
Florida	5.5	5.8	11.4
Kansas City	5.0	0.0	5.0
Los Angeles	10.6	3.8	14.4
Minneapolis	1.7	0.4	2.1
New York/Boston	3.2	2.8	6.0
Phoenix	4.3	0.0	4.3
Pittsburgh	1.5	1.6	3.1
St. Louis	6.0	0.0	6.0
Salt Lake City	2.4	0.1	2.4
San Antonio	5.5	4.6	10.0
San Francisco	3.4	2.8	6.2
Seattle	1.1	2.5	3.6

Given entry barriers, product characteristics, and the need to understand important near-term/transitory stakeholder outcomes, EPA continued to use the economic impact model designed for previous analyses (EPA, 1998, 1999b, 2009). The model considers how regional markets may operate in near-term time horizons when 1) the number of companies is limited and 2) the companies sell similar or identical products.[4] Under these circumstances, the short-run production decision rule that a cement company makes differs from pure competition. The company continues to consider the *production effect* described above; however, the company adds another dimension to the decision-making process by also considering the *market price effect* that is associated with producing an additional ton of cement. Given the small number of cement producers, adding an extra ton of cement to the regional market may *lower* the market

[4] This economic model is formally known as a multi-firm Cournot oligopoly model.

cement price and reduce the profits on all the other cement sold. If the price effect is large enough, companies may find it more profitable to reduce production below the levels implied by pure competition. As a result, short-run regional market prices tend to be higher than marginal production costs (i.e., there may be a preexisting market distortion within cement markets *prior* to regulation).[5] The size of the existing distortion depends on the seller's market share and how responsive cement consumers are to changes in the cement price. Economic theory suggests the market distortion will typically be higher the smaller the number of sellers and when the quantity demanded is less sensitive to price (i.e., the demand elasticity is inelastic) (see Appendix A).

3.2.3 Economic Impact Model Results

3.2.3.1 Market-Level Results

Market-level impacts include the regional price and quantity adjustments for Portland cement, including the changes in imports for the appropriate regions. As shown in Table 3-5, the average national price for Portland cement increases by 5%, or $4.50 per metric ton, while overall U.S. cement consumption falls by approximately 5%. Domestic production falls by 11%, or 10 million tons per year. Cement imports increase in response to higher domestic cement prices; imports increase by 10%, or 3 million metric tons.

Table 3-5. National-Level Market Impacts: 2005

		Changes from Baseline	
	Baseline	**Absolute**	**Percent**
Market Price ($/metric ton)	$83.70	$4.50	5.4%
Market Output (million metric tons)	126	−6	−4.8%
Domestic production	93	−10	−10.8%
Imports	33	3	10.0%

As shown in Table 3-6, price increases are the highest in regions with high compliance costs per metric ton. For example, the Cincinnati market price increase ($10 per metric ton) also includes kilns with higher average compliance costs and a kiln with the highest per-unit

[5] This ultimately influences the partial-equilibrium model's estimates of the social cost of the regulatory program since bigger existing market distortions tend to widen the gap between price and marginal cost in these markets and lead to higher deadweight loss estimates than under the case of perfectly competitive markets. The Office of Management and Budget (OMB) explicitly mentions the need to consider market power–related welfare costs in evaluating regulations under Executive Order 12866 (EPA, 1999a).

Table 3-6. Regional Compliance Costs and Market Price Changes ($/metric ton of cement): 2005

Market	Incremental Compliance Costs ($/metric ton of estimated cement production)			Baseline Price	Market Price Change	
	Mean	Minimum	Maximum		Absolute	Percent
Atlanta	$3.60	$1.10	$5.90	$81.30	$2.80	3.4%
Baltimore/Philadelphia	$6.20	$1.20	$10.00	$81.70	$6.10	7.5%
Birmingham	$3.60	$1.10	$4.80	$82.60	$3.80	4.6%
Chicago	$6.80	$0.90	$10.10	$66.90	$4.80	7.2%
Cincinnati	$8.10	$4.00	$14.10	$84.20	$10.40	12.4%
Dallas	$5.60	$3.50	$8.50	$75.10	$4.90	6.5%
Denver	$3.00	$1.00	$8.10	$88.70	$6.30	7.1%
Detroit	$6.50	$4.00	$10.30	$92.70	$4.20	4.5%
Florida	$3.40	$1.20	$5.50	$90.70	$3.50	3.9%
Kansas City	$8.60	$3.80	$13.80	$86.10	$8.20	9.5%
Los Angeles	$6.00	$3.20	$13.10	$78.20	$4.30	5.5%
Minneapolis	$6.30	$4.50	$8.80	$92.20	$8.50	9.2%
New York/Boston	$2.50	$1.00	$4.50	$89.00	$1.80	2.0%
Phoenix	$1.90	$1.00	$6.00	$83.10	$4.20	5.1%
Pittsburgh	$7.60	$6.90	$8.00	$88.00	$4.60	5.2%
St. Louis	$4.80	$3.80	$5.60	$84.10	$4.50	5.4%
Salt Lake City	$5.90	$1.60	$9.90	$91.40	$10.40	11.4%
San Antonio	$4.00	$0.80	$7.70	$82.30	$3.30	4.0%
San Francisco	$3.10	$1.00	$5.00	$96.90	$3.30	3.4%
Seattle	$1.20	$1.00	$1.40	$88.00	$0.70	0.8%
Grand Total	$5.20	$0.80	$14.10	$83.90	$4.50	5.4%

compliance costs ($14 per metric ton).[6] It is important to note that EPA uses a time horizon where transportation costs between regions are high enough that interregional trade is unlikely to occur, at least in the short run. The regional differences in unit compliance costs and the

[6] The per-unit compliance costs were calculated by dividing the total annualized cost per kiln by the kiln's estimated cement production within the economic impact model.

significant simulated changes in relative regional prices suggest domestic cement plants may be more likely to consider short-run shipments of cement between regional markets. Choices would depend on the additional benefits of selling cement to these markets and the costs of transporting the cement outside the regional market. Although EPA has not quantified this effect, additional flexibility would tend to temper prices increases in some of these markets.

Imports also tend to limit price increases in certain regions. This tends to reinforce U.S. production declines because cement plants have more difficulty passing on compliance costs in the form of higher prices when compared with similar plants operating in regions without import competition. Because imports are only modeled for markets with imports in the baseline without regulation, Table 3-7 separates the results into markets with and without imports as well as providing the results for all markets. As shown in Table 3-7, median price increases in regions with imports are lower than the median price increases in regions without import competition. In some regions with imports, the reductions in U.S. production are significant. As shown in Table 3-7, the maximum simulated U.S. regional production change is 23%. To the extent there are any unobserved constraints on import supply that are not captured in the import supply elasticity parameter, price and U.S. production adjustments for regional markets with imports would tend to become more similar to regional markets without imports.

3.2.3.2 Industry-Level Results

As shown in Table 3-8, compliance costs vary by cement plant, and this variation suggests some plants will be more adversely affected than others. To assess these differences, EPA collected industry operating profit data and identified plants with operating profit increases and losses. Absent plant-specific data, EPA assumed each plant's baseline profits were consistent with the median operating profit margin reported by the PCA (2008c, Table 44). In 2005, this value was $18 per metric ton, or 16%. Using this assumption, total operating profits for 59 plants (58%) decrease by $387 million with regulation. These plants tend to have higher per ton compliance costs. The remaining plants' compliance burden is offset by higher regional cement prices, and total plant operating profits increase by $147 million. These 44 plants have lower unit compliance costs compared with their competitors.

Table 3-7. Summary of Regional Market Impacts

	Regional Markets		
	With Imports	**Without Imports**	**All Markets**
Change in Market Price			
Absolute ($/metric ton)			
Mean	$4.70	$6.40	$4.50
Median	$4.20	$5.40	$4.40
Minimum	$0.70	$4.20	$0.70
Maximum	$10.40	$10.40	$10.40
Percentage of baseline price			
Mean	5.5%	7.5%	5.4%
Median	4.9%	6.2%	5.3%
Minimum	0.8%	5.0%	0.8%
Maximum	11.4%	12.4%	12.4%
Change in Domestic Production			
Absolute (thousand metric tons)			
Mean	−559	−271	−501
Median	−421	−247	−372
Minimum	−74	−189	−74
Maximum	−1,539	−403	−1,539
Percentage of baseline production			
Mean	−11.8%	−6.6%	−10.8%
Median	−11.6%	−5.5%	−10.4%
Minimum	−6.8%	−4.4%	−4.4%
Maximum	−22.8%	−10.9%	−22.8%

EPA notes that since conducting this analysis, one high mercury-emitting plant has invested in control technology estimated to reduce emissions by approximately 85 percent. The current analysis does not include these actual costs in the baseline but rather estimates aggregate compliance costs based on the averaging methodologies applied to all other modeled plants. In addition, because this investment occurred after the analysis was conducted, the baseline benefits likewise do not include the approximately 85% emissions reduction. Finally, EPA did not estimate the change in social costs that would occur if the 2 high mercury-emitting plants were to shut down, because the Agency believes these plants will ultimately be able to meet the emissions limit by applying multiple mercury controls, which were accounted for in the cost analysis. EPA also acknowledges that if these 2 high mercury-emitting plants ultimately are able to meet the emissions limit, they will not likely be able to do so by the required compliance date.

Within the group of plants with operating losses, EPA identified 10 domestic plants with negative operating profits and significant utilization changes that could temporarily idle until market demand conditions improve (see Table 3-9). The plants have unit compliance costs close to $8 per ton; they account for approximately 8% of domestic capacity. These plants are modeled as continuing to operate despite low capacity utilization and short run negative profits. The model results for them are included in the summary results for Tables 3-5, 3-6, 3-7, and 3-8 but are also reported separately in Table 3-9.

If the plant owners did decide to permanently shut down these plants, the reduction in domestic supply would lead to additional projected market price increases. This would lead to an increased production at other plants, a possible increase in imports (depending if the plant that chooses to close is in a market where imports are anticipated) and a decrease in control cost. This scenario cannot be easily modeled. In an effort to bound this effect, the price increase needed to reduce national consumption by the amount of production that would be lost if the ten plants dropped from 55.5% capacity utilization to 0.0% capacity utilization was estimated using the demand elasticity of 0.88. This ignores changes in other plants is response to an increased potential market share and increases in imports. Both of these would tend diminish the price increase. The predicted price change was multiplied by the change in production associated with the ten plants dropping capacity utilization to zero and multiplied by one half to estimate the change in surplus associated with the price and quantity change. This gave a result of a $10 million increase in social cost. This number was then reduced by the avoided pollution control cost of $34 million at the ten plants because if the plants were to idle or shut down, they would not incur compliance costs. This resulted in a net reduction of $24 million in social cost when these firms idle or shut down as compared to the modeled scenario, where firms continue to operate a low capacity but incur compliance costs. Because of the method of estimating this adjustment it cannot be distributed between producer and consumer surplus. An estimate of the social cost is provided with and without this adjustment.

Table 3-8. Distribution of Industry 2005

	Changes in Total Operating Profit:		
	Plants with Loss	**Plants with Gain**	**All Plants**
Number	58	44	102
Cement Capacity (million metric tons)			

Total	55,202	38,145	93,346
Average per plant	952	867	915
Compliance Costs			
Total (thousand)	$308,740	$68,806	$377,546
Average ($/metric cement)	$5.59	$1.80	$4.04
Capacity Utilization (percent)			
Baseline	100.3%	98.7%	99.6%
With regulation	81.0%	100.3%	88.9%
Change in total operating profits (million)	−$387	$147	−$241

Table 3-9. Cement Plants with Significant Utilization Changes 2005

	Total
Number	10
Cement Capacity (thousand metric tons)	
Total	7,815
Average per plant	782
Compliance Costs	
Total (thousand)	$62,222
Average ($/metric ton)	$7.96
Capacity Utilization (%)	
Baseline	99.0%
With regulation	55.5%
Change in Operating Profit (million)	−$116

3.2.3.3 Job Effects

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Precise job effect estimates cannot be estimated with certainty and the economic literature does not give clear evidence on the effect of regulation on job effects. Several empirical studies, including Morgenstern et al.,suggest the net employment decline is zero or economically small (e.g., Cole and Elliot, 2007; Berman and Bui, 2001). However, others show the job effects are not trivial (Henderson, 1996; Greenstone, 2002).

EPA has most often estimated employment changes associated with plant closures due to environmental regulation or changes in output for the regulated industry (EPA, 1999a; EPA, 2000). This partial equilibrium approach focuses only on the “demand” portion of the projected change in employment and neglects other employment changes. EPA provides this estimate because it employs the most detailed modeling for the industry being regulated even if it does not capture all types of employment impacts. In addition to the employment effects identified by Morgenstern et al., we also expect that the substitutes for cement (e.g., asphalt) would expand production as consumers shift away from cement to other products. This would also lead to increased employment in those industries. Focusing only on the “demand effect”, it can be seen that the estimate from the historical approach is within the range presented by the Morgenstern “demand effect” portion. This strengthens our comfort in the reasonableness of both estimates. In April of this year, EPA started including an estimate based on the Morgenstern approach because it is thought to be a broader measure of the employment impacts of this type of environmental regulation. Thus, this analysis goes beyond what EPA has typically done, and uses Morgenstern et al. (2002) to provide the basis for the estimates. Morgenstern et al. (2002) model three economic mechanisms by which pollution abatement activities can indirectly influence jobs:

- higher production costs raise market prices, higher prices reduce consumption, and employment within an industry falls ("demand effect");
- pollution abatement activities require additional labor services to produce the same level of output ("cost effect"); and
- postregulation production technologies may be more or less labor intensive (i.e., more/less labor is required per dollar of output) ("factor-shift effect").

This transfer of results from the Morgenstern study is uncertain but avoids ignoring the "cost effect" and the "factor-shift effect" In examinining job effects. EPA selected this paper because the parameter estimates provide a transparent and tractable way to transfer estimates for an employment effects analysis. Simialr estimates were not available from other studies.

- Using the historical approach, we calculated "demand effect" employment changes by assuming that the number of jobs declines proportionally with the economic model's simulated output changes. As shown in Table 3-10, using this limited approach, the employment falls by an 1,500 jobs, or approximately −10%.[7] By comparison, using the Morgenstern approach, we estimate that the net employment effects could range between 600 job losses to 1,300 job gains.

EPA has solely used this historical estimate in the past as a measure of the projected employment change associated with a regulation. However there are a number of serious shortcomings with this approach. First, and foremost, the historical approach only looks at the employment effects on the regulated industry from reduced output. Second, to arrive at that estimate, EPA needed to string together a number of strong assumptions. The employment impacts are independent of the performance of the overall economy. This rule takes effect in three years. If the economy is strong, the demand for cement strong, it is unlikely that any contraction in the industry will take place, even with the regulation. Second, we assume that all plants have the same limited ability to pass on the higher costs. In reality, plants should be modeled as oligopolists for each of their regional markets. Finally, EPA assumed that employment is directly proportional to output. This is unlikely, and biases the results towards higher employment losses. The Morgenstern methodology is a more complete consideration of probable impacts of a regulation on the economy.

[7] To place this reduction in context, it is a similar to the decline experienced during the latest economic downturn; approximately 2,000 jobs (see Appendix A, Table A-3).

Table 3-10. Job Losses/Gains Associated with the Final Rule

Method	1,000 Jobs
Partial equilibrium model (demand effect only)	**−1.5**
Literature-based estimate (net effect [A + B + C below])	**0.3 (−0.6 to +1.3)**
A. Literature-based estimate: Demand effect	−0.8 (−1.7 to +0.1)
B. Literature-based estimate: Cost effect	0.5 (+0.2 to +0.9)
C. Literature-based estimate: Factor shift effect	0.6 (+0 to +1.2)

We calculated a similar "demand effect" estimate that used the Morgenstern paper. EPA selected this paper because the parameter estimates (expressed in jobs per million [$1987] of environmental compliance expenditures) provide a transparent and tractable way to transfer estimates for an employment effects analysis. Similar estimates were not available from other studies. To do this, we multiplied the point estimate for the total demand effect (−3.56 jobs per million [$1987] of environmental compliance expenditure) by the total environmental compliance expenditures used in the partial equilibrium model. For example, the jobs effect estimate is estimated to be 807 jobs (−3.56 × $378 million × 0.6).[8] The timeframe for EPA's regulatory analysis focuses on a single year effect, by contrast the Morganstern analysis used annualized inputs, and translates to annualized impacts. Demand effect results are provided in Table 3-10. It is not appropriate to substitute the data from that approach in to the Morgenstern due to the incompatibilities of the underlying data. Since the result from the historical approach is within the confidence bounds for the Morgenstern results for the "demand effect", we are comfortable that the more general Morgenstern result is a good representation of the change in employment.

We also present the results of using the Morgenstern paper to estimate employment "cost" and "factor-shift" effects. Although using the Morgenstern parameters to estimate these "cost" and "factor-shift" employment changes is uncertain, it is helpful to compare the potential job gains from these effects to the job losses associated with the "demand" effect. Table 3-10 shows that using the "cost" and "factor shift" employment effects may offset employment loss

[8] Since Morgenstern's analysis reports environmental expenditures in 1987 dollars, we make an inflation adjustment to the engineering cost analysis using the consumer price index (195.3/113.6) = 0.6)

estimates using either “demand” effect employment losses. The 95% confidence intervals are shown for all of the estimates based on the Morgenstern parameters. As shown, at the 95% confidence level, we cannot be certain if net employment changes are positive or negative.

Although the Morgenstern paper provides additional information about the potential job effects of environmental protection programs, there are several qualifications EPA considered as part of the analysis. First, EPA has used the weighted average parameter estimates for a narrow set of manufacturing industries (pulp and paper, plastics, petroleum, and steel). Absent other data and estimates, this approach seems reasonable and the estimates come from a respected peer-reviewed source. However, EPA acknowledges the final rule covers an industry not considered in the original empirical study. By transferring the estimates to the cement sector, we make the assumption that estimates are similar in size. In addition, EPA assumes also that Morgenstern et al.’s estimates derived from the 1979–1991 are still applicable for policy taking place in 2013, almost 20 years later. Second, the economic impact model only considers near-term employment effects in the cement industry where production technologies are fixed. As a result, the economic impact model places more emphasis on the short-term “demand effect,” whereas the Morgenstern paper emphasizes other important long-term responses. For example, positive job gains associated with “factor shift effects” are more plausible when production choices become more flexible over time and industries can substitute labor for other production inputs. Third, the Morgenstern paper estimates rely on sector demand elasticities that are different (typically bigger) from the demand elasticity parameter used in the cement model. As a result, the demand effects are not directly comparable with the demand effects estimated by the cement model. Fourth, Morgenstern identifies the industry average as economically and statistically insignificant effect (i.e., the point estimates are small, measured imprecisely, and not distinguishable from zero). EPA acknowledges this fact and has reported the 95% confidence intervals in Table 3-10. Fifth, Morgenstern’s methodology assumes large plants bear most of the regulatory costs. By transferring the estimates, EPA assumes a similar distribution of regulatory costs by plant size and that the regulatory burden does not disproportionately fall on smaller plants.

3.3 Other Economic Analyses: Direct Compliance Cost Methods

Field Co

In addition to the market-level partial equilibrium analysis, EPA developed a separate economic analysis for the remaining 20 kilns that EPA anticipates will be affected by the final rule. These costs ($88 million, or 19%) were not included in the economic impact model analysis because of uncertainties and difficulties with developing an appropriate set of baseline cement market conditions for future years.

The total annualized costs for two white cement kilns are $2 million, or approximately $9 per metric ton of cement production. Using reported 2005 data from the USGS on the average mill net value of white cement ($176 per metric ton), this cost represents 5% of the product value.

EPA also conducted sales tests for 18 other kilns that were not included in the partial equilibrium analysis. The total annualized NESHAP cost for these 18 kilns is approximately $75 million. The median cost per ton is approximately $3.80 and ranges from $1.90 to $4.40 per ton of cement production. In addition, 7 of these 18 kilns would face an additional control cost above the NESHAP (approximately $1 dollar per metric ton) to meet the NSPS limits for SO_2 and NO_x.

The USGS reports that the real price of cement per metric ton (2005 dollars) has typically ranged between $75 and $100 since 1990. A sales test using these price data shows cost-to-sales ratios (CSRs) could range between 2% and 6%

Sales Test Ratio = Control Costs ($/ton)/F.O.B Cement Prices ($/ton).

From 2000 to 2006, the PCA reports that the average operating profit rates for the industry ranged from 17 to 21% (PCA, 2008c). If these profit data are representative of operating profit rates for new kilns, kilns could potentially significantly reduce their operating profit rates. As a result, companies may have the incentive to look for less expensive alternatives to meet the emission standards. If these alternatives are limited or not cost effective, the final rule may lead companies to consider delaying rates of construction of new kilns until market conditions change (e.g., increases in demand that lead to rising cement prices) to cover additional control costs.

3.4 Social Cost Estimates

Field Co

For the kilns modeled in our partial equilibrium model, the market adjustments in price and quantity were used to estimate the changes in aggregate economic welfare using applied welfare economics principles (see Appendix C). Higher cement prices and reduced consumption lead to consumer welfare losses ($540 million). Domestic producers (in aggregate) experience a net loss of $239 million. As noted in the previous section, individual domestic producers may gain or lose depending on the change in compliance costs versus the change in the regional market prices. The total domestic surplus loss (consumer and producers) totals $792 million.

For the kilns not modeled in our partial equilibrium model, the $88 million in engineering costs were multiplied by 1.8 to approximate the likely additional social cost associated with oligopoly market response. Thus the social cost estimate for the 20 kilns not in the partial equilibrium model is $158 million. Because of the approximation used, we cannot estimate how the $158 million is distributed between consumers and producers.

Table 3-11. Distribution of Social Costs ($\$10^6$): 2005

Description	Social Cost Estimates: Final NESHAP and NSPS	Social Cost Estimates: Final NESHAP and More Stringent NSPS	EIA Social Cost Method
Change in consumer surplus	$551	$551	Partial-equilibrium model (baseline year 2005)
Change in domestic producer surplus	$241	$241	Partial-equilibrium model (baseline year 2005)
20 Kilns	$158	$187	Direct Compliance Method (scaled by 1.8 for oligopoly)
Change in domestic surplus	$950	$979	Combined methods
Adjustment if ten low utilization facilities idle or close (net negative because shut down facilities will not incur compliance costs).	-$24	-$24	
Total:	**$926-$950**	**$955-$979**	**Change with and without adjustment**
	Final NSPS Only	**More Stringent NSPS Only**	
Total:	**$72**	**$101**	**Direct compliance cost method** (scaled by 1.8 for oligopoly)
	Final NESHAP Only		
Change in consumer surplus	$551		Partial-equilibrium model (baseline year 2005)
Change in domestic producer surplus	$241		Partial-equilibrium model (baseline year 2005)
NSPS kilns (7 kilns)	$52		Direct compliance cost method (scaled by 1.8 for oligopoly)
Other kilns (13 kilns)	$86		Direct compliance cost method (scaled by 1.8 for oligopoly)
Change in domestic surplus	$930		Combined methods
Adjustment if ten low utilization facilities idle or close	$-24		
Total:	**$904-$930**		**Change with and without adjustment**

The estimated social cost of the final rule is $926-950 million. This estimate includes the results for existing kilns included in the partial-equilibrium analysis ($792 million),the final NESHAP direct compliance costs 20 kilns not included in the economic impact model, ($77 million), and the additional NSPS direct compliance cost for 7 kilns coming on line in the future ($11 million). The social estimates are significantly higher than the engineering analysis estimate of annualized costs totaling $466 million. This is a direct consequence of EPA's assumptions about existing market structure discussed extensively in previous cement industry rulemakings and in Section 2 and Appendix B of this RIA. Under baseline conditions without regulation, the existing domestic cement plants are assumed to choose a production level that is less than the level produced under perfect competition. As a result, a preexisting market distortion exists in the cement markets covered by the final rule (i.e., the observed baseline market price is higher than the [unobserved] market price that a model of perfect competition would predict). The imposition of additional regulatory costs tends to widen the gap between price and marginal cost in these markets and contributes to additional social costs. The above social costs for 2013 include annualized capital costs over the expected lifetime of the equipment and an opportunity cost of capital (7%) discount rate. To facilitate comparisons of benefits and costs when estimates vary of time across multiple years, EPA typically estimates a "consumption equivalent" present value measure of costs. This could be computed using a consumption rate of interest of 3% and 7%. However, this calculation was not necessary since the cost and benefit analyses only produce estimates for a single year (OAQPS, 1999a).

3.5 Energy Impacts

Executive Order 13211 (66 FR 28355, May 22, 2001) provides that agencies will prepare and submit to the Administrator of the Office of Information and Regulatory Affairs, OMB, a Statement of Energy Effects for certain actions identified as "significant energy actions." Section 4(b) of Executive Order 13211 defines "significant energy actions" as any action by an agency (normally published in the *Federal Register*) that promulgates or is expected to lead to the promulgation of a rule or regulation, including notices of inquiry, advance notices of final rulemaking, and notices of final rulemaking: (1) (i) that is a significant regulatory action under Executive Order 12866 or any successor order, and (ii) is likely to have a significant adverse effect on the supply, distribution, or use of energy; or (2) that is designated by the Administrator of the Office of Information and Regulatory Affairs as a significant energy action.

This rule is not a significant energy action as designated by the Administrator of the Office of Information and Regulatory Affairs because it is not likely to have a significant adverse impact on the supply, distribution, or use of energy. EPA has prepared an analysis of energy impacts that explains this conclusion below.

To enhance understanding regarding the regulation's influence on energy consumption, EPA examined publicly available data describing the cement sector's energy consumption. The *AEO 2010* (DOE, 2010) provides energy consumption data. As shown in Table 3-12, this industry accounts for approximately 0.4% of the U.S. total energy consumption. As a result, any

Table 3-12. U.S. Cement Sector Energy Consumption (Trillion BTUs)[a]: 2013

	Quantity	Share of Total Energy Use
Residual fuel oil	0.9	0.00%
Distillate fuel oil	10.8	0.00%
Petroleum coke	47.3	0.10%
Other petroleum[b]	30.2	0.00%
Petroleum subtotal	89.2	0.10%
Natural gas	19.8	0.00%
Steam coal	206.6	0.20%
Metallurgical coal	6.8	0.00%
Coal subtotal	213.4	0.20%
Purchased electricity	38.9	0.00%
Total	399.44	0.40%
Delivered Energy Use	72,407	72.20%
Total Energy Use	100,592	100.00%

[a] Fuel consumption includes consumption for combined heat and power.

[b] Includes petroleum coke, lubricants, and miscellaneous petroleum products.

Source: U.S. Department of Energy, Energy Information Administration. 2010. Supplemental Tables to the Annual Energy Outlook 2010. Table 10 and Table 39. Available at <http://www.eia.doe.gov/oiaf/aeo/supplement/supref.html>.

energy consumption changes attributable to the regulatory program should not significantly influence the supply, distribution, or use of energy. EPA has also estimated the amount of additional electricity consumption associated with add-on controls. The analysis shows the additional national electrical demand to be 780 million kWh per year and the natural gas use to be 1.2 million MMBTU per year for existing kilns. For new kilns, assuming that of the 16 new kilns to start up by 2013, all 16 will add alkaline scrubbers and ACI systems, the electrical demand is estimated to be 199 million kWh per year. This is less than 0.1% of *AEO 2010* forecasts of total electricity and natural gas use.

3.6 Assessment

Although the economic analyses presented in this section cannot provide precise estimates of the final NESHAP's and NSPS's economic impacts, the evidence presented in this section suggests that the economic impacts may be significant across several dimensions (price, consumption, production, and international trade). There are several broad issues we emphasize as stakeholders review the analysis. First, OAQPS's partial equilibrium analysis of NESHAPs has traditionally been designed to assess small (marginal) changes in industry conditions. The overall engineering cost analysis estimates are significant relative to the size of the U.S. cement market; EPA acknowledges that use of demand and import supply elasticities can be tenuous in these cases because the exact functional relationships (demand and supply) are less certain when simulated outcomes move further away from the observed pre-policy equilibrium. Second, the partial equilibrium assumes that transportation costs between regions are high enough that interregional trade is unlikely to occur, at least in the short run. Allowing interregional trade would expand the cement market definitions and increase the number of producers in each market. As discussed above, as the number of producers in a market increases, the production decision becomes more consistent with decisions made in pure competition; the additional trading opportunities may tend to moderate the relative price changes simulated within the model. Third, as discussed earlier in this section, the choice of market structure increases the agency's social cost estimate; it is almost 2 times higher than a model that assumes perfect competition. Therefore, the analysis may overstate the social costs of the rule. EPA continues to believe the market structure is reasonable and provides an upper-bound social cost estimate for the following reasons: (1) high transportation costs and other production economics tend to limit the number of sellers (particularly over a short time horizon), so each seller has a substantial regional market share; (2) timely market entry is also constrained by the high capital costs that involve purchases and construction of large rotary kilns that are not readily movable or transferable to other uses[9]; (3) cement producers offer very similar or identical products; and (4) the Office of Management and Budget (OMB) explicitly mentions the need to consider market power–related welfare costs in evaluating regulations under Executive Order 12866.

[9] In addition, large plants are typically more economical because they can produce cement at lower unit costs; this reduces entry incentives for smaller capacity cement plants.

EXHIBIT 22

United States Environmental Protection Agency

Regulatory Impact Analysis for the Proposed Standards of Performance for Greenhouse Gas Emissions for New Stationary Sources: Electric Utility Generating Units

EPA-452/R-12-001
March 2012

Regulatory Impact Analysis for the Proposed Standards of Performance for Greenhouse Gas Emissions for New Stationary Sources: Electric Utility Generating Units

U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Health and Environmental Impacts Division
Research Triangle Park, NC

EXECUTIVE SUMMARY

This Regulatory Impact Analysis (RIA) discusses potential benefits, costs, and economic impacts of the proposed Standards of Performance for Greenhouse Gas Emissions for New Stationary Sources for Electric Utility Generating Units (herein referred to as EGU GHG NSPS).

ES.1 Background and Context of Proposed Rule

The proposed EGU GHG NSPS will limit greenhouse gas emissions (GHG) from new fossil fuel fired electric generating units (EGU) constructed in the United States in the future.[1] This rulemaking will apply to carbon dioxide (CO_2) emissions from new electric generating sources that exceed 25 megawatts (MW) in capacity. The United States Environmental Protection Agency (EPA) is proposing requirements for these sources because CO_2 is a GHG and power plants are the country's largest stationary source emitters of GHGs. As stated in the EPA's Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clean Air Act (74 FR 66,518; Dec. 15, 2009) and summarized in Chapter 3 of this RIA, the anthropogenic buildup of GHGs in the atmosphere is very likely the cause of most of the observed global warming over the last 50 years. This action is taken in response to a proposed settlement agreement entered into on December 23, 2010 to issue rules that will deal with GHGs from certain fossil fuel-fired EGUs.

The statutory authority for this action is the Clean Air Act (CAA) section 111(b), which covers the regulation of new, modified, and reconstructed sources. For the purposes of this rule, a new source is one that commences construction after the publication of the proposed rule, other than those sources EPA has classified as "transitional" sources described later in this RIA. A reconstructed source is generally defined as an existing source that conducts extensive replacement of components and is treated as a new source under CAA section 111. A modification is any physical change in, or change in the method of operation of, a source that increases the amount of any air pollutant emitted by the source or results in the emission of any air pollutant not previously emitted.

EPA is not proposing a standard of performance for a group of sources it is calling transitional sources as long as they commence construction[2] within 12 months from the date of

[1] For purposes of this rule, covered EGUs do not include simple cycle combustion turbines. In addition, units subject to emission requirements under the CAA solid waste combustion provisions (Section 129) would not be subject to requirements under this proposed rule.

[2] EPA's regulations define "commenced construction" as, in general, undertaking a continuous program of construction or entering into a binding contract to do so (40 CFR 51.165).

this proposal. Transitional sources are affected EGUs that have received approval for their complete Prevention of Significant Deterioration (PSD) preconstruction permits, but that have not “commenced construction” by the date of today’s proposed rulemaking. EPA is aware of approximately 15 transitional sources, six of which are expected to utilize carbon capture and sequestration (CCS) technology.

CAA section 111(d) covers regulation of existing stationary sources that are not regulated under other parts of the CAA (i.e., pollutants regulated under NAAQS requirements or NESHAP requirements) and to which a new source performance standard (NSPS) would apply if such existing source were a new source. This rulemaking affects CAA section 111(b) new sources of GHG emissions from fossil fuel-fired EGUs but does not address GHG emissions from existing sources. EPA is currently examining options for developing CO_2 emission guidelines that will be used by states to develop plans establishing standards of performance as required by CAA section 111(d). CAA Section 111 (b) requires that this standard be reviewed every eight years, thus this regulatory requirement will likely be reviewed and potentially revised after the 2020 timeframe. Therefore, this economic analysis focuses on benefits and costs of this proposal for the years through 2020.

This proposed rule is consistent with the President’s goal to ensure that “by 2035 we will generate 80 percent of our electricity from a diverse set of clean energy sources - including renewable energy sources like wind, solar, biomass and hydropower, nuclear power, efficient natural gas, and clean coal.”[3] Additionally, this rule demonstrates to other countries that the United States is taking action to limit GHGs from its largest emissions sources, in line with our international commitments. The impact of GHGs is global, and U.S. action to reduce GHG emissions complements ongoing programs and efforts in other countries.

ES.2 Summary of Proposed Rule

This proposal requires that all new fossil-fuel fired units that exceed 25 MW in capacity be able to meet an emission rate standard of 1,000 pounds of CO_2 per megawatt hour (lbs CO_2/MWh) calculated over a rolling 12-month period. It also proposes an alternative compliance option that would allow units to meet the 1,000 lbs CO_2/MWh standard using a 30-year averaging period. These standards could be met either by natural gas combined cycle (NGCC) generation with no additional GHG control or coal-fired generation using CCS. The base case modeling EPA performed for this rule (as well as modeling that EPA has performed for

[3] “Blueprint for a Secure Energy Future.” March 30, 2011. Available online at: http://www.whitehouse.gov/sites/default/files/blueprint_secure_energy_future.pdf

other recent air rules) project that, even in the absence of this action, new fossil-fuel fired capacity constructed through 2020 will most likely be natural gas combined cycle capacity. Alternatively, with available federal funding and appropriate market conditions, coal-fired capacity with CCS could also be built. Any projected combustion turbine capacity would not be affected by this rule. Analyses performed both by EPA and the U.S. Energy Information Administration (EIA)[4] project that generation technologies other than coal (including natural gas and renewable sources) are likely to be the technology of choice for new generating capacity due to current and projected economic market conditions. This means that technologies planned for new sources currently envisioned by owners and operators of EGUs will meet the regulatory requirements of this NSPS or are not covered by the NSPS.

ES.3 Key Findings of Economic Analysis

As explained in detail in this document, energy market data and projections support the conclusion that, even in the absence of this rule, existing and anticipated economic conditions in the marketplace will lead electricity generators to choose technologies that meet the proposed standards. Therefore, based on the analysis presented in Chapter 5, EPA anticipates that the proposed EGU GHG NSPS will result in negligible CO_2 emission changes, energy impacts, quantified benefits, costs, and economic impacts by 2020. Accordingly, EPA also does not anticipate this rule will have any impacts on the price of electricity, employment or labor markets, or the US economy. Nonetheless, this rule may have several important beneficial effects described below.

This NSPS provides legal assurance that any new coal-fired plants must limit CO_2 emissions. Rather than relying solely on changeable energy market conditions to provide low emissions from new power plants in the future, this rule prevents the possible construction of uncontrolled, high-emitting new sources that might continue to emit at high levels for decades, contributing to accumulation of CO_2 in the atmosphere. In Chapter 5 of this RIA, we present a sensitivity analysis indicating that even in the unlikely event that market conditions change sufficiently to make the construction of new conventional coal-fired units economical from the perspective of private investors, the level of avoided negative health and environmental effects expected would imply net social benefits from this proposed rule.

The rule will reduce regulatory uncertainty by defining section 111(b) requirements for limiting GHG from new EGU sources. In addition, EPA intends this rule to send a clear signal about the future of CCS technology that, in conjunction with other policies such as Department

[4] Annual Energy Outlook (AEO) 2009- 2012.

of Energy (DOE) financial assistance, the agency estimates will support development and demonstration of CCS technology from coal-fired plants at commercial scale, if that financial assistance is made available and under the appropriate market conditions.[5] Carbon capture also has the potential to help to improve U.S. energy production through enhanced oil recovery, as highlighted by a series of regional assessments conducted for DOE.[6]

[5] A number of the sources that EPA has identified as transitional sources have received some form of DOE financial assistance to demonstrate CCS. Several additional projects have received funding but have not yet received air permits. Beyond these projects, prospects for additional federal funding are dependent on the overall budget process.

[6] U.S. Department of Energy. DOE web page, "Ten Basin-Oriented CO2-EOR Assessments Examine Strategies for Increasing Domestic Oil Production.," Available online at: http://www.fossil.energy.gov/programs/oilgas/eor/Ten_Basin-Oriented_CO2-EOR_Assessments.html.

CHAPTER 5
COSTS, BENEFITS, ECONOMIC, AND ENERGY IMPACTS

5.1 Synopsis

This chapter reports the compliance cost, economic, and energy impact analysis performed for the EGU GHG NSPS. EPA used IPM, developed by ICF Consulting, in this analysis. IPM is a dynamic linear programming model that can be used to examine air pollution control policies throughout the United States for the entire power system. EPA used the IPM model to forecast likely future electricity market conditions with and without the proposed rule.

Even in a baseline scenario without the proposed rule, the only capacity additions subject to this rule projected during the analysis period (through 2020[1]) are compliant with the requirements of this rule (e.g., combined cycle natural gas and small amounts of coal with CCS supported by DOE funding). This conclusion also holds for several sensitivity analyses EPA performed. As a result, under a wide range of future electricity market conditions, this proposed EGU GHG NSPS is not expected to change GHG emissions for newly constructed EGUs, and is anticipated to impose negligible costs, economic impacts, or energy impacts on the EGU sector or society. An additional illustrative analysis, presented at the end of this chapter, indicates that even in the unlikely event that electricity market conditions change enough to support additional new coal, the proposed EGU GHG NSPS would provide net benefits. This analysis concluded based on sensitivity analyses that the price of natural gas would have to increase to approximately $10/mmBtu for coal boilers without CCS to become competitive with combined cycle natural gas units, which is projected to be very unlikely.[2]

5.2 Background

Over the last decade, EPA has conducted extensive analyses of regulatory actions impacting the power sector. These efforts support the Agency's understanding of key policy variables and provide the framework for how the Agency estimates the costs and benefits associated with its actions. Current forecasts for the mix of new, and utilization of existing, generating capacity are a key input into informing the design of EPA's proposal. Given excess capacity within the existing fleet and relatively low forecasts of electricity demand growth, there is limited new capacity, of any type, expected to be constructed over the next decade. A small number of new coal-fired power plants have been built in recent years; however, EPA

[1] Note that while the analysis presented in this RIA is for the year 2020, IPM projections were also made for 2030 and are available in the docket.
[2] This chapter presents all costs in 2007$.

does not forecast the construction of any new unplanned coal-fired additions over the time horizon of this analysis (through the year 2020). For more detailed discussion of this forecast, see section 5.5.

Under current and foreseeable future market conditions affecting new capacity additions, gas-fired generating technologies can produce electricity at a lower levelized cost than coal-fired generating technologies, and therefore utilities are expected to rely heavily on combustion turbines and combined cycle plants using natural gas when they do need to expand capacity during the time horizon considered for this analysis. Current and projected natural gas prices are considerably lower than the prices observed over the past decade, largely due to advances in hydraulic fracturing and horizontal drilling techniques that have opened up new shale gas resources and substantially increased the supply of economically recoverable natural gas. According to EIA,

> Shale gas refers to natural gas that is trapped within shale formations. Shales are fine-grained sedimentary rocks that can be rich sources of petroleum and natural gas. Over the past decade, the combination of horizontal drilling and hydraulic fracturing has allowed access to large volumes of shale gas that were previously uneconomical to produce. The production of natural gas from shale formations has rejuvenated the natural gas industry in the United States.
>
> The U.S. Energy Information Administration's Annual Energy Outlook 2012 (Early Release) estimates that the United States possessed 2,214 trillion cubic feet (Tcf) of technically recoverable natural gas resources as of January 1, 2010. Natural gas from proven and unproven shale resources accounts for 542 Tcf of this resource estimate. Many shale formations, especially the Marcellus, are so large that only small portions of the entire formations have been intensively production-tested. Consequently, the estimate of technically recoverable resources is highly uncertain, and is regularly updated as more information is gained through drilling and production. At the 2010 rate of U.S. consumption (about 24.1 Tcf per year), 2,214 Tcf of natural gas is enough to supply over 90 years of use. Although the estimate of the shale gas resource base is lower than in the prior edition of the Outlook, shale gas production estimates increased between the 2011 and 2012 Outlooks, driven by lower drilling costs and continued

drilling in shale plays with high concentrations of natural gas liquids and crude oil, which have a higher value in energy equivalent terms than dry natural gas.[3]

Based on these market conditions, and detailed analysis and modeling conducted by EPA, the levelized cost of generation from a new natural gas power plant is expected to be lower on average than the levelized cost of generation from a new coal-fired power plant.[4,5] This trend has already been observed recently, as natural gas-fired capacity has been the technology of choice for power generation over the last few years (see Figure 5-1).

[3] For more information, see: http://www.eia.gov/forecasts/archive/aeo11/IF_all.cfm#prospectshale; http://www.eia.gov/energy_in_brief/about_shale_gas.cfm

[4] See Table 5-4, which reports the levelized cost of new generation in the Annual Energy Outlook (AEO) 2011.

[5] Note that EPA's analysis, which is consistent with this expectation, is based on sophisticated IPM modeling, and is not based on simplified LCOE assumptions.

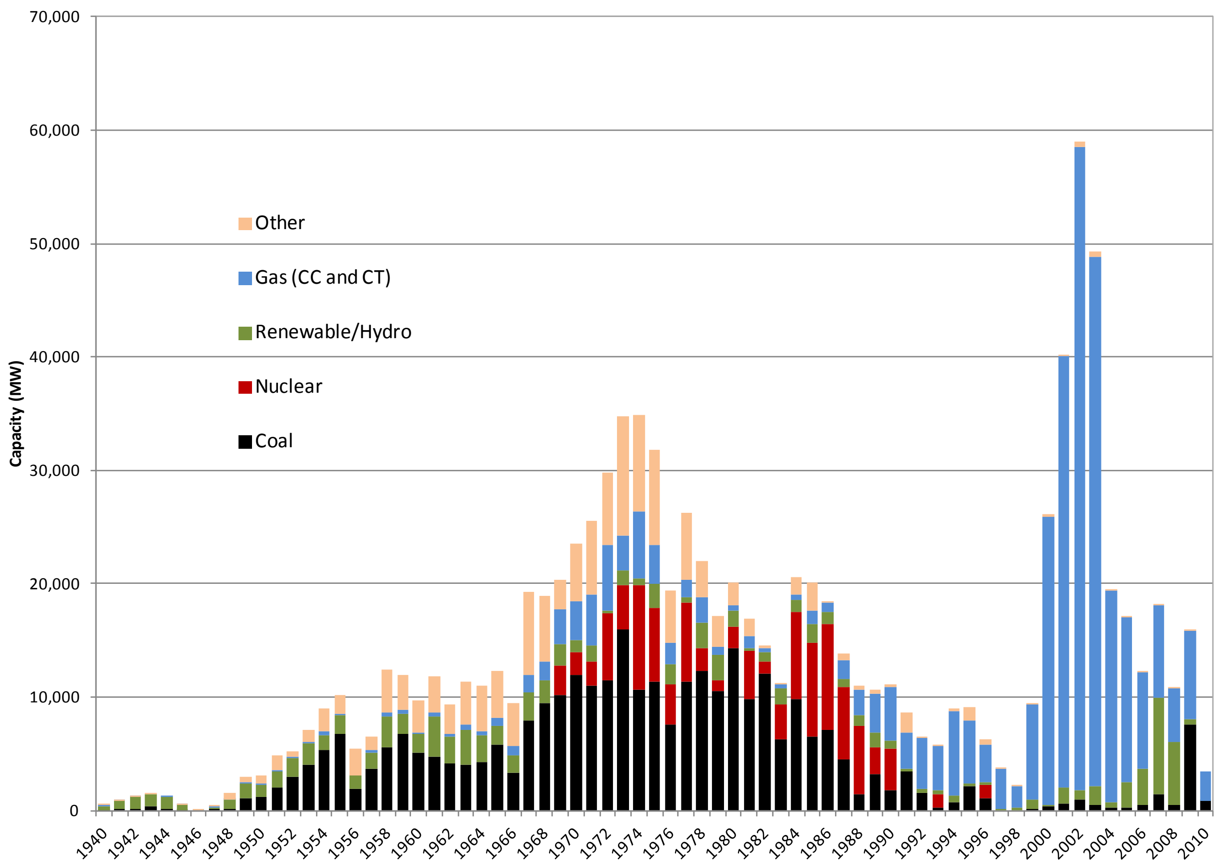

Figure 5-1. Historical U.S. Power Plant Capacity Additions, by Technology

Source: National Electric Energy Data System (NEEDS) v4.10_PTox

Note: Renewables include geothermal, biomass, solar, and wind energy technologies. A considerable amount of renewables were built in 2009 and 2010, and these are reflected in EPA modeling applications but not necessarily in NEEDS.

Numerous energy sector modeling efforts, including recent projections from EIA, have provided results that are consistent with these findings. The Annual Energy Outlook (AEO) for 2011 shows a modest amount of CCS-equipped new coal-fired power coming online past 2012 that would be in compliance with this proposal.[6] EIA includes some additional new coal with CCS in its baseline (2 GW), an assumption which EPA has adopted in IPM. The new CCS is in response to existing Federal incentives for the technology (the Emergency Economic Stabilization Act of 2008 and the American Reinvestment and Recovery Act of 2009). According to the AEO 2011, the majority of new generating capacity is forecast to be either natural gas-fired or renewable, with some lesser amounts of nuclear power. The AEO 2011 is based on

[6] AEO 2011 has a small amount of planned coal capacity that is under construction and expected to come online in the next year. This capacity represents certain units that likely fit the definition of transitional sources under this proposal. It also has 2 GW of unplanned coal capacity, which reflects new coal with CCS in response to Federal incentives.

existing policy and regulations, such as state Renewable Portfolio Standard programs and Federal tax credits for renewables.[7] Based on EIA analysis, DOE concluded, that "the low capital expense, technical maturity, and dispatchability of natural gas generation are likely to dominate investment decisions under current policies and projected prices."[8] The economics favoring new NGCC additions instead of conventional coal are robust under a range of sensitivity cases examined in the AEO. Unplanned additions of coal by 2020 are also not forecast in sensitivity cases that separately examine higher economic growth, lower coal prices, lower capital costs for fossil capacity, no risk premium for greenhouse gas emissions liability from conventional coal, slower oil and gas technology deployment, lower shale gas recovery per play, and lower shale gas recovery per well. In addition, the EIA's AEO 2012 Early Release (AEO 2012 ER) does not forecast new unplanned coal capacity without CCS through 2020. Furthermore, it projects an increase over AEO 2011 in the price of coal relative to natural gas, strengthening the conclusion that natural gas-fired generating technologies are likely to be the fossil fuel of choice during the analysis period. The AEO 2012 ER also has lower electricity demand projections than those used in IPM, reflecting an extended economic recovery and increasing energy efficiency in end-use appliances,[9] which would result in the need for less new capacity in general.

EPA uses IPM to support its understanding of the economic and emissions impacts of air regulations on the power sector. IPM forecasts show patterns of future power plant deployment that are similar to those presented in AEO 2011, and also forecasts no construction of new conventional coal-fired power plants under the base case.[10]

A number of major utilities have made public announcements consistent with these modeling results.[11]

IPM has been used for evaluating the economic and emission impacts of environmental policies for over two decades. The economic modeling presented in this chapter has been developed specifically for analysis of the power sector. Thus, the model has been designed to

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[7] http://www.eia.gov/forecasts/aeo/chapter_legs_regs.cfm

[8] Department of Energy (2011). *Report on the First Quadrennial Technology Review. Available at http://energy.gov/sites/prod/files/QTR_report.pdf.*

[9] AEO 2012 Early Release Overview

[10] http://www.epa.gov/airmarkets/progsregs/epa-ipm/BaseCasev410.html#documentation

[11] For example: "We have no other coal-fueled generation planned at this time… When we do need new capacity, it is highly likely that we will look to natural gas plants instead of coal, especially if natural gas prices remain as low as projected." AEP January 1, 2011, Washington Post; "If you actually look at the economics today, you would be burning gas, not coal," Jack Fusco, Calpine, 12/1/2010, Marketplace; "Coal's most ardent defenders are in no hurry to build new ones in this environment." John Rowe, Exelon, 9/2011, EnergyBiz; "With low gas prices, gas-fired generation kind of snowplows everything else" Lew Hay, NextEra, 11/1/2010, Dow Jones.

reflect the industry as accurately as possible. EPA uses the best available information from utilities, industry experts, gas and coal market experts, financial institutions, and government statistics as the basis for the detailed power sector modeling in IPM. More detail on IPM can be found in the model documentation, which provides additional information on the assumptions discussed here as well as all other assumptions and inputs to the model.

5.3 External Review of EPA Applications of IPM

EPA has used IPM extensively over the past two decades to analyze options for reducing power-sector emissions. The model has been used by the Agency to support regulatory initiatives as well as legislative proposals designed to address air emissions for the power sector. All of the IPM scenarios conducted for this rulemaking are available at EPA's website and in the public docket.[12]

The model undergoes periodic formal peer review, which includes separate expert panels for both the model itself and EPA's key modeling input assumptions. For example, over the past ten years several separate panels of independent experts have been convened to review IPM's coal supply and transportation assumptions, natural gas assumptions, and model formulation.

The rulemaking process also provides opportunity for expert review and comment by a variety of stakeholders, including owners and operators of the electricity sector that is represented by the model, public interest groups, and other developers of U.S. electricity sector models. The feedback that the Agency receives provides a highly detailed check for key input assumptions, model representation, and modeling results.

The Agency has used IPM in several recent regulatory contexts. The model has been used to support the Agency's analytics for the Clean Air Interstate Rule, CSAPR, MATS, and over a dozen legislative analytical efforts to forecast the costs, emission changes, and power sector impacts of various policies to reduce power sector emissions. As part of the rulemaking process, EPA is required to respond to every significant comment submitted.

The model has also been used by states (e.g., for Regional Greenhouse Gas Initiative, the Western Regional Air Partnership, Ozone Transport Assessment Group), other Federal and State agencies, environmental groups, and industry, all of whom subject the model to their own review procedures.

[12] http://www.epa.gov/airmarkt/progsregs/epa-ipm/index.html

More specifically, the model has received extensive review by energy and environmental modeling experts over the past two decades. States have used the model extensively to inform issues related to ozone in the northeastern portion of the U.S. This groundbreaking work set the stage for the NO_x SIP call, which has helped reduce summer NO_x emissions and the formation of ozone in densely populated areas in the northeast. In the late 1990's, the Science Advisory Board reviewed IPM as part of the CAA Amendments Section 812 prospective studies that are periodically conducted. The model has also undergone considerable interagency scrutiny as part of a series of legislative analyses over the past decade. These analyses explored a variety of approaches to controlling emissions from the power sector, and the results were presented to Congress in a comparative manner in order to evaluate the merits of policy proposals. The model was also used to support the Agency's power sector analyses of legislative climate proposals in 2005, continuing through 2010. In addition, Regional Planning Organizations throughout the U.S. have extensively examined IPM as a key element in the state implementation plan (SIP) process for the National Ambient Air Quality Standards. The Agency has also used the model in a number of comparative modeling exercises sponsored by Stanford University's Energy Modeling Forum over the past 15 years.

5.4 IPM is a Detailed Bottom-Up Model

EPA applies IPM to consider nationwide impacts of environmental policies, which can also be considered at a regional level of detail appropriate to the functional organization of the power section. Although the Agency typically focuses on broad system effects when assessing the economic impacts of a particular policy, EPA's application of IPM includes a detailed and sophisticated regional representation of key power sector variables. For example, the model includes 32 power regions with detailed representation of the inter-regional transmission system and reflects the regional aspects of natural gas and coal markets. When considering which new units are most cost effective to build and operate, the model considers the relative economics of various technologies based on their unique capital costs, operation and maintenance (O&M) costs, fuel costs and emission profiles. The capital costs for new units are regionalized through the application of regional adjustment factors that capture regional differences in labor, material, and construction costs. These regional cost differentiation factors are based on assumptions used in the EIA's AEO.

As part of the model's assessment of the relative economic value of building a new power plant, the model incorporates a detailed representation of the fossil-fuel supply system that supports fuel price projections, a key component of new power plant economics. The model includes an endogenous representation of the North American natural gas supply system through a natural gas module that reflects a full supply/demand equilibrium of the North American gas market. This module consists of 114 supply, demand, and storage nodes and 14 liquefied natural gas regasification facility locations that are tied together by a series of linkages (i.e., pipelines) that represent the North American natural gas transmission and distribution network.

IPM also endogenously models the coal supply and demand system throughout the continental U.S., and reflects non-power sector demand and imports/exports. IPM reflects 84 coal supply curves, 12 coal sulfur grades, and the coal transport network, which consists of 1,230 linkages representing rail, barge, and truck and conveyer linkages. The coal supply curves in IPM, which are publicly available, were developed during a thorough bottom-up, mine-by-mine based approach that depict the coal choices and associated supply costs that power plants will face over the modeling time horizon. The IPM documentation outlines the methods and data used to quantify the economically recoverable coal reserves, characterize their cost, and build the 84 coal supply curves that are implemented in EPA modeling applications. The coal curves used by EPA were developed in consultation with Wood Mackenzie, one of the leading energy consulting firms and specialists in coal supply. These curves have been independently reviewed by industry experts and have been made available for public review on several occasions over the past two years during the rulemaking process for CSAPR and MATS.

5.5 Base Case and Sensitivity Analysis of Future Generating Capacity

5.5.1 Base Case Analysis

EPA began its analysis of the economic impacts of the proposed NSPS by conducting a base case analysis of future generating capacity. This base case incorporates the final MATS and the final Transport Rule (finalized as CSAPR).[13] In addition to MATS and CSAPR, the baseline takes into account emissions reductions associated with the implementation of all finalized federal rules, state rules and statutes, and other binding, enforceable commitments that are applicable to the power industry and which govern the installation and operation of pollution controls during the timeframe covered in the analysis. EPA's IPM modeling for this rule relies on EIA's *Annual Energy Outlook for 2010*'s electric demand forecast for the US and employs a set of EPA assumptions regarding fuel supplies, the performance and cost of electric generation technologies, pollution controls, and numerous other parameters.

[13] http://www.epa.gov/airquality/powerplanttoxics and http://www.epa.gov/airtransport.

The IPM base case projection is based on an electricity demand growth assumption of 0.8 percent annually on average, similar to EIA's Annual Energy Outlook for 2010, and slightly higher than the 0.7 percent annual average growth in the AEO 2012 ER. Total electricity demand is projected to be 4,086 billion kWh by 2015. Table 5-2 shows current electricity generation alongside EPA's projection for 2020 using IPM. This new demand will be fulfilled by existing generating capacity that is currently not being fully utilized, and new renewable and gas-fired generating capacity (see Table 5-1). The change in coal represents only retirements of existing plants and no new unplanned coal builds. These projections are the result of least-cost dispatching using IPM, and reflect the most cost-effective dispatch and investment option, given a variety of variables and constraints. Although most new generating capacity will be renewable and natural gas-fired, U.S. electricity demand will continue to be met by a diverse mix of electricity generation sources (see Table 5-2). In addition, coal is projected to continue to provide the largest share of America's electricity.[14] By 2020, EPA forecasts roughly 27 GW of new renewable capacity, 2 GW of coal with CCS, and 10 GW of new natural gas-fired capacity. Although 2 GW of coal with CCS is included in the base case in response to incentives under existing law, overall coal capacity is forecast to decline in response to current economics, along with some retirements due to other air regulations (CSAPR and MATS).

[14] Coal-fired generation is projected to increase above 2009 actual levels. 2020 natural gas-fired generation is projected to be lower than 2010, due in large part to the smaller relative difference in delivered natural gas and coal prices in different areas of the country projected to occur in 2020 than occurred in 2010. While the projected narrowing of this gas price and coal price differential may increase dispatch (generation) from existing coal units, it is insufficient to shift the economic decision to favor new conventional coal-fired capacity, which requires consideration of capital costs in addition to generation costs. The same trend is seen in AEO 2011 projections.

Table 5-1. Total Generation Capacity in 2010 and Projected by 2020 (GW)

	2010	2020
Pulverized Coal	316	304
Natural Gas Combined Cycle	199	212
Combustion Turbine	135	143
Oil/Gas Steam	111	90
Non-Hydro Renewables	31	73
Hydro	99	99
Nuclear	102	106
Other	5	4
Total	**998**	**1,030**

Source: 2010 data from EPA's NEEDS v.4.10 PTR. 2020 projections from Integrated Planning Model run by EPA.

Notes: The sum of the table values in each column may not match the total figure due to rounding.

"Non-Hydro Renewables" include biomass, geothermal, solar, and wind electric generation capacity. The capacity of a generating unit that is co-firing gas in a coal boiler is split in this table between "pulverized coal" and "Oil/Gas Steam" proportionally by fuel use.

Table 5-2. 2010 U.S. Electricity Net Generation and EPA Base Case Projections for 2020 (Billion kWh)

	Historical 2010	Projected 2020
Coal	1,828	1,976
Oil	35	0.126
Natural Gas	901	869
Nuclear	807	840
Hydroelectric	258	286
Non-hydro Renewables	139	289
Other	4	45
Total	**3,972**	**4,305**

Notes: The sum of the table values in each column may not match the total figure due to rounding.
Source: 2010 data from EIA Electric Power Annual 2010, Table 2.1; 2020 projection from IPM run by EPA, 2011.

5.5.2 Sensitivity Analyses

Forecasts suggesting that new coal is unlikely to be built by 2020 have been shown to be robust under a range of alternative assumptions that influence the industry's decisions to build new power plants. For example, EIA typically supplements the AEO with a series of distinct scenarios that explore specific issues and examine a future state of the world that deviates from the core parameter estimates that underlie the AEO reference case. Even under alternative scenarios where assumptions might improve the relative economic value of building new coal-fired power plants, the AEO 2011 does not project new coal capacity being built through 2025, beyond the coal capacity already planned outside of the modeling. Relevant scenarios include higher economic growth forecast, lower cost of coal supply, lower capital costs of fossil fuel-fired energy technologies, and less optimistic natural gas supply.[15] Although new coal capacity is built in some of these scenarios after 2025, CAA Section 111(b) requires that this standard be reviewed every eight years, thus this regulatory requirement will likely be reviewed and potentially revised after the 2020 timeframe, which serves as the primary focus of this analysis. In addition to studying the alternative scenarios analyzed by EIA, EPA also conducted three additional sensitivity analyses using IPM: a low shale gas recovery scenario, a high electricity demand scenario, and a combination of the two.[16] The lower shale recovery scenario assumed, that 50 percent less natural gas is recovered from each shale play relative to the base case (effectively lowering shale reserves by 50 percent, similar to the AEO 2011 low shale gas recovery scenario). The high electricity demand scenario assumed that electricity demand grows at an annual average rate of 1.1 percent, similar to EIA's high economic growth scenario for AEO 2010 (compared to about 0.8 percent in the EPA baseline, which is similar to the reference case in AEO 2010). Figure 5-2 and 5-3 illustrate electricity demand and natural gas price in these sensitivity analyses. Note that the EPA structured the sensitivity analyses such that natural gas prices and electricity demand growth are both considerably higher than the comparable AEO 2011 scenarios.[17]

[15] Conversely, modeling in support of the AEO 2011 show that new natural gas combined cycle capacity is expected to be higher in 2020 in the low fossil cost and high economic growth scenarios relative to the reference case.

[16] Although EPA and EIA do not typically combine scenarios (as EPA did with the natural gas and demand sensitivity in this analysis), this scenario was performed to demonstrate that even when considering the occurrence of two independent and highly unlikely assumptions that influence new power plant additions, new unplanned coal is not expected to be built through 2020.

[17] EPA's baseline electricity demand forecast used in IPM v4.10 is based on the demand forecast in AEO 2010. AEO 2010 electricity demand forecast for the year 2020 is roughly 2.5% higher than the 2020 forecast in AEO 2011. EPA's sensitivity with higher electricity demand growth (using the AEO 2010) uses an electricity demand for 2020 that is about 6% higher than the reference case AEO 2011 demand for 2020, and about 3% higher than the demand in the AEO 2011 high economic growth scenario. The EPA sensitivity with higher electric demand represents a very conservative view of electricity demand in 2020 (meaning that its electricity demand projection is considerably higher than the most recent reference case forecast, therefore representing a future in which new coal-fired capacity would be of correspondingly higher economic value to build relative to the reference case forecast conditions).

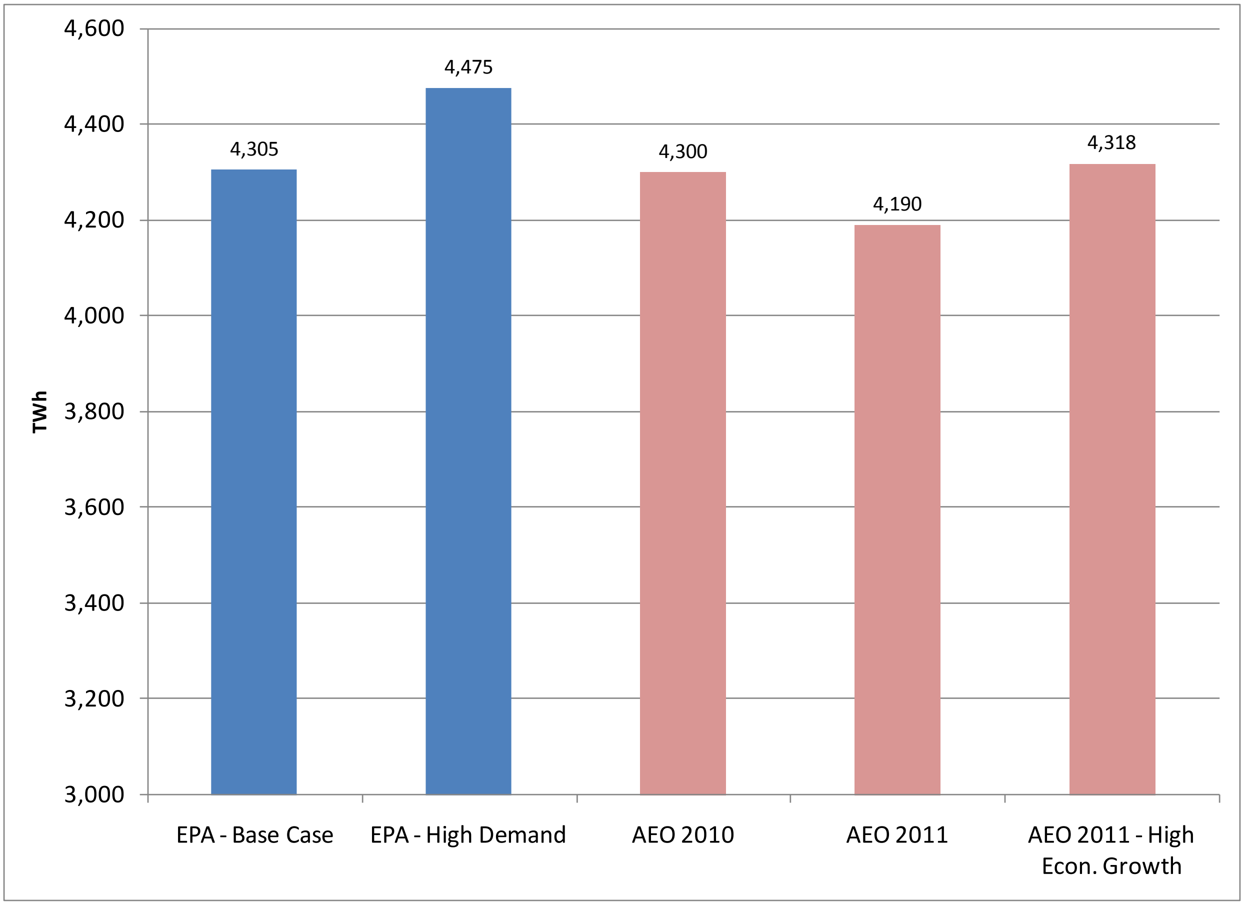

Figure 5-2. Projected Levels of Electricity Demand in 2020, EPA and EIA

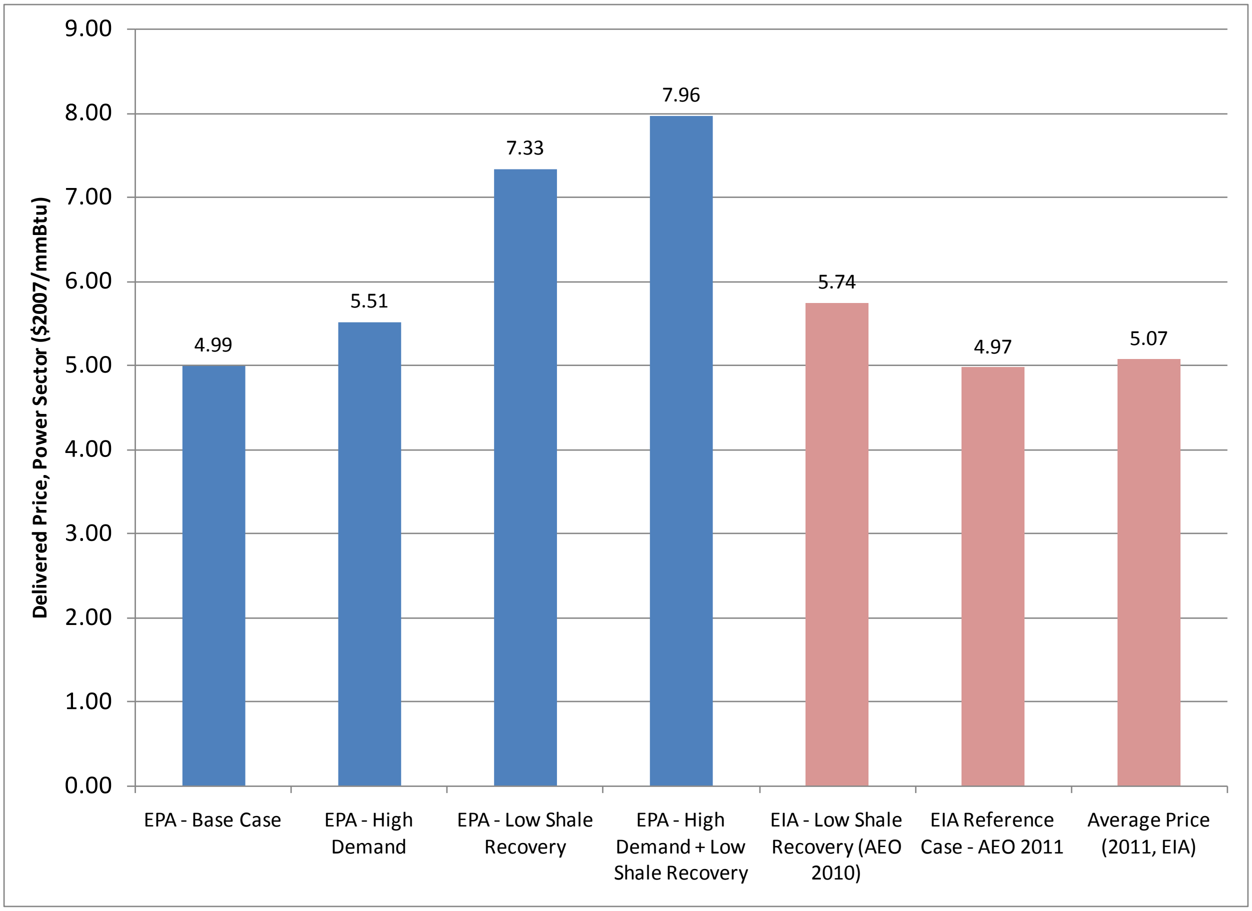

Figure 5-3. Projected Natural Gas Prices in 2020, EPA and EIA (Delivered, Power Sector)

None of these analyzed scenarios resulted in new conventional coal-fired capacity being built in 2020 (see Figure 5-4) beyond 2 GW of coal with CCS, which is built in response to the financial incentives for CCS included in the Emergency Economic Stabilization Act of 2008 and American Recovery and Reinvestment Act of 2009, which authorized and/or appropriated funding to DOE for CCS deployment.[18] In the short-term, most new capacity is projected as a mix of wind and natural gas in response to the competitive marketplace for fuels and other energy policies (such as tax credits and state renewable portfolio standards). These scenarios show similar results as EIA, and serve to further confirm the high likelihood that no new coal capacity is likely to be built by 2020 in baseline forecasts. See Table 5-3 for new capacity projections in 2020.

[18] A number of the sources that EPA has identified as transitional sources have received some form of DOE financial assistance to demonstrate CCS. Several additional projects have received funding but have not yet received air permits. Beyond these projects, prospects for additional federal funding are dependent on the overall budget process.

Table 5-3. Projected New Capacity in 2020

	EPA-Base Case	EPA-High Demand	EPA-Low Shale Recovery	EPA-High Demand + Low Shale Recovery
Coal +CCS	2.0	2.0	2.0	2.0
Natural Gas Combined Cycle	7.0	22.7	7.3	24.8
Combustion Turbine	3.0	3.2	2.4	2.4
Non-Hydro Renewables	26.9	27.6	27.3	31.5
Total	**38.9**	**55.5**	**39.0**	**60.7**

5.6 Analysis of Applicability of Proposed EGU GHG NSPS to Projected New Generating Capacity

As the second step in the analysis, EPA analyzed the applicability of the NSPS to new generating capacity anticipated to be built through 2020, and whether the requirements would require the regulated community to take actions different from those projected in the base case.

The proposed EGU GHG NSPS discusses potential requirements for new units Analysis performed by EPA, along with information from other sources, suggests that the standards as specified in this proposed rule are likely to result in negligible emission changes, other quantified benefits, energy impacts, costs, or economic impacts by 2020. This is because analyses performed both by EPA and EIA, as well as statements and actions of a number of major utilities, demonstrate that generation technologies other than coal (mostly natural gas and renewable sources) are likely to be the technologies of choice for new sources due to current and projected market conditions.[19]

5.6.1 New Units

This proposal requires that all new fossil-fuel fired units greater than 25 megawatt capacity be able to meet an emission rate standard of 1,000 lbs CO_2/MWh on a gross basis. It also proposes an alternative compliance option that would allow new units to meet the 1,000 lbs CO_2/MWh standard using a 30 year averaging period. These standards could be met either by natural gas combined cycle generation or coal-fired generation using CCS.

[19] EPA does not anticipate any oil or gas steam boilers to be constructed, either. Although these types of units would be subject to this rule, they have not been a technology of choice for the sector in recent years and are generally smaller (less than the 25 MW applicability threshold included as part of this rule). In addition, the operating economics also do not favor this technology, similar to the dynamic with conventional new coal-fired capacity.

Of the new generating capacity projected to be constructed by 2020, only the fossil-fuel-fired boilers would be affected by the proposed EGU GHG NSPS. The NGCC units, which are the basis of the proposed standard, are projected to meet the proposed standard through their inherent design.[20] As discussed in section 5.5, no new conventional coal-fired boilers are projected to be built (excluding new coal built with CCS). This implies that the NSPS will require no changes in design or construction of new EGUs forecasted in the base case. Thus, under the baseline projections as well as the sensitivity analyses presented above, the proposed EGU GHG NSPS will not result in any reduction in emissions, or any costs.

Engineering cost analysis, even outside of a least-cost system dispatch modeling environment, reaches similar conclusions. A comparison of levelized wholesale electricity costs for differing generation technologies and natural gas prices are shown in Figure 5-4 and Table 5-4. It is important to note that both EIA and EPA include a capital charge rate adder (3 percent) for new conventional coal-fired generating capacity without CCS, which reflects the additional cost of raising capital that is currently reflected in the marketplace, related at least in part to uncertainty surrounding future greenhouse gas emission reduction requirements.[21] Note that this figure only shows the costs to the generator and does not reflect the additional social costs that are associated with damages from greenhouse gas emissions or conventional air pollutants. As the figure shows, with a delivered natural gas price of $5 per million British Thermal Units (mmBtu) and a delivered coal price of $2 per mmBtu, which reflect forecasted prices from IPM in 2020,[22] electricity generated by natural gas combined cycle units is less expensive on average than coal generation.

[20] Natural gas combustion turbines are not covered by this proposal.

[21] EIA includes "a 3-percentage-point increase is added to the cost of capital for investments in GHG-intensive technologies, such as coal-fired power plants without CCS and CTL plants." Source: EIA AEO 2009, Issues in Focus. *Reflecting Concerns Over Greenhouse Gas Emissions in AEO2009*, available at: http://www.eia.gov/forecasts/archive/aeo09/issues.html
See also http://www.epa.gov/airmarkets/progsregs/epa-ipm/index.html

[22] EIA projects a U.S. average power sector delivered coal price of $2.08/MMBtu in 2020 ($2007). EPA and EIA both project delivered (power sector) natural gas price of roughly $5/mmBtu in 2020.

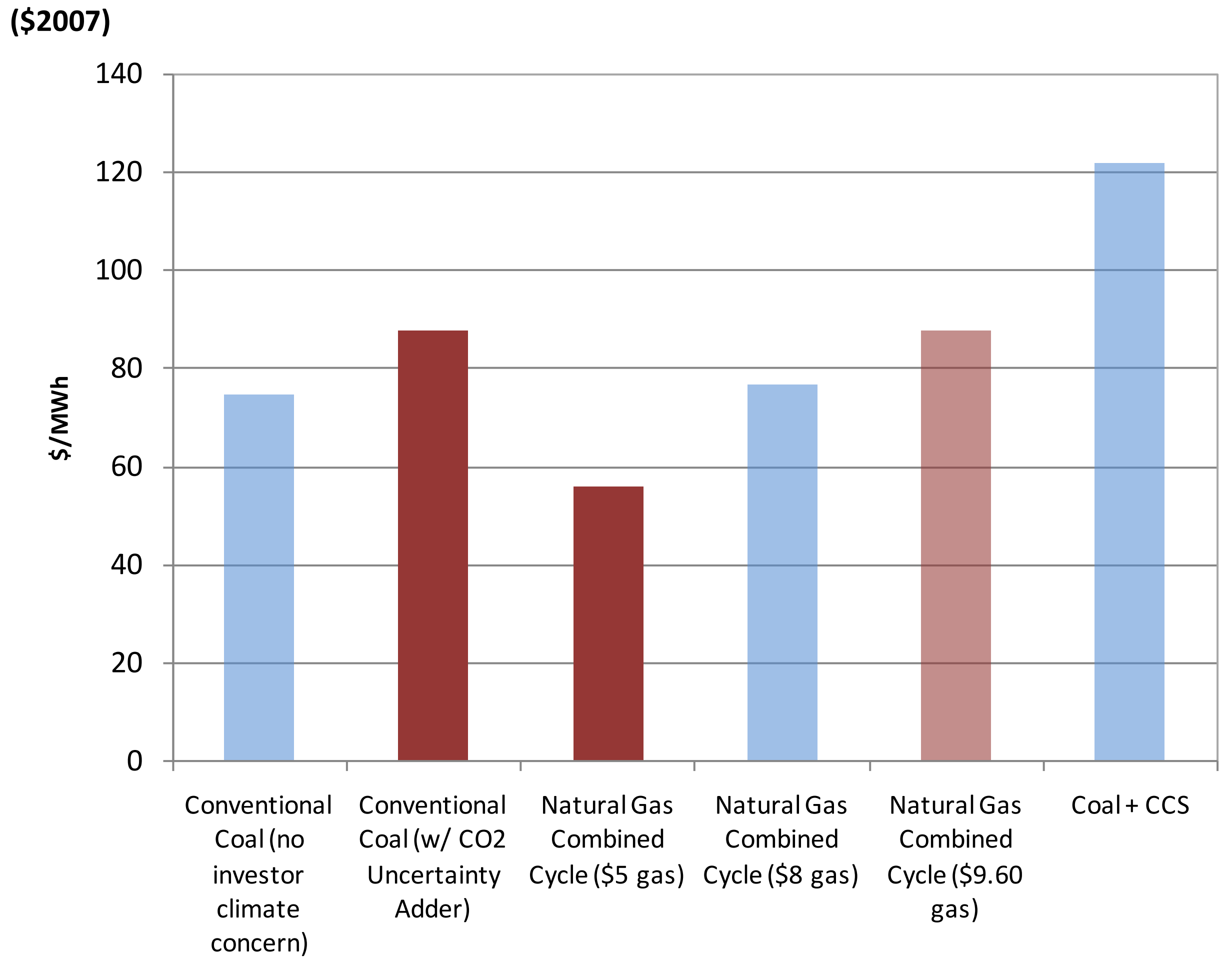

Figure 5-4. Illustrative Wholesale Levelized Cost of Electricity of Alternative New Generation Technologies, EPA[23]

Notes: Assumptions derived from EPA's application of IPM. Technologies include Coal without CCS, Natural Gas Combined Cycle with natural gas costing $5 per mmBtu, Natural Gas Combined Cycle with $8 per mmBtu costs of natural gas, and Integrated Gasification Combined Cycle with CCS (with 90 percent capture). In this graph coal is a high sulfur bituminous at $2 mmBtu. Conventional Coal is at a heat rate of 8,875 Btu/kWh net, capacity factor of 85 percent assumed across all technologies.

[23] Although EPA believes that this cost data is broadly representative of the economics between new coal and new natural gas facilities, this analysis assumes representative new units and does not reflect the full array of new generating sources that could potentially be built. To the extent that other types of new units that would be affected by this rule could be built, they could exhibit different costs than presented here. For example, smaller new conventional coal facilities which would be more expensive on a $/kw basis and have a relatively higher LCOE, and some technologies could potentially have a lower LCOE if fuel could be obtained cheaply and capital costs remained similar, or lower than, an new base load convention coal plant (petroleum coke or waste coal). These differences do not fundamentally change the analysis presented in this chapter.

It is only when gas prices reach approximately $9.60/mmBtu (in 2007 dollars), that new coal-fired generation without CCS becomes competitive, in terms of dollars per megawatt hour wholesale cost of electricity generation (none of the EPA or EIA sensitivities with alternate assumptions for natural gas approach this price level).

It is important to note that this analysis is based on assumptions regarding the average national cost of generation at new facilities. As reported by the EIA, there is expected to be significant spatial variation in the costs of new generation due to design differences, labor wage and productivity differences, location adjustments, among other potential differences.[24] EPA acknowledges that there is some uncertainty around these estimates, and is unable to provide estimates for all variants. However, the results are expected to hold for the majority of situations. The analysis also does not explicitly consider new units designed to combust waste coal or petroleum coke (pet coke), which may be affected by this rule, but also may exhibit different local economics.[25]

This rule also proposes an alternative compliance option that would allow new units to meet the 1,000 lbs CO_2/MWh standard using a 30 year averaging period.[26] To the extent market participants have alternative views of both the cost and development of CCS, new conventional coal-fired capacity (or IGCC) could be built and operated for some time, with the intention to apply CCS with high removal efficiency at some later date, in order to achieve the required average rate over the 30 year period. Also the above analysis reflects national averages, and given their specific situation, a market participant could determine that the economics of building a coal-powered facility that immediately achieves a CO_2 capture and/or removal rate consistent with the emission standard are favorable.

[24] http://www.eia.gov/oiaf/beck_plantcosts/pdf/updatedplantcosts.pdf

[25] This analysis also does not explicitly consider new units designed to combust waste coal or petroleum coke (pet coke), which may be affected by this rule, but can exhibit different economics. Most other energy models, including EIA's application of NEMS, do not consider these technologies for new electricity sources because they are marginal technologies that are rarely built, and highly dependent upon specific local factors that are difficult to model and highly speculative (like the ability to obtain a very inexpensive local supply of suitable fuel). The models do include these technologies as part of the existing universe of sources, however. For context, there are currently 59 units nationwide that are designed to combust either waste coal or petroleum coke, with a total capacity of roughly 5 GW (or 0.5% of the entire fleet). To the extent that these technologies would be built absent this rule due to unique local economics and fuel supply, there would be certain costs and benefits associated with this proposed rule, although they would be expected to be small because these sources are not often built. EPA is taking comment and solicits additional information on its consideration of these technologies in the analysis.

[26] IPM does not consider the impact of elevation on performance, and utilizes a uniform elevation performance-based assumption.

Table 5-4. Estimated Levelized Cost of New Generation Resources from EIA, U.S. Average (2016)

Plant Type	U.S. Average Levelized Costs (2009 $/ MWh) for Plants Entering Service in 2016					
	Capacity Factor (%)	Levelized Capital Cost	Fixed O&M	Variable O&M (Including fuel)	Transmission Investment	Total System Levelized Cost
Conventional Coal	85	65.3	3.9	24.5	1.2	94.8
Advanced Coal	85	74.6	7.9	25.7	1.2	109.4
Advanced Coal with CCS	85	92.7	9.2	33.1	1.2	136.5
Natural Gas-fired						
Conventional Combined Cycle	87	17.5	1.9	45.6	1.2	66.1
Advanced Combined Cycle	87	17.9	1.9	42.1	1.2	63.1
Advanced CC with CCS	87	34.6	3.9	49.6	1.2	89.1
Conventional Comb. Turbine	30	45.8	3.7	71.5	3.5	124.5
Advanced Combustion Turbine	30	31.6	5.5	62.9	3.5	103.5
Advanced Nuclear	90	90.1	11.1	11.7	1.0	113.9
Wind	34	83.9	9.6	0	3.5	97.0
Wind - Offshore	34	209.3	28.1	0	5.9	243.2
Solar PV	25	194.6	12.1	0	4.0	210.7
Solar Thermal	18	259.4	46.6	0	5.8	311.8
Geothermal	92	79.3	11.9	9.5	1.0	101.7
Biomass	83	55.3	13.7	42.3	1.3	112.5
Hydro	52	74.5	3.8	6.3	1.9	86.4

Source: EIA, AEO 2011

Others have researched the cost and efficiency of varying levels of capture relative to building other energy technologies.[27] This ongoing research indicates that lower levels of carbon capture at new coal facilities could be cost competitive, and the costs of meeting the proposed emission rate immediately could be achievable. For example, The Clean Air Task Force has compiled data that indicates the levelized cost of electricity for a new supercritical pulverized coal unit with 50 percent CCS (or 1,080 lb/MWh CO_2, which is just above the proposed standard) could be $116/MWh compared to $147/MWh for 90 percent removal. However, investment decisions will be made on a case by case basis dependent upon a number of factors, all of which are difficult to estimate in advance.

[27] Technical Options for Lowering Carbon Emissions from Power Plants. Clean Air Task Force (June, 2011). Available at: http://www.coaltransition.org/filebin/pdf/Technical_Options_for_Lowering_Carbon_Emissions_from_Power.pdf

5.6.2 Reconstructed Units

The EPA's CAA Section 111 regulations define reconstructed sources as, in general, existing sources (i) that replace components to such an extent that the capital costs of the new components exceed 50 percent of the capital costs of an entirely new facility, and (ii) for which compliance with standards of performance for new sources is technologically and economically feasible (40 CFR 60.15). The Agency is aware that, in theory, operators of existing power plants may choose to reconstruct them, but we are not aware of any announced plans to do so. This provision is rarely triggered. In light of this limited experience concerning reconstructions, the Agency lacks adequate information that is needed to propose a standard of performance for reconstructions. As a result, in today's action, the EPA is not including a proposal for reconstructions. Instead, we solicit comment on how we should approach reconstructions and, depending on the information we receive, we may propose and finalize a standard for reconstructions at a later time.

5.6.3 Modified and Transitional Units

Modified and transitional units are described in the preamble and in Chapter 2 of this RIA. EPA does not anticipate any costs being associated with these units.

5.7 Costs, Economic, and Energy Impacts of the Proposed Rule for New Electric Generating Units

Under a wide range of electricity market conditions – including EPA's baseline scenario as well as multiple sensitivity analyses – EPA projects that the industry will choose to construct new units that already meet these standards, regardless of this proposal. As a result, EPA anticipates that the proposed EGU GHG NSPS will result in negligible CO_2 emission changes, energy impacts, or costs for new units constructed by 2020. Likewise, the Agency does not anticipate any notable impacts on the price of electricity or energy supplies. Additionally, for the reasons described above, the proposed rule is not expected to raise any reliability concerns, since reserve margins will not be impacted and the rule does not impose any requirements on existing facilities.

5.8 Comparison of Emissions from Generation Technologies

As discussed earlier in this chapter, natural gas combined cycle units are on average expected to be more economical to build and operate than new coal units. These natural gas units also have lower emission profiles for CO_2 and criteria air pollutants than new coal units. While the proposed EGU GHG NSPS is anticipated to have negligible costs or quantified benefits under a range of likely market conditions, it is instructive to consider the differences in emissions of CO_2 and conventional air pollutants between the two types of units.

As Table 5-5 below shows, emissions from a typical new natural gas combined cycle facility are significantly lower than those from a traditional coal unit.[28] For example, a typical new supercritical pulverized coal facility that burns bituminous coal in compliance with new utility regulations (e.g., CSAPR and MATS) would have considerably greater CO_2, sulfur dioxide (SO_2), NO_x, toxic metals, acid gases, and particulate emissions than a comparable natural gas combined cycle facility. A typical natural gas combined cycle unit emits two million metric tons less CO_2 per year than a typical new conventional coal unit, as well as 930 fewer short tons SO_2 and 1,200 fewer short tons of NO_x each year. Importantly, these differences in emissions assume a new coal unit that complies with all applicable regulations, including MATS. Reductions in SO_2 emissions are a particularly significant driver for monetized health benefits, as SO_2 is a precursor to the formation of particulates in the atmosphere, and particulates are associated with premature death and other serious health effects. Further information on these pollutants' health effects is included in the next subsection.

[28] Estimated emissions of CO_2, SO_2, and NO_X for the illustrative new coal and natural gas combined cycle units could vary depending on a variety of assumptions including heat rate, fuel type, and emission controls, to name a few.

Table 5-5. Illustrative Emissions Profiles, New Coal and Natural Gas-Fired Generating Units[29]

	Conventional Coal		Natural Gas CC		Coal with CCS	
	Emissions (tons/year)	Emission Rate (lbs/MWh net)	Emissions (tons/year)	Emission Rate (lbs/MWh net)	Emissions (tons/year)	Emission Rate (lbs/MWh net)
SO_2	940	0.42	10	0.0041	50	0.022
NO_x	1,400	0.62	200	0.09	1,100	0.47
CO_2	3.6 million	1,800	1.7 million	820	0.4 million	200

Notes: SO_2 and NO_x in short tons, CO_2 in metric tons. As discussed in Section 5.4, the illustrative units represent relative emissions for new well controlled 600 MW (net) baseload units running at 85 percent capacity factor (85% capacity factor reflects operation of new baseload units and does not necessarily reflect the historic capacity factors of existing units with specifications similar to these illustrative units). Assumed coal is high sulfur bituminous with scrubber and SCR, data are based on EPA assumptions used in IPM.

5.9 Benefits of Reducing GHGs and Conventional Pollutants

Because emissions of CO_2 and criteria air pollutants adversely affect human health and welfare, the differences in emissions presented above translate into differences in the external social costs associated with different generation technologies. Here we provide a general discussion about the differences in emissions of CO_2 and criteria air pollutants in the previous illustrative example.

5.9.1 Social Cost of Carbon

The social cost of carbon (SCC) is a metric to estimate the monetary value of benefits associated with marginal changes in CO_2 emissions, and may therefore be utilized to understand the value of the difference in CO_2 emissions between the two representative units discussed in Section 5.8. The SCC is an estimate of the monetized damages associated with an incremental increase in carbon emissions in a given year. It is intended to include (but is not limited to) changes in net agricultural productivity, human health, property damages from increased flood risk, and the value of ecosystem services due to climate change. Federal agencies typically use SCC estimates to assess the benefits of rulemakings that achieve marginal reductions in CO_2 emissions. These estimates were developed through an interagency process that included EPA and other executive branch entities, and concluded in February 2010. The

[29] The emissions presented here are estimated on an output basis to enable easier comparisons and to illustrate the potential impacts of moving from new coal to new natural gas. This analysis assumes representative new units and does not reflect the full array of new generating sources that could potentially be built (e.g., a small new conventional coal plant or a waste coal or petroleum coke facility). However, the emissions associated with other facilities that could be built, and which would be subject to this proposal, would not change noticeably (i.e., these new facilities would be subject to emissions standards for other pollutants and would emit similar levels of SO_2, NO_X, and CO_2, on an output basis).

SCC Technical Support Document (SCC TSD) provides a complete discussion of the methods used to develop these SCC estimates.[30]

The interagency group selected four SCC values for use in regulatory analyses: $7, $26, $42, and $81 per metric ton of CO_2 emissions in 2020, in 2007 dollars.[31,32] The first three values are based on the average SCC from three integrated assessment models, at discount rates of 5, 3, and 2.5 percent, respectively. SCCs at several discount rates are included because the literature shows that the SCC is quite sensitive to assumptions about the discount rate, and because no consensus exists on the appropriate rate to use in an intergenerational context. The fourth value is the 95th percentile of the SCC from all three models at a 3 percent discount rate. It is included to represent higher-than-expected impacts from temperature change further out in the tails of the SCC distribution.

The SCC increases over time because future emissions are expected to produce larger incremental damages as physical and economic systems become more stressed in response to greater climatic change. Note that the interagency group estimated the growth rate of the SCC directly using the three integrated assessment models rather than assuming a constant annual growth rate. This helps to ensure that the estimates are internally consistent with other modeling assumptions. Table 5-6 presents the SCC estimates for the years 2015 to 2050. In order to calculate the dollar value for emission reductions, the SCC estimate for each emissions year would be applied to changes in CO_2 emissions for that year, and then discounted back to the analysis year using the same discount rate used to estimate the SCC.

When attempting to assess the incremental economic impacts of carbon dioxide emissions, the analyst faces a number of serious challenges. A recent report from the National Academies of Science (NRC 2009) points out that any assessment will suffer from uncertainty,

[30] Docket ID EPA-HQ-OAR-2009-0472-114577, *Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866, Interagency Working Group on Social Cost of Carbon*, with participation by Council of Economic Advisers, Council on Environmental Quality, Department of Agriculture, Department of Commerce, Department of Energy, Department of Transportation, Environmental Protection Agency, National Economic Council, Office of Energy and Climate Change, Office of Management and Budget, Office of Science and Technology Policy, and Department of Treasury (February 2010). Also available at http://epa.gov/otaq/climate/regulations.htm

[31] Note that upstream emissions changes were not considered for this rule. There may be changes in greenhouse gas emissions (in particular, methane) due to changes in fossil fuel extraction and transport in response to this proposal, but those were not quantified.

[32] The interagency group concluded that a global measure of the benefits from reducing U.S. GHG emissions should be the standard practice when conducting regulatory impact analysis in support of federal rule makings. See Interagency Working Group on Social Cost of Carbon. 2010. Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866.

speculation, and lack of information about (1) future emissions of greenhouse gases, (2) the effects of past and future emissions on the climate system, (3) the impact of changes in climate on the physical and biological environment, and (4) the translation of these environmental impacts into economic damages.[33] As a result, any effort to quantify and monetize the harms associated with climate change will raise serious questions of science, economics, and ethics and should be viewed as provisional.

The interagency group noted a number of limitations to the SCC analysis, including the incomplete way in which the integrated assessment models capture catastrophic and non-catastrophic impacts, their incomplete treatment of adaptation and technological change, uncertainty in the extrapolation of damages to high temperatures, and assumptions regarding risk aversion. Current integrated assessment models do not assign value to all of the important physical, ecological, and economic impacts of climate change recognized in the climate change literature because of lack of precise information on the nature of damages and because the science incorporated into these models understandably lags behind the most recent research. The limited amount of research linking climate impacts to economic damages makes the interagency modeling exercise even more difficult. The interagency group hopes that over time researchers and modelers will work to fill these gaps and that the SCC estimates used for regulatory analysis by the Federal government will continue to evolve with improvements in modeling. It is important to emphasize that the interagency process is committed to updating these estimates as the science and economic understanding of climate change and its impacts on society improves over time. Specifically, they have set a preliminary goal of revisiting the SCC values within two years, or at such time as substantially updated models become available, and to continue to support research in this area. Additional details on these limitations are discussed in the SCC TSD.

[33] National Research Council (2009). *Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use*. National Academies Press. See docket ID EPA-HQ-OAR-2009-0472-11486.

Table 5-6. Social Cost of CO_2, 2015-2050[a] (in 2007 dollars)

Year	Discount Rate and Statistic			
	5% Average	3% Average	2.5% Average	3% 95th percentile
2015	$6	$24	$38	$73
2020	$7	$26	$42	$81
2025	$8	$30	$46	$90
2030	$10	$33	$50	$100
2035	$11	$36	$54	$110
2040	$13	$39	$58	$119
2045	$14	$42	$62	$128
2050	$16	$45	$65	$136

[a] The SCC values vary depending on the year of CO_2 emissions and are defined in real terms.

5.9.2 Health Impacts of SO_2 and NO_x

SO_2 is a precursor for fine particulate matter ($PM_{2.5}$) formation. NO_X is a precursor for $PM_{2.5}$ and ozone formation. As such, reductions of SO_2 and NO_X would in turn lower overall ambient concentrations of these pollutants as well as $PM_{2.5}$ and ozone. Reducing exposure to $PM_{2.5}$ and ozone is associated with significant human health benefits, including avoided mortality and morbidity. Researchers have associated $PM_{2.5}$ and ozone exposure with adverse health effects in numerous toxicological, clinical, and epidemiological studies (U.S. EPA, 2009; U.S. EPA, 2006). Health effects associated with exposure to $PM_{2.5}$ include premature mortality for adults and infants, cardiovascular morbidity such as heart attacks and hospital admissions, and respiratory morbidity such as asthma attacks, bronchitis, hospital and emergency room visits, work loss days, restricted activity days, and respiratory symptoms. Health effects associated with exposure to ozone include premature mortality and respiratory morbidity such as asthma attacks, hospital and emergency room visits, and school loss days. For a full discussion of the human health benefits of reducing SO_2 and NO_X emissions from power sector sources, including reducing methyl mercury, SO_2, and NO_2 exposure, please refer to the RIA for CSAPR (U.S. EPA, 2011).

In addition to human health benefits, reducing SO_2 and NO_X emissions would also result in human welfare improvements by improving ecosystem services—the benefits that the public obtains from ecosystems that directly or indirectly contribute to social welfare. SO_2 and NO_X emissions can adversely impact vegetation, certain manmade materials, acidic deposition, nutrient enrichment, visibility, and climate (U.S. EPA, 2009; U.S. EPA, 2008). Reducing these harmful emissions improves human welfare. For more information about the welfare benefits of SO_2 and NO_X emission reductions from power sector sources, please refer to the Regulatory Impact Analysis for the CSAPR (U.S. EPA, 2011).

Because the health and welfare benefits of SO_2 and NO_x emissions in terms of incidences of health effects avoided or monetized value of health or welfare improvements depend on power plant location, the potential benefits cannot be quantified precisely for the purposes of this illustrative example. However, reducing one thousand tons of annual SO_2 from U.S. EGUs in 2020 has been estimated[34] to yield between 3 and 9 incidences of premature mortality avoided annually and annual monetized $PM_{2.5}$-related health benefits (including these incidences of premature mortality avoided) between $30 million and $75 million (2007$) using a 3% discount rate or between $28 million and $67 million (2007$) using a 7% discount rate (where the range is due to EPA's use of two alternative primary estimates of $PM_{2.5}$ mortality impacts, a lower primary estimate based on Pope et al. (2002) and a higher primary estimate based on Laden et al. (2006)). Additionally, reducing one thousand tons of annual NO_X from U.S. EGUs in 2020 has been estimated[35] to yield up to 1 incidence of premature mortality avoided annually and annual monetized $PM_{2.5}$-related health benefits (including these incidences of

[34] The SO_2 and NO_X benefit per-ton (BPT) values presented here consist of only $PM_{2.5}$-related health benefits from reductions in SO_2 and NO_X (precursors to $PM_{2.5}$ formation). EPA relied on air quality modeling used to develop a previous rulemaking affecting power sector emissions of SO_2 and NO_X to develop these BPT values (Air Quality Modeling Technical Support Document for the final Transport Rule; http://epa.gov/airtransport/pdfs/AQModeling.pdf). EPA utilized Transport Rule (Cross-State Air Pollution Rule) modeling rather than air quality modeling of EPA's Mercury and Air Toxics Standards (MATS) because EPA did not estimate NO_X BPT values for MATS and because the utilized Transport Rule modeling reduced emissions of SO_2 and NO_X independently, allowing for better estimation of $PM_{2.5}$-related SO_2 and NO_X BPT values. The air quality modeling utilized reflects emission reductions in the eastern U.S. In order to better understand the relative difference between BPT values for emission reductions in the east and west, see Table 5C-3 of the MATS Regulatory Impact Analysis (RIA) <www.epa.gov/ttn/ecas/regdata/RIAs/matsriafinal.pdf>. Using this existing air quality modeling, EPA used BenMAP (www.epa.gov/air/benmap) to estimate the benefits of air quality improvements using projected 2020 population, baseline incidence rates, and economic factors. These BPT values are methodologically consistent with those reported in Fann et al. (2009). As EPA models avoided premature deaths among populations exposed to levels of PM2.5, we have lower confidence in levels below the lowest measured level (LML) for each study. However, studies using data from more recent years, during which time $PM_{2.5}$ concentrations have fallen, continue to report strong associations with mortality. For more information refer to the MATS RIA. The average BPT values reflect a specific geographic distribution of SO_2 and NO_X reductions resulting in a specific reduction in $PM_{2.5}$ exposure and may not fully reflect local or regional variability in population density, meteorology, exposure, baseline health incidence rates, or other factors that might lead to an over-estimate or under-estimate of the actual benefits associated with $PM_{2.5}$ precursors. These BPT values are purely illustrative as EPA does not assert a specific location for the illustrative coal and natural gas combined cycle units and is therefore unable to specifically determine the population that would be affected by their emissions. Therefore, the benefits for any specific unit can be very different than the estimates shown here. EPA notes that the BPT estimates do not reflect emission reductions after implementation of EPA's Mercury and Air Toxics Standards.

[35] Ibid.

premature mortality avoided) of between $2.5 million and $6.2 million (2007$) using a 3% discount rate or between $2.3 million and $5.6 million (2007$) using a 7% discount rate.

5.10 Illustrative Analysis of the Social Costs of New Generating Sources

As the analysis in sections 5.5 and 5.6 demonstrated, under a wide range of likely electricity market conditions – including EPA's baseline scenario as well as multiple sensitivity analyses – EPA projects that the industry will choose to construct new units that already meet these standards, regardless of this proposal.

In this section, we consider the unlikely scenario where future market conditions support the construction of new conventional (advanced, but without CCS) coal capacity during the analysis period in the absence of the rule. The analysis in this section indicates that in this scenario, the proposed EGU GHG NSPS is highly likely to provide net benefits to society as a whole.

The starting point for this analysis is the illustrative comparison (presented in Figure 5-4 above) of the relative private costs of constructing and operating a representative new conventional coal EGU and a representative NGCC unit.[36] This comparison shows that, at forecast relative fuel prices, there is a significant difference in the levelized cost of these two generating technologies. However, in the context of a social welfare analysis, the appropriate comparison between multiple options is on the basis of benefits and costs to society *as a whole*, and not solely the private cost to an investor.

From the perspective of society, the appropriate cost comparison for new generation capacity should account for the pollution damages associated with the competing generation technologies in addition to private generating costs. This section further explores how the potential social benefits and costs of this NSPS standard may change across a wide range of natural gas prices, a key factor in the potential cost of the policy. It begins by estimating illustrative environmental damages per MWh for coal relative to gas generation and then uses

[36] By fixing generation in this comparison, we are assuming that both technologies generate the same benefits in the form of electricity generating services. We assume in the discussion that the benefit of electricity production to consumers outweighs the private and social investment cost. However, at particularly high fuel prices this might not be the case. For a discussion of when comparing the levelized costs of different generating technologies provides informative results and when it does not see, for example, Joskow 2010 and 2011.

these estimates to conduct an illustrative sensitivity analysis for the potential social costs of the policy in this illustrative example.[37]

It should be emphasized that the analysis presented here is illustrative, although EPA believes that it leads to a robust conclusion. From an analytical perspective, the challenge is to estimate expected benefits and costs given uncertainty about future market conditions. An ideal benefit-cost analysis would first model projected generation capacity and capacity additions for every plausible set of market conditions (e.g., different combinations of natural gas and coal supplies and electricity demand). The effects of the proposed EGU GHG NSPS could then be estimated in each of those scenarios including the resulting estimated benefits and costs (which would depend on the amount of new generation capacity built, the technologies used, the location of new generating plants, and so on). The analysis would then estimate the conditional probability distribution of those outcomes (for example, the probability distribution of future natural gas prices or future electricity demand conditional on the current information on supply). Finally, the analysis would integrate the estimated benefits and costs over the conditional probability distribution of outcomes, to arrive at the expected net benefits of the rule.

The analysis just described is beyond the scope of the current RIA, and EPA believes that the sensitivity cases presented in section 5.6.1, combined with the illustrative analysis here, provide a robust picture of the likely costs and benefits of the standard. Nonetheless, EPA is inviting comment on whether a more detailed analysis would be practical, feasible, and an effective use of limited analytical resources, and if so, how it might be carried out and what information it would be expected to provide. If commenters believe that such an analysis would be practical and appropriate, EPA invites comment on what variables should be treated as uncertain (e.g., natural gas and coal prices, electricity demand) and on the specific conditional and potentially joint probability distributions that should be used for the future state of those variables.

In the spirit of the "ideal" analysis just described, in the remainder of this section EPA provides an illustrative analysis focusing on uncertainty in the price of natural gas, which is a key determinant of the economics of electricity generation and therefore the potential impacts of this proposed rule.

[37] From an economic perspective, the analysis in sections 5.5 and 5.6 considered the net benefits of the rule under expected market conditions, and found those to be zero (because the rule would not affect what new capacity is built under those market conditions). The analysis in this section, while still purely illustrative, is an initial step toward estimating the expected net benefits of the rule as a function of market conditions.

5.10.1 Illustrative Environmental Damages per MWh

As previously discussed in this chapter, the damages associated with emissions from new sources of electricity generation are greater for coal-fired units than for natural gas combined cycle units (even when accounting for compliance with EPA's recent Mercury and Air Toxics Standard). To gauge the general effect of accounting for both the private and external costs of electricity generation for new generation options we continue with the illustrative example from Section 5.8. The external costs are defined as the damages associated with pollution that are not accounted for in the private investor's decision making.[38]

To illustrate the external costs associated with new generation options we combine the illustrative emission profiles for the new units, as provided in Table 5-5, and the illustrative emissions and damage estimates discussed in the previous two sections.[39] Specifically, for each generating technology we multiply the CO_2 emissions by the estimates of the SCC and add that to the SO_2 emissions[40] multiplied by the $PM_{2.5}$-related SO_2 benefit per-ton estimates,[41] subsequently dividing by MWh to estimate the external costs per unit of generation.

Table 5-7 reports the additional pollution damages from the illustrative new coal plant relative to the illustrative new natural gas plant given different mortality risk studies and assumptions about the discount rate. These pollution damages should be relatively invariant across natural gas prices and other economic factors. Depending on the discount rate and mortality risk study used, damages associated with generation from a representative new coal unit are $11 to $81 per MWh, while damages associated with the illustrative new natural gas combined cycle unit are $3 to $31 per MWh (2007$).[42]

It is important to note that although the ranges appear to overlap, for any set of assumptions (i.e., any specific mortality risk study and choice of SCC value) estimate the

[38] See Baumol and Oates, 1988.

[39] Only the direct emissions of two pollutants (CO_2 andSO_2) are considered in this illustrative exercise. Other pollutants and lifecycle emissions are not considered.

[40] See footnote 32 in section 5.8.

[41] See footnote 34 in section 5.9.2 for a description of the benefit-per-ton values. In this exercise they are interpreted as damage-per-ton values.

[42] Different discount rates are applied to SCC than to the other damage estimates because CO_2 emissions are long-lived and subsequent damages occur over many years. Moreover, several rates are applied to SCC because the literature shows that it is sensitive to assumptions about discount rate and because no consensus exists on the appropriate rate to use in an intergenerational context. The SCC interagency group centered its attention on the 3 percent discount rate but emphasized the importance of considering all four SCC estimates. See the "SCC TSD," Interagency Working Group on Social Cost of Carbon (IWGSC). 2010. Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866. Docket ID EPA-HQ-OAR-2009-0472-114577. http://www.epa.gov/otaq/climate/regulations/scc-tsd.pdf for details.

pollution damages associated with new coal generation are significantly higher than those associated with new natural gas combined cycle generation in this illustrative, but representative example. For example, considering the SO_2 per ton damages based on Pope et al. 2002 using a 7% discount rate and the SCC estimate based on the 3% discount rate, new generation based on conventional coal in this example would result in an additional $17 per MWh in pollution damages compared to a new NGCC plant. Alternately, damages that reflect the SO_2 per ton damage estimate based on Laden et al. 2006 using a 3% discount rate and the SCC estimate based on a 2.5% discount rate suggest an additional $33 of pollution damages per MWh from a new conventional coal unit compared to a new NGCC plant.

As with the relative investment costs of a new coal unit and a new natural gas combined cycle system, the actual environmental damages associated with these two technologies depends on the location under consideration and the specific fuels that would be used. An ideal benefit-cost analysis would account for these local circumstances (and consider alternative sources of generation).[43] However, these factors will not change the qualitative conclusion. The damages associated with CO_2 emissions, which are the focus of this rule, do not depend on the location of generation. Furthermore, the damages associated with sulfur dioxide emissions from a new very well-controlled coal-fired unit firing low-sulfur coal would still be greater than the damages from a new natural gas combined cycle unit independent of the location.

[43] EPA does not assert a specific location for the illustrative coal and natural gas combined cycle units and is therefore unable to specifically determine the population that would be affected by their SO_2 emissions. Therefore, the benefits for any specific unit can be very different than the estimates shown here.

Table 5-7. Pollution Damages ($/MWh) from Illustrative New Coal Unit *Relative to* New Natural Gas Combined Cycle Unit[44]

SCC Discount Rate	Damages from CO_2
5%	$3
3%	$11
2.5%	$18
3% (95th percentile)	$34

Mortality-Risk Study	Damages from SO_2 Only Discount Rate Applied to Health Co-Benefits 3% Discount Rate	7% Discount Rate
Pope (2002)	$6	$6
Laden (2006)	$16	$14

SCC Discount Rate	Combined Damages from CO_2 and SO_2 Discount Rate Applied to Health Co-Benefits 3% Discount Rate	7% Discount Rate
5%	$9 - $19	$9 - $17
3%	$17 - $27	$17 - $25
2.5%	$24 - $33	$24 - $32
3% (95th percentile)	$41 - $50	$40 - $48

Notes: Values in first two tables may not sum due to rounding.
The range of costs within each SCC value and discount rate for SO_2 pollution damages pairing reflects the use of two core estimates of $PM_{2.5}$-related premature mortality, Pope et al. (2002) representing the lower of our core estimates and Laden et al. (2006) represent the higher of our core estimates. Assumed coal is high sulfur bituminous with scrubber and SCR. The combinations of health studies and discount rates represent lower and higher valuations of impacts of SO_2 emissions in the Eastern U.S. EPA has evaluated the range of potential impacts per MWh by combining all SCC values with health damages values at the 3 percent and 7 percent discount rates. To be consistent with concepts of intergenerational discounting, values for health damages, which occur within a generation, would only be combined with SCC values using a lower discount rate, e.g. the 7 percent health damages estimates would be combined with 5 percent or lower SCC values, but the 3 percent health damages would not be combined with the 5 percent SCC value. While the 5 percent SCC and 3 percent health damages estimate falls within the range of values we analyze, this individual estimate should not be used independently in an analysis, as it is represents a combination of discount rates that is unlikely to occur. Combining the 3 percent SCC values with the 3 percent health damage values assumes that there is no difference in discount rates between intragenerational and intergenerational impacts.

[44] The damages presented here are estimated on an output basis to enable easier comparisons and to illustrate the potential impacts of moving from new coal to new natural gas. This analysis assumes representative new units and does not reflect the full array of new generating sources that could potentially be built (e.g., a comparison of a small new conventional coal plant with a small natural gas plant, or a comparison of a waste coal or petroleum coke facility to a natural gas plant of a comparable size and capacity factor). However, the damages associated with other facilities that could be built, and which would be subject to this proposal, would not change noticeably (i.e., these new facilities would be subject to emissions standards for other pollutants and would emit similar levels of SO_2 and CO_2, on an output basis) except for differences in local conditions, as discussed below.

The conclusion from this analysis is that there are significant environmental damages associated with electricity generation from a representative new conventional coal unit relative to a representative new natural gas combined cycle unit.[45] Other studies of the social costs of coal and natural gas fired generation provide similar findings (Muller et. al, 2011; NRC, 2009).[46] An important implication is that if market conditions changed sufficiently so that new coal units became marginally more profitable to operate, these new units are still likely to impose a net cost to society relative to a new natural gas plant. This idea is discussed in more detail in the next section.[47]

5.10.2 Social Benefits and Costs across a Range of Gas Prices - Sensitivity Analysis

We now discuss how a consideration of the environmental damages associated with new coal and natural gas EGUs informs the comparison of the two technologies from the standpoint of net benefits – building on the illustrative comparison of a representative new coal unit and a representative natural gas unit developed in Sections 5.8 and 5.9

At current natural gas prices relative to other fuels, the difference in the estimated levelized cost of electricity for a representative NGCC unit is roughly $27 per MWh less than for a representative new conventional coal unit (see Figure 5-4). This is consistent with EPA's projection, discussed at length above, that the proposed EGU GHG NSPS will not impose any social costs (or generate quantified net benefits) under current and likely future market conditions.

Because the impacts of this proposed rule depend on future natural gas prices, which are uncertain, EPA conducted an illustrative analysis of the impacts of the rule over a wide range of natural gas prices. This analysis considers two distinct thresholds in the price of natural

[45] As previously noted in this section and the previous sections on the costs and damages associated with these technologies, EPA does not assert a specific location for the illustrative coal and natural gas combined cycle units and is therefore unable to specifically determine the population that would be affected by their SO_2 emissions. Therefore, the benefits for any specific unit can be very different than the estimates shown here, though the proportion associated with CO_2, which is a well dispersed global pollutant, will not be affected by location.

[46] Muller et al. 2011 conclude that, "coal-fired power plants have air pollution damages larger than their value added", while the same is not true for natural gas plants (see Table 5). However, these comparisons are based on typical existing coal and natural gas units, including natural gas boilers, and are not sensitive to location. The NRC 2009 study shows that only the most polluting natural gas units may cause greater damages than even the least polluting existing coal plants (compare Tables 2-9 and 2-15). However, the NAS comparison does not compare new units located in the same place, and so some of the natural gas units with the greatest damages may be attributable to their location, and includes natural gas steam boilers, which have a higher emission rates per unit of generation than natural gas combined cycle units.

[47] The presence of net benefits for a given regulatory option is a necessary but not a sufficient condition for optimal regulatory design. It does however; signify that the regulatory option is welfare improving for society.

gas at present: one price at which the private cost of a representative new coal unit falls below that of a representative NGCC unit, but the generation cost advantage remains outweighed by the environmental damages from the perspective of society as a whole; and an even higher price at which the environmental damages no longer outweigh the private cost advantage. This analysis presents three relevant ranges within the conditional distribution of future natural gas prices that can be classified as a range of likely gas prices, unexpectedly high natural gas prices, and unprecedented natural gas prices. It is important to note that this illustrative analysis considers variation in the natural gas price holding all else constant; as discussed above, an ideal analysis would vary other conditions simultaneously.[48] In general, this analysis shows that the policy would likely have a net benefit even under scenarios with much higher gas prices. Under some conditions, higher natural gas prices result in a net cost, holding all other parameters constant and disregarding benefits that we are unable to monetize.[49] However, it is important to note that this analysis is limited in the types of social benefits and costs considered, given that it does address the life-cycle pollution associated with fossil fuels along with the limitations of current SCC estimates, as previously discussed.

Likely Natural Gas Prices. As described earlier in this chapter, the base case modeling that EPA performed for this rule (as well as base case modeling that EPA has performed for other recent air rules) indicates that new fossil fuel-fired generating capacity projected to be built through 2020 will be either natural gas-fired combined cycle generation or coal-fired generation with CCS (the latter is assumed to be built with support from federal grants). This conclusion also holds for the high-demand and low-shale-gas sensitivity analyses considered above. As shown earlier in the illustrative analysis, it is only when gas prices reach approximately $9.60/mmBtu, that new conventional coal-fired generation becomes competitive with NGCC in terms of the levelized cost of electricity (in dollars per megawatt hour).

Projections of future market conditions suggest that it is likely that natural gas prices will remain below this level. As noted earlier in this chapter, EIA's projected natural gas price for 2020 in its reference scenario for AEO 2011 is $5.30 (in 2007 dollars). Even EIA's most pessimistic gas sensitivity case ("low shale gas recovery per well") only projects an electricity sector gas price of $7.01/mmBtu (in 2007 dollars) in 2020 (the "low shale gas recovery per play" scenario projects a price of $6.13/mmBtu (in 2007 dollars) in 2020). In other words, even under

[48] For example, high economic growth would raise both natural gas and coal prices at the same time – extending the range of natural gas prices for which NGCC retained a cost advantage.

[49] In reality this is unlikely to be the case. For example, high economic growth would increase both natural gas and coal prices at the same time - making it harder to alter the underlying cost advantage of NGCC generation.

pessimistic natural gas sensitivity cases, NGCC is likely to remain the economic choice for generation over the next two decades even in the absence of this standard. In this scenario, it appears very likely that the costs – and benefits – of the proposed standard will be zero.

Unexpectedly High Natural Gas Prices. In this illustrative analysis, at natural gas prices above approximately $9.60/mmBtu, the private levelized cost of electricity for a representative new conventional coal unit falls below that of a new NGCC unit. Therefore, above that price level some new conventional coal units might be constructed in the absence of the standard, provided there is sufficient demand and new coal without CCS is competitive with other generating technologies.[50] However, these coal units would also impose additional environmental and health damages in the form of global warming pollution and particulate matter (as a result of SO_2 and NO_x emissions) – an element of social costs that are avoided by building an NGCC unit instead.

For a range of natural gas prices above $9.60/mmBtu, the resulting external costs will outweigh the difference in the private costs in this illustrative example – indicating that the proposed standard would yield net benefits. For example, at gas prices of $10/MMBtu, the illustrative conventional coal unit would generate power for $3/MWh less than an NGCC unit,[51] but result in greater pollution damages of $9 to$50/MWh (see table 5-7).[52] Under the proposed standard, if in this example the NGCC unit were built instead, the resulting net social benefit would be $6 to $47/MWh.

For context, we note that these circumstances are far less likely than the zero cost scenario outlined above. To put this gas price point into historical context, $9.60/MMBtu is higher than any average annual gas price (in 2007 dollars) observed over the last 10 years, and it has only been reached temporarily in 8 of the last 120 months.[53,54] Looking forward, the

[50] See section 5.4 for a discussion of how local conditions and other factors influencing the levelized cost comparison may influence the natural gas price where the levelized cost of the conventional coal unit and the NGCC unit are the same.

[51] Assuming an increase of $6.80/MWh in the cost of gas generation for every $1/MMBtu increase in natural gas prices.

[52] Again, assuming that coal prices do not increase along with natural gas prices as they historically have. See previous footnote.

[53] See: http://www.eia.gov/dnav/ng/hist/n3045us3A.htm. EIA reports average annual delivered natural gas prices to the electricity sector for the past 15 years (since 1996) and reports average monthly delivered natural gas prices to the electricity sector over the past 10 years (since 2001).

[54] It is important to note that relatively high gases prices in a single month or year will not drive the investment decision in the technology employed for new generating units. Instead that decision will be motivated by expectations of relative fuel prices over the lifetime of the unit. Therefore given the historical path of natural gas prices and the forecasts for the future, it is highly unlikely that expectations of sustained high natural gas prices, to the degree necessary to drive technology choices, will be realized.

continued development of unconventional natural gas resources in the U.S. suggests that gas prices would actually tend to be towards the lower end of the historical range. As discussed above, none of the EIA sensitivity cases (which represent future price trajectories for both gas and coal) show scenarios where non-compliant coal becomes more economic than NGCC before 2020.

Unprecedented Natural Gas Prices. At extremely high natural gas prices, the private generating costs of non-compliant coal would be sufficiently lower than the cost of new natural gas that the net social benefit of the standard could be negative (i.e., a net cost) under some assumptions for environmental damages. For example, at gas prices of $15/MMBtu, the illustrative conventional coal unit would generate power for roughly $37/MWh less than an NGCC unit but result in social costs of $9 to $50/MWh (see table 5-7). Under the proposed standard, if an NGCC unit were built instead, the resulting net social impact would range from a net cost of $28 to a net benefit of $13/MWh. The point at which this standard would result in net social costs depends heavily upon the value for damages from GHGs and SO_2. For example, assuming an SCC using a 3% discount rate, along with a 7% discount rate for estimating benefits from reduced SO_2 and the mortality-risk estimate from Pope (2002), natural gas prices above $12/mmBtu in this illustrative example would result in net social costs from the proposed standard. Alternatively, using an SCC value of 3% and using the mortality-risk estimate from Laden (2006) along with a 3% discount rate for PM benefits, the corresponding threshold for natural gas prices would be $14/mmBtu. Natural gas prices above these levels would be unprecedented. Average annual natural gas prices delivered to the electricity sector have not exceeded $9.47 /mmBtu (in 2007 dollars) over the last 15 years, and projected prices do not begin to approach this level in any of EIA's scenarios.[55,56] As a result, based on historical gas prices as well as projections, EPA believes that there is an extremely small probability that natural gas prices will reach (let alone remain at) levels at which this standard would generate net social costs.

We emphasize that differences in generating costs, plant design, local factors, and the relative differences between fuels costs can all have major impacts on the precise circumstances under which this standard would be projected to have no costs, net benefits or

[55] http://www.eia.gov/dnav/ng/ng_pri_sum_dcu_nus_a.htm. EIA reports average annual delivered natural gas prices to the electricity sector for the past 15 years (since 1996) and reports average monthly delivered natural gas prices to the electricity sector over the past 10 years (since 2001).

[56] Note that while EIA forecasts natural gas prices to rise, it also forecasts coal price to rise as well. An ideal comparison of levelized costs in future time periods should account for the expected change in both natural gas and coal prices.

net costs. However, based on average annual gas prices over the last 15 years, we project that this standard is most likely to have negligible costs, and, if it does impose costs, it likely also produces positive, although modest, net benefits. There is an exceedingly low probability that it results in net costs.

5.10.3 Illustrative Costs and Benefits of CCS Compared with Conventional Coal

The analysis above focuses on two well developed control technologies, conventional supercritical coal and natural gas combined cycle. Because these technologies are well developed, there is significantly more certainty about operating costs than for new, emerging technologies like coal with CCS. As a result, any analysis that examines the relative social costs of coal vs. coal with CCS is considerably more uncertain and should primarily be used as a guide to the key sensitivities in the relative social costs. EPA compared the costs and damages for a model pulverized coal (PC) EGU using supercritical steam conditions (like the one used in the comparisons above) to and IGCC plant with a CCS system (e.g. Selexol). See technical memo "Control Cost and Environmental Impacts of the Proposed GHG NSPS on new Coal-Fired Electric Utility Generating Units" for more details.

EPA analyzed the cost and emission impacts for two scenarios. In the first scenario, partial capture achieves the proposed emissions rate of 1,000 lb CO_2/MWh gross output. This requires that approximately 39% of the CO_2 is captured and stored. EPA has not previously developed costs for such a unit, therefore, this analysis may not fully realize all of the cost savings possible from building a unit with significantly less than 90% capture (for instance, an IGCC could be built with a conventional gas turbine, rather than one designed for higher temperature characteristics of a higher hydrogen content fuel). A 90% capture system was also examined to analyze the cost of several proposed new coal-fired EGUs using CCS. In the near term, any new coal-fired EGU with CCS would most likely be located in areas amenable to using the captured CO_2 in enhanced oil recovery (EOR) operations. This is because EOR provides a revenue stream that is not available for other forms of geologic storage. For example, the Texas Clean Energy project[57] is planning to capture 90% of the CO_2 and sell it for enhanced oil recovery.

To evaluate the potential revenues from EOR we examined two options. We considered a case where CO_2 could be sold for \$45/ton based on recent DOE studies for the 90% capture case.[58] We also considered a lower revenue sensitivity where CO_2 could be sold for \$15/ton

[57] http://www.texascleanenergyproject.com/

[58] US DOE / NETL studies have assumed a delivered CO_2 price ranging from \$40 - \$45/tonne. "Improving Domestic Energy Security and Lowering CO_2 Emissions with "Next Generation" CO_2-Enhanced Oil Recovery (CO_2-EOR)",

(equivalent to the cost assumed for the transport and storage of CO_2 in the analysis) for the partial capture case. Costs for the IGCC unit with 90% capture and the supercritical pulverized coal-fired (SPC) unit without CCS were derived from IPM version 4.10.[59] These cost estimates are generally consistent with the range of studies estimating the cost of CCS that are available, however there is uncertainty around any such projections of technology costs, particularly for early movers of this technology. Capital costs for the IGCC unit with 39% capture were assumed to be 90% of the capital costs for an IGCC unit with 90% CCS. EPA estimated the benefits associated with avoided CO_2 and SO_2 emissions in a similar fashion to the one described above. See technical memo "Control Cost and Environmental Impacts of the Proposed GHG NSPS on new Coal-Fired Electric Utility Generating Units" for more details.

Table 5-8. Illustrative Costs and Benefits for two CCS Scenarios Compared to Conventional Coal Plant (per MWh 2007$)

	SPC to IGCC with 39% Capture	SPC to IGCC with 90% Capture
Additional Gross Annual Private Costs	$17	$34
Revenue from EOR	$5 (@$15/ton)	$37(@$45/ton)
Net Additional Annual Private Costs	$12	($3)
Value of Monetized Benefits		
SCC 3% with Pope 7%	$13	$24
SCC 3% with Laden 3%	$23	$34
Net Monetized Benefits		
SCC 3% with Pope 7%	$1	$27
SCC 3% with Laden 3%	$11	$37

This analysis suggests that the relative social cost of CCS compared to conventional coal is sensitive to the achieved generating costs for CCS units, the revenue stream from EOR, and the monetary value of avoided climate and other air pollution damages. However, it also suggests that, at relatively low prices for EOR revenue ($15/MWh), CCS generation can generate net social benefits compared to conventional coal generation. As before, it is important to note that these comparisons omit additional benefits that may be associated with the abatement of greenhouse gas emissions.

DOE/NETL-2011/1504 (June 2011); and "Storing CO_2 with Enhanced Oil Recovery, DOE/NETL-402/1312 (February 2008).

[59] http://www.epa.gov/airmarkets/progsregs/epa-ipm/BaseCasev410.html

5.11 Macroeconomic and Employment Impacts

This proposed EGU GHG NSPS is not anticipated to change GHG emissions for newly constructed electric generating units, and is anticipated to impose negligible costs or quantified benefits. EPA typically presents the economic impacts to secondary markets (e.g., changes in industrial markets resulting from changes in electricity prices) and impacts to employment or labor markets associated with proposed rules based on the estimated compliance costs and other energy impacts, which serve as an input to such analyses. However, since the EPA does not forecast a change in behavior relative to the baseline in response to this proposed rule, there are no notable macroeconomic or employment impacts expected as a result of this proposed rule.

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EXHIBIT 23

United States Environmental Protection Agency

Regulatory Impact Analysis for the Proposed Standards of Performance for Greenhouse Gas Emissions for New Stationary Sources: Electric Utility Generating Units

EPA-452/R-13-003
September 2013

Regulatory Impact Analysis for the Proposed Standards of Performance for Greenhouse Gas Emissions for New Stationary Sources: Electric Utility Generating Units

U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Health and Environmental Impacts Division
Research Triangle Park, NC

EXECUTIVE SUMMARY

This Regulatory Impact Analysis (RIA) discusses potential benefits, costs, and economic impacts of the proposed Standards of Performance for Greenhouse Gas Emissions for New Stationary Sources: Electric Utility Generating Units (herein referred to as the EGU New Source GHG Standards).

1.1 Background and Context of Proposed Rule

The proposed EGU New Source GHG Standards will set emission limits for greenhouse gas emissions (GHG) from new fossil fuel fired electric generating units (EGU) constructed in the United States in the future. This rulemaking will apply to carbon dioxide (CO_2) emissions from any affected fossil fuel-fired EGU that sells more than one-third of its potential electric output and more than 219,000 megawatt-hours (MWh) net-electrical output to the grid on a three year rolling average basis. The United States Environmental Protection Agency (EPA) is proposing requirements for these sources because CO_2 is a GHG and fossil fuel-fired power plants are the country's largest stationary source emitters of GHGs. As stated in the EPA's Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clean Air Act (74 FR 66518) and summarized in Chapter 3 of this RIA, the anthropogenic buildup of GHGs in the atmosphere is very likely the cause of most of the observed global warming over the last 50 years.

On April 13, 2012, the EPA proposed new source performance standards for emissions of carbon dioxide for new affected fossil fuel-fired EGUs (77 FR 22392). After consideration of public comments received – totaling approximately 2.5 million – the EPA determined that significant revisions in its proposed approach are warranted to tailor the required emission limits to the different types of sources in the electricity sector. As such, the EPA is, in a separate action, rescinding the original proposal and is re-proposing standards of performance for new affected fossil fuel-fired EGUs.

The statutory authority for this action is Clean Air Act (CAA) section 111(b), which addresses standards of performance for new, modified, and reconstructed sources. Today's proposal applies to new sources, which are sources that "commence construction" after publication of the proposal. Based on current information, the Wolverine project in Rogers City, Michigan appears to be the only fossil fuel-fired boiler or integrated gasification combined cycle (IGCC) EGU project presently under development without carbon capture and storage (CCS) with an air permit that has not already commenced construction. We anticipate proposing standards for this project when we finalize today's action if the project has not yet commenced construction and has not been canceled.

This rulemaking affects CAA section 111(b) new sources of GHG emissions from fossil fuel-fired EGUs but does not address GHG emissions from existing sources. This rulemaking also does not propose standards for modified or reconstructed sources. CAA Section 111(b) requires that the new source performance standards (NSPS) be reviewed every eight years. As a result, this rulemaking's analysis is primarily focused on projected impacts within the current eight-year NSPS timeframe.[1] EPA's finding of no new, unplanned conventional coal-fired capacity (and therefore, no projected costs or quantified benefits) is robust beyond the analysis period (past 2030 in both U.S. Energy Information Administration – EIA – and EPA baseline modeling projections) and across a wide range of alternative potential market, technical, and regulatory scenarios that influence power sector investment decisions. Sections 5.8 to 5.11 of this RIA discuss the social costs and benefits of the proposed standards in any limited cases where new coal plant builds are affected by the standard.

This rule is consistent with the Climate Action Plan announced by the President in June 2013 to cut the carbon pollution that causes climate change and affects public health. The President directed EPA to work expeditiously to complete carbon pollution standards for new power plants.[2] It is also consistent with the President's goal to ensure that "by 2035 we will generate 80 percent of our electricity from a diverse set of clean energy sources - including renewable energy sources like wind, solar, biomass and hydropower, nuclear power, efficient natural gas, and clean coal."[3] Additionally, this rule demonstrates to other countries that the United States is taking action to limit GHGs from its largest emissions sources, in line with our intention to demonstrate global leadership. The impact of GHGs is global, and U.S. action to reduce GHG emissions complements ongoing programs and efforts in other countries.

1.2 Summary of the Proposed Rule

This rule proposes emission standards for affected fossil fuel-fired units within existing subparts – natural gas-fired stationary combustion turbines and fossil fuel-fired electric utility steam generating units (boilers and IGCC). All affected new fossil fuel-fired EGUs would be required to meet an output-based emission rate of a specific mass of CO_2 per MWh of

[1] Conditions in the analysis year of 2022 are represented by a model year of 2020.
[2] "The President's Climate Action Plan." June 2013. Available online at: http://www.whitehouse.gov/sites/default/files/image/president27sclimateactionplan.pdf
[3] "Blueprint for a Secure Energy Future." March 30, 2011. Available online at: http://www.whitehouse.gov/sites/default/files/blueprint_secure_energy_future.pdf

electricity generated energy output on a gross basis. These standards would be met on a 12-operating month rolling average basis. The EPA is proposing standards of performance for affected sources within the following subcategories: (1) natural gas-fired stationary combustion turbines with a heat input rating to the turbine engine that is greater than 850 million British Thermal units per hour (MMBtu/hr); (2) natural gas-fired stationary combustion turbines with a heat input rating to the turbine engine that is less than or equal to 850 MMBtu/hr; and (3) all fossil fuel-fired boilers and IGCC units. The respective emission limits are shown in table 1-1.

Table 1-1. Proposed Emission Limits

Source	Emission Limit (lb CO_2/MWh Gross Basis)
Stationary natural gas-fired combustion turbine EGUs with a heat input rating greater than 850 MMBtu/hr	1,000
Stationary natural gas-fired combustion turbine EGUs with a heat input rating less than or equal to 850 MMBtu/hr	1,100
Fossil fuel-fired boilers and IGCCs	1,100

This action also proposes an alternative emission limit, available only to new fossil-fuel fired boilers and IGCCs, which can be met over an 84-operating month rolling average basis. The alternative emission limit will be between 1,000 and 1,050 lb CO2/MWh of gross energy output.

1.3 Key Findings of Economic Analysis

As explained in detail in this document, energy market data and projections support the conclusion that, even in the absence of this rule, existing and anticipated economic conditions will lead electricity generators to choose new generation technologies that meet the proposed standard without the need for additional controls. The base case modeling the EPA performed for this rule (as well as modeling that the EPA has performed for other recent air rules) projects that, even in the absence of this action, new fossil-fuel fired capacity constructed through 2022 and the years following will most likely be natural gas combined cycle capacity. Alternatively, coal-fired capacity with partial CCS could also be built at costs similar to the costs power companies are paying for other, lower CO_2-emitting, non-natural gas, baseload generation technologies. Analyses performed both by the EPA and the EIA[4] project that generation technologies other than those utilizing coal (including natural gas-fired and renewable sources)

[4] Annual Energy Outlook (AEO) 2009- 2013.

are likely to be the technology of choice for new generating capacity due to current and projected economic market conditions.

Therefore, based on the analysis presented in Chapter 5, the EPA anticipates that the proposed EGU New Source GHG Standards will result in negligible CO_2 emission changes, energy impacts, quantified benefits, costs, and economic impacts by 2022. Accordingly, the EPA also does not anticipate this rule will have any impacts on the price of electricity, employment or labor markets, or the US economy. Nonetheless, this rule may have several important beneficial effects described below.

This NSPS would provide regulatory certainty that any new coal-fired power plant must limit CO_2 emissions by implementing some form of partial capture and storage. Therefore, the proposed regulation would provide an incentive for supporting research, development, and investment into technology to capture and store CO_2. Rather than relying solely on dynamic energy market conditions to limit emissions from new power plants, this rule provides additional certainty to help incentivize innovation that would lead to lower CO_2 emissions in the future. The proposed rule is also a prerequisite for the regulation of existing sources within this source category under CAA section 111(d).

While sector-wide modeling does not project any new coal-fired EGUs without CCS to be built in the absence of this proposal, we recognize that a few companies may choose to construct coal or other solid fossil fuel-fired units. In Chapter 5 of this RIA we present an analysis of the project-level costs of a new coal-fired unit with and without CCS, and estimate the social benefits of requiring CCS on a new uncontrolled unit. We also present a sensitivity analysis indicating that even in the unlikely event that market conditions change sufficiently to make the widespread construction of new conventional coal-fired units economical from the perspective of private investors, this rule would result in net benefits from avoided negative health and environmental effects.

The rule will reduce regulatory uncertainty by defining requirements for emission limits for GHG from new fossil fuel-fired EGU sources. In addition, the EPA intends this rule to send a clear signal about the current and future status of CCS technology. Identifying partial implementation of CCS technology as the best system of emission reductions (BSER) for coal-fired power plants promotes further development of CCS, which is important for long-term CO_2 emission reductions. Particularly because the CCS technologies have had limited application to date, additional CCS applications are expected to lead to improvements in these technologies' performance and consequent reductions in their cost. Moreover, partial implementation of CCS is a viable CO_2 control for new coal-fired power plants as identified in the BSER determination. Acknowledging that CCS is a viable control will encourage continued research, including, for example, continued research collaboration between the U.S. and China.[5,6]

[5] Statement by Department of Energy Secretary Steven Chu. Statement by Secretary Chu. http://energy.gov/articles/building-clean-energy-partnerships-china-and-japan.

[6] Friedman, Dr. Julio S. "A U.S. – China CCS Roadmap." Lawrence Livermore National Laboratory Carbon Management Program. http://www.nrcce.wvu.edu/cleanenergy/docs/Friedmann.pdf.

CHAPTER 5
COSTS, BENEFITS, ECONOMIC, AND ENERGY IMPACTS

5.1 Synopsis

This chapter reports the compliance cost, benefits, economic, and energy impact analyses performed for the proposed EGU New Source GHG Standards. EPA analyzed and assessed a wide range of potential scenarios and outcomes, using a detailed power sector model, other government projections for the power sector, and additional economic assessments and analysis to determine the potential impacts of this action.

The primary finding of this assessment is that in the absence of this proposed rule, all projected unplanned[1] capacity additions affected by this proposal during the analysis period would already be compliant with the rule's requirements (e.g., combined cycle natural gas, low capacity factor natural gas combustion turbine, and small amounts of coal with CCS supported by Federal and State funding). The analysis period is defined as through 2022[2] to reflect that CAA Section 111(b) requires that the NSPS be reviewed every eight years. EPA's conclusion was based on:

- EIA power sector modeling projections
- EPA power sector modeling projections
- Electric utility integrated resource planning (IRP) documents
- Projected new EGUs reported by industry to EIA

EPA's finding of no new, unplanned conventional coal-fired capacity is robust beyond the analysis period (past 2030 in both EIA and EPA baseline modeling projections) and across a wide range of alternative potential market, technical, and regulatory scenarios that influence power sector investment decisions. As a result, the proposed EGU New Source GHG Standards are not expected to change GHG emissions for newly constructed EGUs, and are anticipated to yield no monetized benefits and impose negligible costs, economic impacts, or energy impacts on the electricity sector or society. While EPA does not project any new coal-fired EGUs without CCS to be built in the absence of this proposal, this chapter presents an analysis of the project-level costs of building new coal-fired capacity with and without CCS to demonstrate

[1] Unplanned capacity represents projected capacity additions that are not under construction.
[2] IPM output for other years has been made available in the docket and is discussed where appropriate throughout the document.

that a requirement of partial CCS would not preclude new coal construction. An additional illustrative analysis, presented at the end of this chapter, shows that even in the unlikely event that new, noncompliant EGU capacity would be built in the absence of this rule the proposed EGU New Source GHG Standards would provide net social benefits under a range of assumptions.

5.2 Requirements of the Proposed GHG EGU NSPS

In this action, the EPA is proposing standards of performance for two basic categories of new units that have not commenced construction: (i) fossil fuel-fired electric utility steam generating units (boilers and IGCC units); and (ii) natural gas-fired stationary combustion turbines that generate electricity for sale and meet certain size and operational criteria.

The EPA is proposing standards of performance for affected sources within the following subcategories: (1) natural gas-fired stationary combustion turbines with a heat input rating to the turbine engine that is greater than 850 MMBtu/hr; (2) natural gas-fired stationary combustion turbines with a heat input rating to the turbine engine that is less than or equal to 850 MMBtu/hr; and (3) all fossil fuel-fired boilers and IGCC units. All affected new fossil fuel-fired EGUs would be required to meet an output-based emission rate of a specific mass of CO_2 per MWh of electricity generated energy output on a gross basis. New natural gas-fired stationary combustion turbines with a heat input rating greater than 850 MMBtu/hr would be required to meet a standard of 1,000 lb CO_2/MWh of gross energy output. New natural gas-fired stationary combustion turbines with a heat input rating less than or equal to 850 MMBtu/hr would be required to meet a standard of 1,100 lb CO_2/MWh of gross energy output. New fossil fuel-fired boilers and IGCC units would be required to meet a standard of 1,100 lb CO_2/MWh of gross energy output. These standards would be met on a 12-operating month rolling average basis. An alternative emission limit, available only to new fossil-fired boilers and IGCC units, can be met over an 84-operating month rolling average basis. The alternative emission limit will be between 1,000 and 1,050 lb CO2/MWh of gross energy output.

The proposed action applies to sources based on electric sales. More specifically, a facility is covered if it sells more than 1/3 of its potential electric output and more than 219,000 MWh net electric output to the grid. The proposed definition does not explicitly exclude simple cycle combustion turbines, but as a practical matter, it is generally expected not to apply as most simple cycle combustion turbines sell less than 1/3 of their potential electric output. For potential combustion turbines that anticipate selling more than 1/3 of their potential electric output, there are more cost effective and lower emitting technologies that could be constructed consistent with the proposed standards as will be demonstrated later in this chapter. Please refer to the preamble for additional detail concerning affected sources and standards of performance.

5.3 Power Sector Modeling Framework

5.3.1 Modeling Overview

Over the last decade, EPA has conducted extensive analyses of regulatory actions impacting the power sector. These efforts support the Agency's understanding of key policy variables and provide the framework for how the Agency estimates the costs and benefits associated with its actions. Current forecasts for the utilization of new and existing generating capacity are a key input into informing the design of EPA's proposal. Given excess capacity within the existing fleet and relatively low forecasts of electricity demand growth, there is limited new capacity - of any type - expected to be constructed over the next decade. A small number of new coal-fired power plants have been built in recent years; however, EPA does not expect the construction of any new, unplanned, conventional coal-fired capacity through the analysis period. This conclusion is based in part on the Agency's own power sector modeling utilizing IPM as well as EIA's Annual Energy Outlook 2013 (AEO 2013) projections.

IPM, developed by ICF Consulting, is a state-of-the-art, peer reviewed, dynamic linear programming model that can be used to project power sector behavior under future business as usual conditions and examine prospective air pollution control policies throughout the United States for the entire electric power system. EPA used IPM to project likely future electricity market conditions with and without the proposed rule. In addition to IPM, EPA has closely examined the AEO 2013 from the EIA.

To produce the AEO, EIA employs the National Energy Modeling System (NEMS), an energy-economy modeling system of the United States. According to EIA:[3]

"NEMS projects the production, imports, conversion, consumption, and prices of energy, subject to assumptions on macroeconomic and financial factors, world energy markets, resource availability and costs, behavioral and technological choice criteria, cost and performance characteristics of energy technologies, and demographics."

The Electricity Market Module of NEMS produces projections of power sector behavior that minimize the cost of meeting electricity demand subject to the sector's inherent constraints, including the availability of existing generation capacity, transmission capacity and

[3] http://www.eia.gov/oiaf/aeo/overview/

cost, cost of utility and nonutility technologies, expected load shapes, fuel markets, regulations, and other factors. EIA's AEO projections independently support EPA's conclusions in that it projects no new generation capacity being constructed through the analysis period that would not already meet the level of the standard even in the absence of the standard. Both sets of modeling results are presented in Section 5.4.

5.3.2 The Integrated Planning Model

IPM is a multi-regional, dynamic, deterministic linear programming model of the U.S. electric power sector. It provides forecasts of least cost capacity expansion, electricity dispatch, and emission control strategies while meeting energy demand and environmental, transmission, dispatch, and reliability constraints. EPA has used IPM for over two decades to better understand power sector behavior under future business as usual conditions and evaluate the economic and emission impacts of prospective environmental policies. The model is designed to reflect electricity markets as accurately as possible.[4] EPA uses the best available information from utilities, industry experts, gas and coal market experts, financial institutions, and government statistics as the basis for the detailed power sector modeling in IPM. The model documentation provides additional information on the assumptions discussed here as well as all other model assumptions and inputs.[5]

Although the Agency typically focuses on broad system effects when assessing the economic impacts of a particular policy, EPA's application of IPM includes a detailed and sophisticated regional representation of key power sector variables and its organization. When considering which new units are most cost effective to build and operate, the model considers the relative economics of various technologies based on a wide spectrum of current and future considerations, including capital costs, operation and maintenance costs, fuel costs, utility sector regulations, and emission profiles. The capital costs for new units account for regional differences in labor, material, and construction costs. These regional cost differentiation factors are based on assumptions used in the EIA's AEO.

As part of IPM's assessment of the relative economic value of building a new power plant, the model incorporates a detailed representation of the fossil-fuel supply system that is used to forecast equilibrium fuel prices, a key component of new power plant economics. The model includes an endogenous representation of the North American natural gas supply system through a natural gas module that reflects full supply/demand equilibrium of the North

[4] http://www.epa.gov/airmarkt/progsregs/epa-ipm/index.html
[5] http://www.epa.gov/airmarkt/progsregs/epa-ipm/BaseCasev410.html#documentation

American gas market. This module consists of 114 supply, demand, and storage nodes and 14 liquefied natural gas regasification facility locations that are tied together by a series of linkages (i.e., pipelines) that represent the North American natural gas transmission and distribution network.

IPM also endogenously models the coal supply and demand system throughout the continental U.S., and reflects non-power sector demand and imports/exports. IPM reflects 84 coal supply curves, 12 coal sulfur grades, and the coal transport network, which consists of 1,230 linkages representing rail, barge, and truck and conveyer linkages. The coal supply curves in IPM, which are publicly available[6], were developed during a thorough bottom-up, mine-by-mine approach that depicts the coal choices and associated supply costs that power plants will face over the modeling time horizon. The IPM documentation outlines the methods and data used to quantify the economically recoverable coal reserves, characterize their cost, and build the 84 coal supply curves. The coal supply curves were developed in consultation with Wood Mackenzie, one of the leading energy consulting firms and specialists in coal supply. These curves have been independently reviewed by industry experts and have been made available for public review on several occasions over the past two years during other rulemaking processes.

EPA has used IPM extensively over the past two decades to analyze options for reducing power sector emissions. Recently, the model has been used to forecast the costs, emission changes, and power sector impacts for the Clean Air Interstate Rule (CAIR), Cross-State Air Pollution Rule (CSAPR), and the Mercury and Air Toxics Standards (MATS).[7]

The model undergoes periodic formal peer review, which includes separate expert panels for both the model itself and EPA's key modeling input assumptions.[8] The rulemaking process also provides opportunity for expert review and comment by a variety of stakeholders, including owners and operators of the electricity sector that is represented by the model, public interest groups, and other developers of U.S. electricity sector models. EPA is required to respond to significant comments submitted regarding the inputs used in IPM, its structure, and application. The feedback that the Agency receives provides a highly detailed check for key input assumptions, model representation, and modeling results. IPM has received extensive review by energy and environmental modeling experts in a variety of contexts. For example, in

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[6] v4.10 of the coal supply curves may be found in Appendix 9-4 of http://www.epa.gov/airmarkt/progsregs/epa-ipm/BaseCasev410.html#documentation

[7] All of the IPM projections conducted for this rulemaking are available at EPA's website and in the public docket.

[8] http://www.epa.gov/airmarkets/progsregs/epa-ipm/past-modeling.html

the late 1990's, the Science Advisory Board reviewed IPM as part of the CAA Amendments Section 812 prospective studies that are periodically conducted.[9] The model has also undergone considerable interagency scrutiny when it has been used to conduct over one dozen legislative analyses (performed at Congress' request) over the past decade. In addition, Regional Planning Organizations throughout the U.S. have extensively examined IPM as a key element in the state implementation plan (SIP) process for achieving the National Ambient Air Quality Standards. The Agency has also used the model in a number of comparative modeling exercises sponsored by Stanford University's Energy Modeling Forum over the past 15 years.

IPM has also been employed by states (e.g., for RGGI, the Western Regional Air Partnership, Ozone Transport Assessment Group), other Federal and State agencies, environmental groups, and industry, all of whom subject the model to their own review procedures. States have used the model extensively to inform issues related to ozone in the northeastern U.S. This groundbreaking work set the stage for the NO_x SIP call, which has helped reduce summer NO_x emissions and the formation of ozone in densely populated areas in the northeast.

5.4 Analyses of Future Generating Capacity

5.4.1 Base Case Power Sector Modeling Projections

EPA conducted analysis and modeling in support of the April 2012 EGU GHG New Source Standards proposal, and concluded that new unplanned noncompliant base load power plants are not expected to be economic well beyond the analysis period. EPA conducted an analysis of the economic impacts by modeling a base case scenario of future electricity market conditions. EPA's IPM modeling relied on the AEO 2010 for the electric demand forecast for the U.S. and employed a set of EPA assumptions regarding fuel supplies, the performance and cost of electric generation technologies, pollution controls, and numerous other parameters.[10] The base case accounts for the effects of the finalized MATS and CSAPR rules, and New Source Review settlements and state rules through December 2010 impacting sulfur dioxide (SO_2), NO_x, directly emitted particulate matter and CO_2.[11]

The most current EIA projections are reflected in AEO 2013 and are summarized in the following tables alongside the EPA projections. New coal-fired capacity through 2030 in the

[9] http://www.epa.gov/air/sect812/
[10] http://www.epa.gov/airmarkt/progsregs/epa-ipm/proposedEGU_GHG_NSPS.html
[11] The legal status of CSAPR and CAIR has no impact on this proposal's evaluation, as neither CSAPR nor CAIR significantly influences the type of new capacity additions projected to be economic.

AEO 2013 reference case is entirely CCS-equipped and would be in compliance with this proposal (0.3 GW). The projected CCS-equipped capacity is assumed to occur in response to existing Federal, State, and local incentives for the technology.[12] According to the AEO 2013 – which represents existing policies and regulations influencing the power sector - the vast majority of new, unplanned generating capacity is forecast to be either natural gas-fired or renewable.[13] The economics favoring new natural gas combined cycle (NGCC) additions instead of conventional coal are robust under a range of sensitivity cases examined in the AEO 2013. Sensitivity cases that separately examine higher economic growth, lower coal prices, no risk premium for greenhouse gas emissions liability from conventional coal, and lower oil and natural gas resources also forecast zero unplanned additions of coal-fired capacity without CCS in the analysis period. Recent previous versions of the AEO came to similar conclusions. Based on these previous AEO analyses, DOE concluded that "the low capital expense, technical maturity, and dispatchability of natural gas generation are likely to dominate investment decisions under current policies and projected prices."[14]

In comparing the EPA and EIA modeling projections reported here, the most important variables influencing the choice of technology for new generating capacity are more favorable to new coal-fired capacity in the EPA analysis. For example, electric demand in 2020 was assumed to be 4,305 billion kWh (taken from AEO 2010) in EPA's modeling projections, which is over 4% higher than electric demand in AEO 2013.[15] Projected fuel prices for natural gas and coal are also more favorable to new coal-fired capacity relative to new NGCC capacity in the EPA analysis than in the AEO 2013 projections.

[12] These programs include the Emergency Economic Stabilization Act of 2008, the American Reinvestment and Recovery Act of 2009 (which assisted in funding for such programs as the Clean Coal Power Initiative through DOE and tax credits for Clean Energy Manufactures through DOE and the Treasury Department), as well as loans provided by USDA for CO2 capture projects.

[13] http://www.eia.gov/forecasts/aeo/chapter_legs_regs.cfm

[14] Department of Energy (2011). *Report on the First Quadrennial Technology Review. Available at http://energy.gov/sites/prod/files/QTR_report.pdf.*

[15] In a long-term power sector modeling framework, calendar years are typically grouped into model run years. In EPA's IPM projections reported in this chapter, 2020 is the run year that is representative of results from calendar years 2017-2024. Consequently, the chapter often presents 2020 projections and results from EPA and EIA as opposed to projections for the last year of the analysis period (2022).

Table 5-1. Reference Case Unplanned Cumulative Capacity Additions (GW)

	EPA	AEO 2013		
Capacity Type	**2020**	**2020**	**2025**	**2030**
Conventional Coal	0	0	0	0
Coal with CCS	2	0.3	0.3	0.3
Natural Gas CC	7.0	3.1	17.4	48.2
Natural Gas CT	3.0	15.4	28.0	43.3
Nuclear	0	0	0	0
Renewables[16]	26.9	3.7	6.4	10.5
Distributed Generation	0	0.9	1.9	3.1
Total	**38.9**	**23.4**	**54.1**	**105.4**

Notes: The sum of the table values in each column may not match the total figure due to rounding.
Source: EPA 2020 projection from IPM run by EPA, 2011; EIA 2020-2030 projection from EIA Annual Energy Outlook 2013

The capacity projections of EIA and EPA represent a continuation of current trends, where natural gas-fired capacity has been the technology of choice for base load and intermediate load power generation over the last few years (see Figure 5-2), due in large part to its significant levelized cost of electricity[17] (LCOE) advantage over coal-fired generating technologies. A greater discussion of the relative LCOE of different generating technologies is provided beginning in Section 5.5.

[16] Renewable projections are higher in the EPA reference case due largely to EPA's 2011 modeling projections predating AEO 2013 projections; therefore, all renewable builds that occurred in the interim would be accounted for in AEO 2013 as 'planned' capacity and are omitted from the table above. The overall amount of total renewable capacity by 2020 is largely similar.

[17] The levelized cost of electricity is an economic assessment of the cost of electricity from a new generating unit or plant, including all the costs over its lifetime: initial investment, operations and maintenance, cost of fuel, and cost of capital.

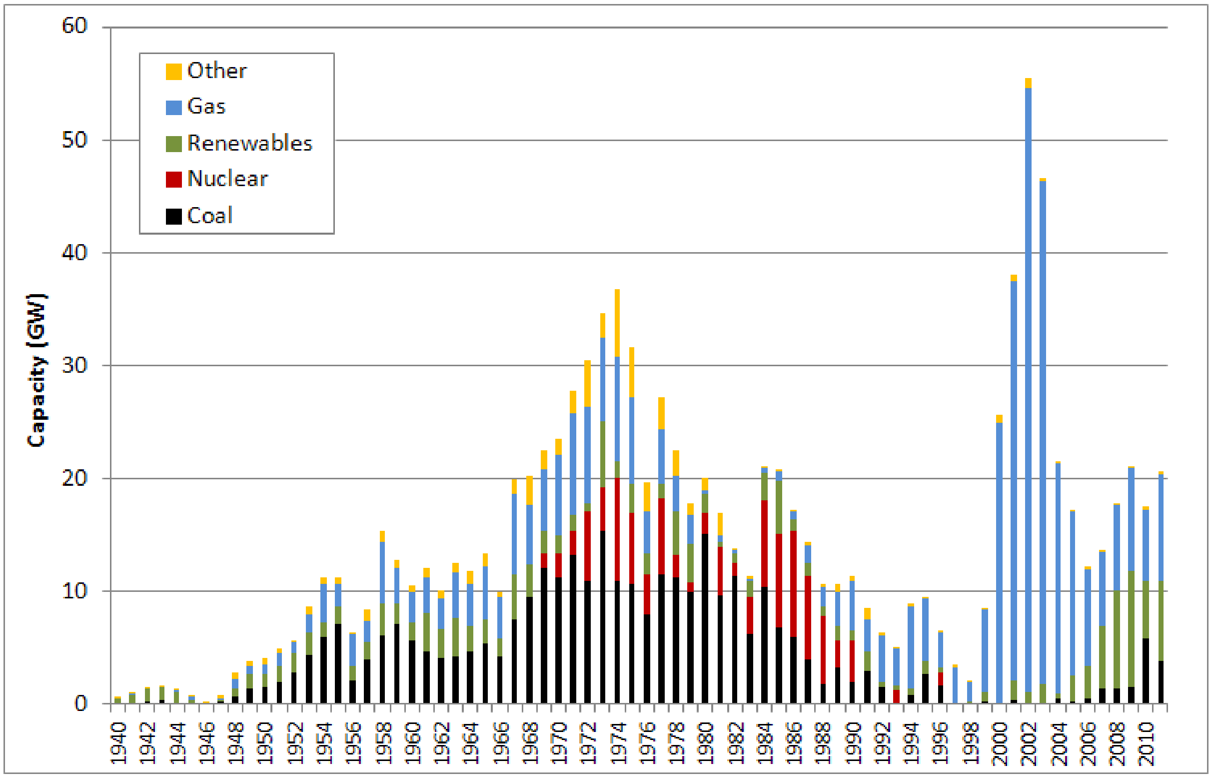

Figure 5-1. Historical U.S. Power Plant Capacity Additions, by Technology, 1940-2011

Source: Form EIA-860 (2011)
Note: Renewables include hydro, geothermal, biomass, solar, and wind energy technologies.

In addition to new builds, increased electricity demand is expected to be partially fulfilled by increased utilization of existing generating capacity. Generation projections are the result of least-cost economic modeling both in IPM and AEO 2013, and reflect the most cost-effective dispatch and investment decisions modeled, given a variety of variables and constraints. Even without the deployment of unplanned conventional coal-fired capacity, U.S. electricity demand will continue to be met by a diverse mix of electricity generation sources with coal projected to continue to provide the largest share of electricity (39% of total 2020 generation in AEO2013 and 46% in EPA's projections), as displayed in Table 5-2.

Table 5-2. 2011 U.S. Electricity Net Generation and Projections for 2020, 2025, and 2030 (Billion kWh)

	Historical	EPA		AEO 2013	
	2011	2020	2020	2025	2030
Coal	1,718	1,976	1,640	1,707	1,745
Oil	15	Negligible	15	16	16
Natural Gas	926	869	1,078	1,127	1,221
Nuclear	790	840	885	912	908
Hydroelectric	318	286	289	291	292
Non-Hydro Renewables	164	289	270	295	310
Other	18	45	5	9	13
Total	**3,949**	**4,305**	**4,182**	**4,356**	**4,506**

Source: Historical data from Form EIA-860, 2011. EPA 2020 projection from IPM run by EPA, 2011; EIA 2020-2030 projection from EIA Annual Energy Outlook 2013Notes: Net summer generating capacity. The sum of the table values in each column may not match the total figure due to rounding. "Non-Hydro Renewables" include biomass, geothermal, solar, and wind electric generation capacity. The capacity of a generating unit that is co-firing gas in a coal boiler is split in this table between "pulverized coal" and "Oil/Gas Steam" proportionally by fuel use.

It has been previously noted that since the time of the IPM Base Case analysis, projections for key market variables are now less favorable to the development of coal-fired capacity. State and regional regulations have necessarily evolved since EPA's 2011 modeling projections, most notably regulations of GHG emissions from the power sector and state renewable portfolio standards (RPS):

- State regulations addressing CO_2 emissions – Several states have adopted measures to address emissions of CO_2 from the power sector. These approaches include flexible market-based programs like California's Assembly Bill 32 and the RGGI in the Northeast, and specific GHG performance standards for new power plants in California, Oregon, New York, and Washington.

- State Renewable Portfolio Standards (RPS) – According to EIA, 30 states and the District of Columbia have an enforceable RPS, or similar laws.[18] There are eight other States that have voluntary goals.[19] These measures, in conjunction with Federal financial incentives, are key drivers of the significant growth in new renewable energy seen over the past few years and expected over the next decade.

[18] http://www.eia.gov/forecasts/aeo/legs_regs_all.cfm#state
[19] http://www.dsireusa.org/rpsdata/index.cfm

- State and Utility IRPs – IRPs, which are usually adopted by utilities in response to state requirements, allow regulators and utilities to consider a broader array of measures to meet future electric demand most cost effectively. IRPs also help electric planners to consider key strategic and policy goals like electric reliability, environmental impacts, and the economic efficiency of power sector investments.[20] In general, these plans confirm the expectation that utilities anticipate that any new sources of generation will be from renewables, in response to state and federal regulations and incentives, and natural gas prices. Furthermore, these plans reflect an expectation of relatively low demand growth due, in part, to policies and regulations to reduce the electricity consumption such as energy efficiency regulations and policies, evolution of the Smart Grid, and demand response measures.

Any recently adopted state and local climate or related electricity sector regulations that are not included in the IPM Base Case analysis, California's AB 32 for example, also make the development of coal-fired capacity less favorable.

5.4.2 Alternative Scenarios from AEO 2013

Power sector modeling that projects no new, unplanned, conventional coal-fired capacity in the analysis period have been demonstrated to be robust under a range of alternative assumptions that influence the industry's decisions to build new power plants. For example, EIA typically supplements the AEO with scenarios that explore key market, technical, and regulatory issues. Of the 26 scenarios contained in the AEO 2013, none projected unplanned, conventional coal capacity in the analysis period, including the four scenarios that may be considered most favorable to the development of coal-fired capacity displayed below:[21]

[20] E.g., http://www.pacificpower.net/about/irp.html

[21] AEO 2013 scenario definitions: High Economic Growth increases annual real GDP growth by 0.4%; Low Coal Cost assumes greater regional productivity growth rates and lower wages, equipment, and transportation costs for the coal industry; Low Oil and Gas Resource reduces the ultimate estimated recovery of shale gas, tight gas, and tight oil by 50%; No GHG Concern removes the perceived risk of incurring costs under a future GHG policy from market investment decisions.

Table 5-3. AEO 2013 Unplanned Cumulative Capacity Additions, GW (2020[22])

Capacity Type	Reference	High Growth	Low Coal Cost	Low Gas Resource	No GHG Concern
Conventional Coal	0	0	0	0	0
Coal with CCS	0.3	0.3	0.3	0.3	0.3
Natural Gas	18.5	19.5	17.6	13.7	17.8
Nuclear	0	0	0	0	0
Non-Hydro Renewables	3.7	13.5	5.0	5.2	4.1
Other	0.9	0.6	0.8	0.2	0.8
Total	**23.4**	**33.9**	**23.8**	**19.3**	**23.1**

5.4.3 Power Sector Fuel Price Dynamics and Trends

As mature technologies, the cost and performance characteristics of conventional coal-fired capacity and NGCC are projected by EPA to be relatively stable over time in comparison to emerging generation technologies.[23] Therefore, expectations of future fuel prices play a key role in determining the overall cost competitiveness of conventional coal versus NGCC.

Current and projected natural gas prices are considerably lower than observed prices over the past decade. This is largely due to advances in hydraulic fracturing and horizontal drilling techniques that have opened up new shale gas resources and substantially increased the supply of economically recoverable natural gas. According to EIA:

> Shale gas refers to natural gas that is trapped within shale formations. Shales are fine-grained sedimentary rocks that can be rich sources of petroleum and natural gas. Over the past decade, the combination of horizontal drilling and hydraulic fracturing has allowed access to large volumes of shale gas that were previously uneconomical to produce. The production of natural gas from shale formations has rejuvenated the natural gas industry in the United States.
>
> Of the natural gas consumed in the United States in 2011, about 95% was produced domestically; thus, the supply of natural gas is not as dependent on foreign producers as is the supply of crude oil, and the delivery system is less subject to interruption. The availability of large quantities of shale gas should enable the United

[22] The 2020 run year represents conditions out through 2022, consistent with the eight year NSPS review cycle.
[23] http://www.epa.gov/airmarkt/progsregs/epa-ipm/docs/v410/Chapter4.pdf

States to consume a predominantly domestic supply of gas for many years and produce more natural gas than it consumes.

The U.S. Energy Information Administration's *Annual Energy Outlook 2013 Early Release* projects U.S. natural gas production to increase from 23.0 trillion cubic feet in 2011 to 33.1 trillion cubic feet in 2040, a 44% increase. Almost all of this increase in domestic natural gas production is due to projected growth in shale gas production, which grows from 7.8 trillion cubic feet in 2011 to 16.7 trillion cubic feet in 2040.[24]

Recent historical data reported to EIA is also consistent with these trends, with 2012 being the highest year on record for domestic natural gas production.[25] The average delivered natural gas price to the power sector was $3.44 per MMBtu in 2012, down from $4.78/MMBtu in 2011.[26]

Increases in the natural gas resource base have led to fundamental changes in the outlook for natural gas. While sources may disagree on the absolute level of increases from shale resources, there is general agreement that recoverable natural gas resources will be substantially higher for the foreseeable future than previously anticipated, exerting downward pressure on natural gas prices.[27,28] EPA and EIA modeling incorporates the impact of these additional resources on the forecasts of the price of natural gas used by electric generating units. The increases in the natural gas resource base are reflected not only in current natural gas prices and projections (e.g., AEO 2013), but also in current capacity planning by utilities and electricity producers across the country. The North American Electric Reliability Corporation's (NERC) Long Term Reliability Assessment, which is based on utility plans for new capacity over a 10-year period, reinforces this consensus by stating that "gas-fired generation [is] the primary choice for new capacity." [29]

EPA's and EIA's modeling frameworks are designed to reflect the longer term, fundamentals-based perspective that electric utilities and developers employ in evaluating

[24] http://www.eia.gov/energy_in_brief/article/about_shale_gas.cfm
[25] http://www.eia.gov/dnav/ng/hist/n9010us2a.htm
[26] http://www.eia.gov/dnav/ng/hist/n3045us3A.htm; Assumes that 1 TCF = 1.023 MMBtu natural gas (http://www.eia.gov/tools/faqs/faq.cfm?id=45&t=8)
[27] National Petroleum Council. 2011. *Prudent Development: Realizing the Potential of North America's Abundant Natural Gas and Oil Resources.* http://www.npc.org/reports/rd.html (see Figure 1.2 on p. 47).
[28] EIA. 2013. U.S. Crude Oil and Natural Gas Proved Reserves, 2011. http://www.eia.gov/naturalgas/crudeoilreserves/pdf/uscrudeoil.pdf
[29] NERC, Long-Term Reliability Assessments for 2012. New capacity includes both planned and conceptual resources as defined by NERC.

capital investments, while utilizing scenario testing to account for broader fuel market uncertainties. Short-term fuel price volatility is not the most relevant factor in this context because new power plants have asset lives measured in decades, not in months or years, and new capacity investment decisions are based on long-run expected prices, not month-to-month, or even year-to year, variations in fuel prices. Shorter-term prices will affect how units are dispatched, but these potential dispatch impacts are considered with other factors over a longer time horizon and factored into the choice of which type of plant to build. In contrast, the uncertainty surrounding long-term fuel prices will exert significantly greater influence on the technology selected for new capacity additions. In a modeling context with perfect foresight, this longer term uncertainty may be evaluated by the scenario testing presented throughout this analysis.

In addition to major changes in the gas supply outlook, there have been notable changes in the coal supply outlook. Coal costs have generally increased over the past few years due primarily to increased production costs. These costs have increased as the most accessible and economically viable mines are depleted, requiring movement into coal reserves that are more costly to mine. The basic trends in coal supply are not expected to change for the foreseeable future.[30]

Taken together, current and expected natural gas and coal market trends are contributing to a fundamental shift in the economic conditions for new power plant development that utilities and developers have recognized and responded to in planning.[31]

5.4.4 Power Sector Fuel Projections

To examine the potential impacts of uncertainty inherent in natural gas and coal markets, the EIA used scenario analysis to generate the 2020 fuel price projections in table 5-5.

[30] http://www.eia.gov/forecasts/aeo/assumptions/pdf/coal.pdf

[31] For example: "We don't have any plans to build new coal plants. So the rules won't have much of an impact. Any additional generation plants we'd build for the next generation will be natural gas." American Electric Power, 3/26/2012, National Journal; "As we look out over the next two decades, we do not plan to build another coal plant. … As the evidence is coming in, [shale gas] is proving to be the real deal. If we have no plans, as one of the largest utilities and largest users of coal in this country, no plans to build a new coal plant for two decades, the regulations are not relevant." Jim Rogers (Duke), 3/27/2012, NPR All Things Considered..; "If you actually look at the economics today, you would be burning gas, not coal," Jack Fusco, Calpine, 12/1/2010, Marketplace; "Coal's most ardent defenders are in no hurry to build new ones in this environment." John Rowe, Exelon, 9/2011, EnergyBiz; "With low gas prices, gas-fired generation kind of snowplows everything else" Lew Hay, NextEra, 11/1/2010, Dow Jones.

Table 5-4. National Delivered 2020 Fuel Prices by AEO 2013 Scenario (2011$/MMBtu)

Scenario[32]	Natural Gas	Coal
Reference	5.00	2.52
High Growth	5.45	2.57
Low Growth	4.64	2.47
High Coal Cost	5.26	2.93
Low Coal Cost	4.85	2.17
High Gas/Oil Resource	3.60	2.47
Low Gas/Oil Resource	6.18	2.78

However, given that power plants are long-lived assets, capacity planning decisions are necessarily undertaken with a forward view of expected market and regulatory conditions. In producing the AEO 2013, EIA capacity expansion projections are informed by a lifecycle cost analysis over a 30-year period in which the expectations of future prices are consistent with the projections realized in the model (i.e. the model executes decisions with perfect foresight of future market, technical, and regulatory conditions). Therefore, the fuel price that informs capacity expansion decisions in 2020 is not the 2020 price, but the entire future fuel price stream. For example, Figure 5-6 displays EIA's natural gas price projections for the Reference Case and several scenarios through 2040.

[32] AEO 2013 scenario definitions: High Economic Growth increases annual real GDP growth by 0.4%; Low Economic Growth decreases real GDP growth by 0.6%; High Coal Cost assumes lower regional productivity growth rates and higher wages, equipment, and transportation costs for the coal industry; Low Coal Cost assumes greater regional productivity growth rates and lower wages, equipment, and transportation costs for the coal industry; High Oil and Gas Resource expands the ultimate estimated recovery of shale gas, tight gas, and tight oil by 100%; Low Oil and Gas Resource reduces the ultimate estimated recovery of shale gas, tight gas, and tight oil by 50%.

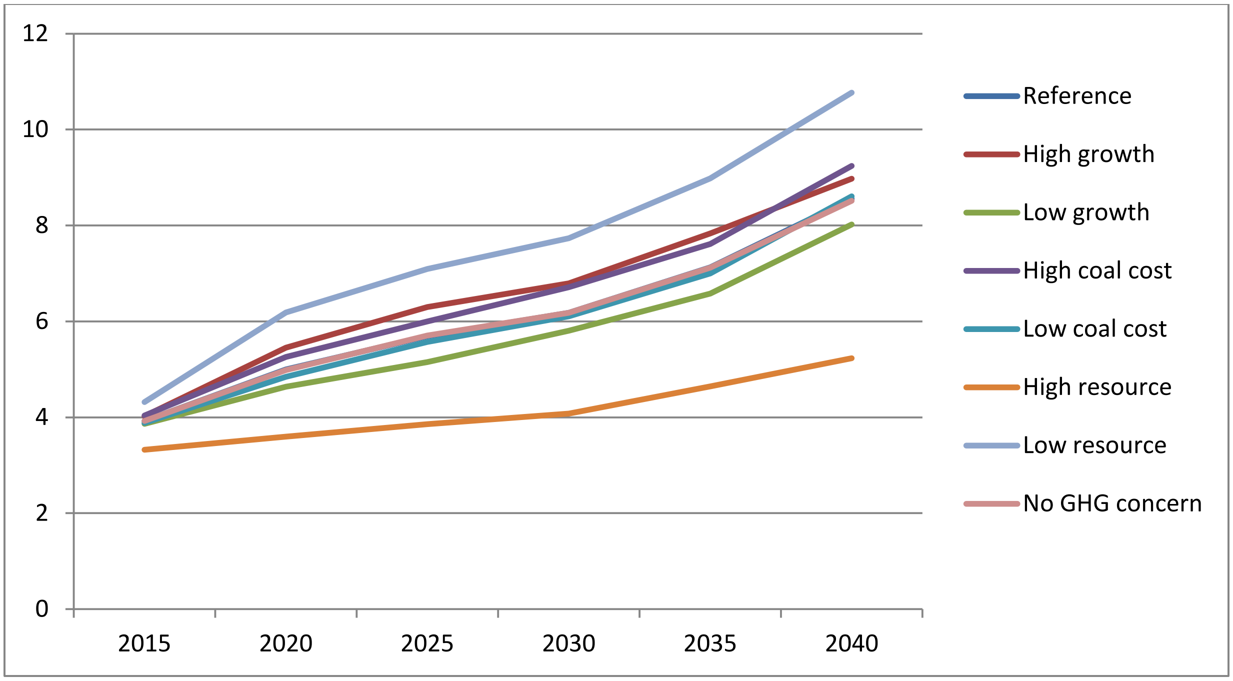

Figure 5-2. National Delivered Natural Gas Prices by Select AEO 2013 Scenario (2011$/MMBtu)

Natural gas prices are expected to increase after 2020 in all scenarios[33]; however, rising natural gas prices through 2040 – including in EIA's low gas/oil resource scenario - are still not sufficient to support new, conventional coal-fired generation in the analysis period (i.e., through 2022), demonstrating that natural gas prices at currently low levels are not required to persist for NGCC to maintain its economic advantage over coal-fired technologies.

While the uniformity of EIA scenarios in projecting no new, unplanned, conventional coal-fired capacity through the analysis period is compelling, the scenario projections cannot fully illustrate the extent of the economic advantage that NGCC maintains over conventional coal – only that the advantage remains intact across a broad range of market and technical scenarios. To identify potential market conditions that could fully erode the private cost advantages of NGCC over conventional coal during the analysis period the following section adopts a static, engineering cost analysis.

[33] Coal prices are also expected to rise in all scenarios.

5.5 Levelized Cost of Electricity Analysis

5.5.1 Overview of the Concept of Levelized Cost of Electricity

New capacity projections from the EPA and EIA reviewed in the previous section indicate that the NSPS is not projected to require changes in the design or construction of new EGUs from what would be expected in the absence of the rule. Thus, under both the baseline projections as well as alternative AEO 2013 scenarios, the proposed EGU New Source GHG Standards are not projected to result in any emission reductions, monetized benefits, or costs.

Despite this conclusion, it is important to supplement the power sector modeling projections to quantify the robustness of the economic advantage of new NGCC relative to new coal without CCS. To achieve this task, EPA will rely on the concept of LCOE. LCOE is a widely used metric that represents the cost, in dollars per output, of building and operating a generating facility over the entirety of its economic life. Evaluating competitiveness on the basis of LCOE is particularly useful in establishing cost comparisons between generation types with similar operating characteristics but with different cost and financial characteristics. The typical cost components associated with LCOE include capital, fixed operating and maintenance (FOM), variable operating and maintenance (VOM), and fuel.

The levelized capital cost is the result of the annualized capital cost spread over the annual output of the generation facility. The annualized capital cost (expressed in $/kw-yr) is the product of the $/kW capital cost and the capital recovery factor (CRF). A CRF may be calculated using the project's interest rate (i) and book life (n).[34]

The levelized capital and FOM costs may be calculated by taking the annualized capital and FOM (expressed in $/kW-yr) and spreading the expense over the annual generation of the facility using the expected average annual capacity factor (the percent of full load at which a unit would produce its actual annual generation if it operated for 8760 hours).

The VOM, which is already expressed in terms of cost per unit output, may be presented with or without fuel expense. The fuel expense is typically the largest component of VOM (non-fuel components to VOM include start-up fuel, consumables, inspections, etc.) and for certain capacity types – such as NGCC – fuel expense may represent the majority of the LCOE. To calculate a levelized fuel cost, it is necessary to introduce the concept of a levelized fuel price.

[34] The interest rate assumed for NGCC projects is 9.06%; the interest rate assumed for coal-fired projects is 9.57%. Both types of projects are assumed to have a 30-year book life, resulting in a capital recovery factor of 9.78% for NGCC projects and 10.23% for coal-fired projects.

Because levelized costs consider the entire lifecycle of the facility, the levelized fuel price calculates the single value payments necessary to reflect the stream of annual delivered fuel prices over the economic life of the facility at a given discount rate.[35] Levelizing fuel prices recognizes the necessity to consider the trajectory of fuel costs over the facility's entire economic life.

It should be noted that there are other important considerations beyond LCOE that impact power plant investment decisions. New power plant developers must consider the particular demand characteristics in any particular region, the existing mix of generators, operational flexibility of different types of generation, prevailing and expected electricity prices, and other potential revenue opportunities (e.g., the capacity value of a particular unit, where certain power markets have mechanisms to compensate units for availability to maintain reliability, sale of co-products, etc.). Broader system-wide power sector modeling – such as the analyses conducted by EPA and scenarios conducted by EIA – is able to more effectively capture these considerations.

5.5.2 Cost and Performance of Technologies

The NGCC and coal-fired generation technology cost and performance assumptions that form the basis for the LCOE analysis in this chapter are sourced from the DOE's NETL.[36] NETL cost and performance characteristics were selected for coal-fired technologies because the NETL estimates were unique in the detail of their cost and performance estimates for a range of CO_2 capture levels for both new super critical pulverized coal (SCPC) and IGCC facilities.[37,38] The CO_2 capture sensitivity analysis included an evaluation of the cost, performance, and

[35] As an illustration of applying a discount rate to a stream of future fuel prices, the levelized fuel price will be less than the mean fuel price if prices are increasing; equal to the mean if fuel prices are constant; and greater than the mean if fuel prices are declining. The weighting of nearer-term prices through the application of a discount rate is consistent with modeling economic behavior. EPA utilized a 5% discount rate to calculate levelized fuel prices, a value consistent with the discount rate embedded in IPM.

[36] http://www.netl.doe.gov/energy-analyses/pubs/Gerdes-08022011.pdf

[37] All potential build types are compliant with all current environmental regulations, including EPA's Mercury and Air Toxics Standards (MATS).

[38] For an emerging technology like CCS, costs can be estimated for a "first-of-a-kind" (FOAK) plant or an "n^{th}-of-a-kind" (NOAK) plant, the latter of which has lower costs due to the "learning by doing" and risk reduction benefits that result from serial deployments as well as from continuing research, development and demonstration projects. The estimates provided in Table 5-5 for a new NGCC unit and for a SCPC plant without CO_2 capture are based on mature technologies and are thus NOAK costs. For plants that utilize technologies that are not yet fully mature, such the IGCC or any plant that includes CO_2 capture, the cost estimates in Table 5-5 represent a plant that is somewhere between FOAK and NOAK, sometimes referred to as "next-of-a-kind". Because there are a number of projects currently under development, the EPA believes it is reasonable to focus on the next-of-a-kind costs provided in Table 5-5. See the preamble for additional discussion.

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environmental profile of these facilities under different configurations that were tailored to achieve a specific level of carbon capture. EPA selected NETL cost and performance characteristics for NGCC to ensure that the cost comparisons between NGCC and coal-fired technologies – the primary comparison made in this chapter – represented a single, internally consistent framework. For technologies where NETL cost and performance estimates were not available or sufficiently recent – such as for nuclear and simple cycle CT – EPA adopted EIA's AEO 2013 estimates of LCOE.

To represent a new SCPC facility, NETL assumed a new boiler with a combination of low-NOx burners (LNB) with overfire air (OFA) and a selective catalytic reduction (SCR) system for NOx control. The plant was assumed to have a fabric filter and a wet limestone FGD scrubber for particulate matter and SO_2 control, respectively. For configurations including CCS, the plant was assumed to have a sodium hydroxide (NaOH) polishing scrubber to ensure that the flue gas entering the CO_2 capture system has a SO_2 concentration of 10 ppmv or less. The SCPC w/ CCS plant configurations were equipped with Fluor's Econamine FG Plus^{SM} process for post-combustion CO_2 capture via temperature swing absorption with a monoethanolamine (MEA) solution as the chemical solvent.

Specific to the partial capture configurations for SCPC, the NETL study identified two options. The first option identified was to process the entire flue gas stream through the MEA capture system, but at reduced solvent circulation rates. The second option was to maintain the same high solvent circulation rate and stripping steam requirement as would be used for full capture, but only treat a portion of the total flue gas stream. The NETL report determined that this "slip stream" approach was the most economical because a reduction in flue gas flow rate will: (1) decrease the quantity of energy consumed by flue gas blowers; (2) reduce the size of the CO_2 absorption columns; and (3) trim the cooling water requirement of the direct contact cooling system.[39] The "slip stream" approach – which leads to lower capital and operating costs – was adopted by EPA for cost and performance estimates under partial capture.

For a new IGCC EGU, the NETL study evaluated a number of IGCC plant configurations. EPA adopted the configurations presented as the most viable – from both an economic and technological perspective – for the no capture, partial capture, and full capture cases. The no CO_2 capture case employed an IGCC that used the two-stage acid gas (Selexol™) process for acid gas control (i.e., hydrogen sulfide (H_2S) and CO_2) but no WGS reactor. The 25 percent CO_2

[39] NETL based this determination primarily upon literature review. Please refer to page 2 of http://www.netl.doe.gov/energy-analyses/pubs/Gerdes-08022011.pdf

capture case utilized the same two-stage Selexol™ unit to maximize CO_2 capture from the unshifted syngas. To achieve higher CO_2 capture levels – including full capture - the IGCC was assumed to be configured with a two-stage WGR with bypass and the two-stage acid gas (Selexol™) scrubbing system. [40] In summary, the technology cost and performance characteristics utilized by EPA in developing the LCOE estimates provided in this chapter are listed below in Table 5-7.

Table 5-5. Technology Cost and Performance (2011$)

Capacity Type	Total Overnight Capital Cost ($/kw)	Fixed Operations & Maintenance ($/kw-yr)	Variable Operations & Maintenance ($/MWh)	2020 Fuel Cost ($/MMBtu)	Net Plant HHV Efficiency (%)
NGCC	891	26.7	1.8	5.00	50.2
SCPC	2,452	70.6	7.7	2.94	39.3
SCPC w/ Partial CCS (1,100 lbs/MWh gross)	3,301	90.7	10.5	2.94	34.5
SCPC w/Full CCS (200 lbs/MWh gross)	4,391	116.6	14.1	2.94	28.4
IGCC	2,969	94.8	9.3	2.94	39.0
IGCC w/ Partial CCS (1,100 lbs/MWh gross)	3,274	103.2	10.1	2.94	37.3
IGCC w/ Full CCS (150 lbs/MWh gross)	4,086	125.6	12.1	2.94	32.6

Notes: The coal assumed is a bituminous coal with a sulfur content of 2.8% (dry) at a price of $2.94/MMBtu, consistent with the NETL analysis from which technology cost and performance as well as fuel price was sourced.[41] The natural gas price is the 2020 price from EIA's AEO 2013 Reference Case. NETL explains that there are a range of future potential costs that are up to 15% below, or 30% above the central estimate provided in Table 5-5.), consistent with a "feasibility study" level of design engineering applied to the various cases in this study. The value of the studies lie not in the absolute accuracy of the individual case results but in the fact that all cases were evaluated under the same set of technical and economic assumptions. This consistency of approach allows meaningful comparisons among the cases evaluated.

[40] For additional detail and discussion on the specific technology configurations selected for this analysis, please refer to the preamble.

[41] http://www.netl.doe.gov/energy-analyses/pubs/BaselineCostUpdate.pdf

5.5.3 Levelized Cost of Electricity of New Generation Technologies

This section presents four LCOE comparisons[42]:

1. NGCC to Uncontrolled Coal – to demonstrate the cost advantages of NGCC over a range of natural gas prices and regional market conditions.

2. Uncontrolled Coal to Coal with partial CCS – to demonstrate that any requirement for CCS could be accommodated and would not, based on the cost increment of constructing and operating the CCS portion, preclude new coal construction.

3. Coal with partial CCS to Nuclear – to demonstrate that the overall cost of building coal with partial CCS is not fundamentally different than the overall cost of constructing a nuclear facility.

4. NGCC to CT – to demonstrate the unlikelihood of a new combustion turbine being built with the expectation of exceeding a 33% annual capacity factor and thus being covered by this proposal.

It should be noted that the LCOE comparisons presented in this section only represent the cost to the generator and do not reflect the additional social costs that are associated with emissions of greenhouse gases or other air pollutants. A broader consideration of the health and welfare impacts of emissions from these technologies is considered beginning in Section 5.7.

Additionally, it is important to note that both EIA and EPA apply a climate uncertainty adder (CUA) - represented by a three percent increase to the weighted average cost of capital – to new, conventional coal-fired capacity types. EIA developed the CUA to address differences in how investments in new capacity are evaluated in power sector models as compared to resource planning exercises commonly conducted by the industry. While baseline power sector modeling scenarios may not specify potential future GHG regulatory requirements, investors in the industry typically incorporate some expectation of a future cost to limit CO_2 emissions in resource planning evaluations that influence investment decisions. [43] Therefore, the CUA reflects the additional risk typically assigned by project developers and utilities to GHG-

[42] "The illustrative unit cost and performance characteristics used in this section assume representative costs associated with spatially dependent components, such as connecting to existing fuel delivery infrastructure and the transmission grid. In practice units may experience higher or lower costs for these components depending on where they are located.

[43] http://www.eia.gov/forecasts/aeo/electricity_generation.cfm

intensive projects in a context of climate uncertainty. When comparing private investment costs, EPA believes the inclusion of the CUA in LCOE estimates is consistent with the industry's current planning and evaluation framework for future projects (demonstrable through IRPs and public utility commission orders) and is therefore necessary to adopt in evaluating the behavioral response to the cost competitiveness of alternative generating technologies.[44]

In defining the CUA, EIA states that "the adjustment should not be seen as an increase in the actual cost of financing, but rather as representing the implicit hurdle being added to GHG-intensive projects to account for the possibility they may eventually have to purchase allowances or invest in other GHG emission-reducing projects that offset their emissions."[45] Therefore, EPA recognizes the application of the CUA is context dependent – as a part of the planning process it is appropriately applied in an evaluative sense to prospective projects, and then removed once a project transitions from planning to execution. Although a perspective that omits the CUA is inconsistent with the purposes of the analysis contained in this section (i.e., analyzing the project characteristics and market conditions that would lead a developer or utility to select a certain project, not determine what the actual project costs would be once that project selection is made), LCOE estimates for uncontrolled coal-fired projects are presented both with and without the CUA. All LCOE estimates of coal-fired facilities with CCS (partial or full) are presented without the CUA.

5.5.4 Levelized Cost of Electricity of NGCC and Uncontrolled Coal

EPA's base LCOE estimates for NGCC, SCPC, and IGCC are displayed below by cost component (capital, FOM, VOM, fuel) and assume a construction date of 2020:

[44] For example, a 2011 Synapse Report lists 15 utilities that adopted a value for CO2 in their integrated resource planning. http://www.synapse-energy.com/Downloads/SynapsePaper.2011-02.0.2011-Carbon-Paper.A0029.pdf. In addition to utilities, several state commissions have mandated the inclusion of a cost of CO2 in long-term planning (e.g., Minnesota utilities must adopt a price beginning in 2017).

[45] http://www.eia.gov/forecasts/aeo/electricity_generation.cfm

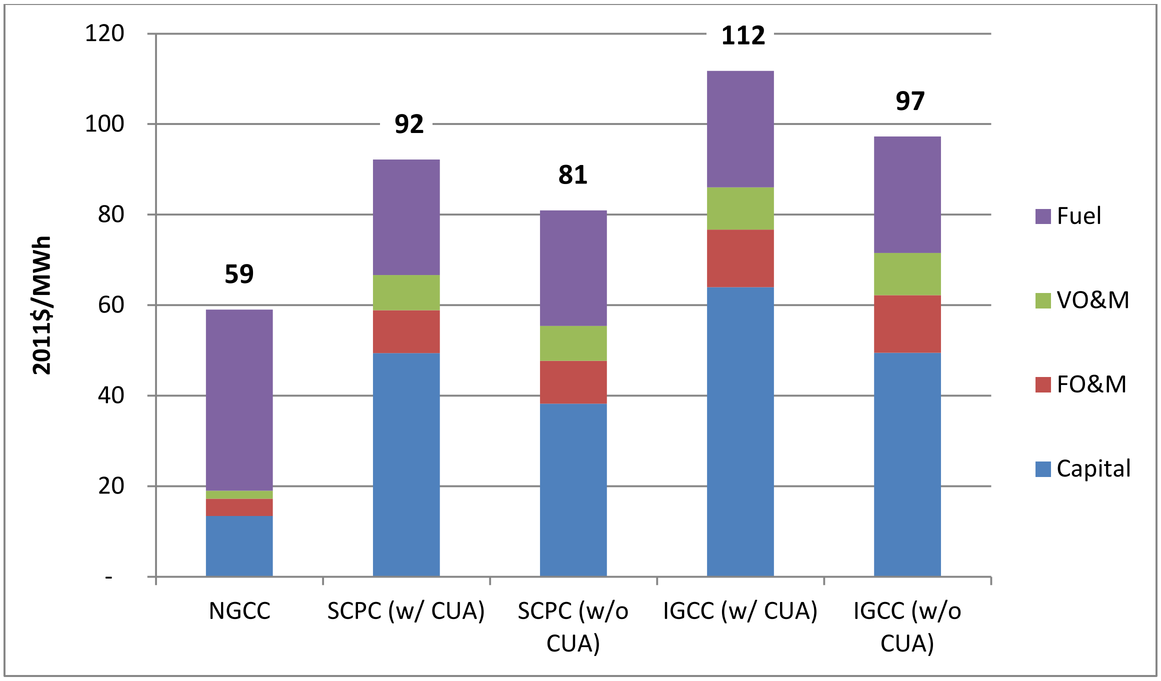

Figure 5-3. Illustrative Wholesale Levelized Cost of Electricity of Alternative New Generation Technologies by Cost Component, EPA[46]

Notes: The coal assumed is a bituminous coal with a sulfur content of 2.8% (dry) at a price of $2.94/MMBtu, consistent with the NETL analysis from which technology cost and performance was sourced[47]. The $2.94/MMBtu delivered coal price is assumed for all years; therefore, the price serves as both the 2020 fuel cost as well as the levelized fuel cost over any future period of time. This assumption produces a 20-year levelized coal price consistent with the AEO2013 Reference Case's $2.79/MMBtu projection average delivered price to the electricity sector for all coals. A capacity factor of 85 percent is assumed across all technologies. For comparison, EIA estimates levelized costs under AEO 2013 assumptions for SCPC and IGCC are $99/MWh and $122/MWh, respectively, including a 3% CUA and excluding transmission investment costs.[48] The levelized costs presented above are based on NETL assumptions and will necessarily differ from AEO 2013 levelized costs for a variety of reasons, including cost and performance characteristics, financial assumptions, and fuel input prices. The LCOE for NGCC assumes a $6.11/MMBtu levelized natural gas price – additional information on this assumption is provided later in this section (see Table 5-6).

On a levelized cost basis, NGCC is significantly cheaper than all of the uncontrolled coal-fired options, including those options that assume no CUA. In addition to the disparity in LCOE totals, the cost composition exhibits fundamental differences between natural gas- and coal-

[46] Although EPA believes that this cost data is broadly representative of the economics between new coal and new natural gas facilities, this analysis assumes representative new units and does not reflect the full array of new generating sources that could potentially be built. To the extent that other types of new units that would be affected by this rule are built, they may exhibit different costs than those presented here. For example, new conventional coal facilities of a size smaller than what is assumed in the base estimate would tend to exhibit a relatively higher LCOE, while some technologies could potentially display a lower LCOE if – all else equal - fuel could be obtained at a lower price than that assumed in this analysis (such as may be the case for petroleum coke or waste coal facilities). These potential differences do not fundamentally change the analysis presented in this chapter.

[47] http://www.netl.doe.gov/energy-analyses/pubs/Gerdes-08022011.pdf

[48] http://www.eia.gov/forecasts/aeo/electricity_generation.cfm

fired facilities, with NGCC dominated by fuel expense and the levelized cost of coal-fired technologies driven by capital expense. Consequently, this section will explore the impact of changes in natural gas price and the capital costs of coal-fired facilities to better quantify the magnitude of the relative cost advantage NGCC exhibits over coal-fired alternatives.

The figure below presents the LCOE of an NGCC facility at three levelized natural gas price levels. For reference, the base LCOE estimates for SCPC and IGCC are included as well.[49]

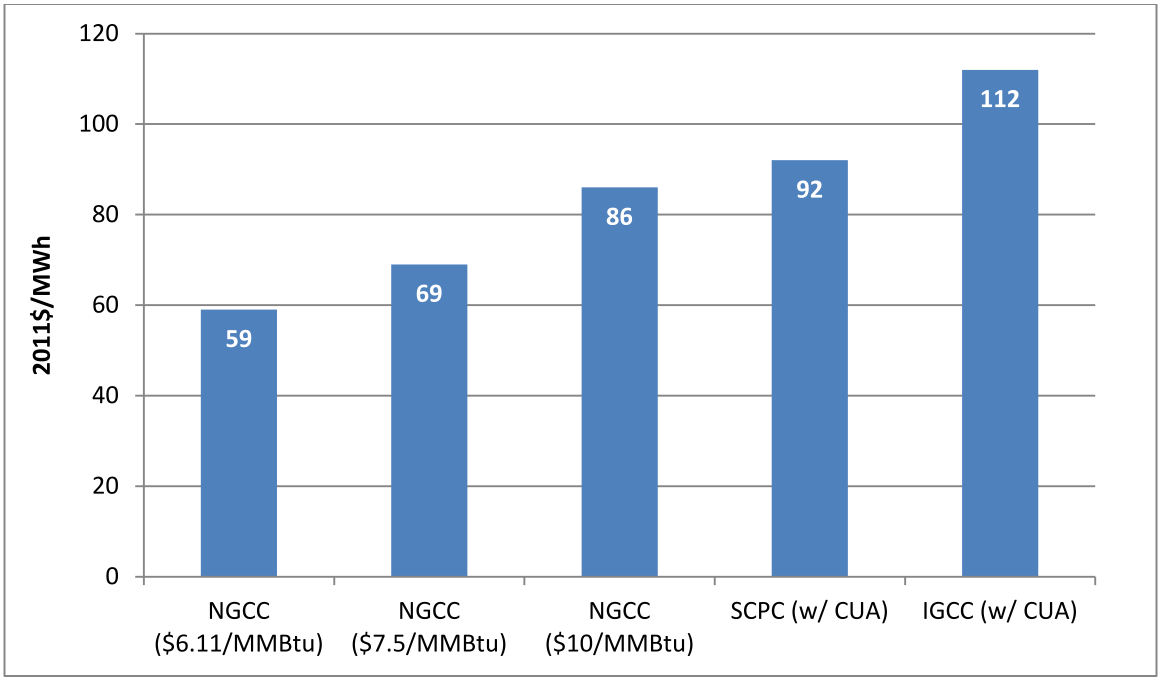

Figure 5-4. Illustrative Wholesale Levelized Cost of Electricity of Alternative New Generation Technologies Across Select Natural Gas Prices, EPA

It is only when natural gas prices exceed $10/MMBtu on a levelized basis (in 2011 dollars) that new coal-fired generation without CCS approaches parity with NGCC in terms of LCOE (none of the EPA sensitivities or AEO 2013 scenarios described in this chapter project national average natural gas prices near that level).[50] To achieve a $10/MMBtu levelized price

[49] Some new units could be designed to combust waste coal or petroleum coke (pet coke), which may be affected by this rule. These technologies could exhibit different local economics, particularly in the delivered price of fuel. From a capital and operating perspective, EPA believes the cost and performance of these units are broadly similar and therefore well represented by new, conventional coal-fired facilities (i.e. SCPC).

[50] As noted earlier in this chapter, investment decisions require consideration of fuel price projections over long periods of time; similarly, the power sector modeling cited here make fuel price projections over long periods of time. Neither these modeling projections nor these LCOE calculations are meant to suggest that the gas price could not reach as high as $10/MMBtu at any given point in time; the point is that these analyses do not

in 2020 would require a significantly more pessimistic natural gas outlook than what is contained in AEO's low natural gas resource scenario. To illustrate, Table 5-6 report the levelized natural gas prices (initial year of 2020) for both a 20-year period (to accommodate the end of EIA's modeling projections in 2040) and 30-year period (calculated by continuing the projected level of price increases through 2050).

Table 5-6. Levelized Natural Gas Prices by Select AEO 2013 Scenario (2011$/MMBtu)

Scenario	20-Year AEO Projection (2020-2039)	30-Year AEO-Based Projection (2020-2049)
Reference	6.11	6.79
High Growth	6.69	7.30
Low Growth	5.64	6.32
High Coal Cost	6.51	7.28
Low Coal Cost	6.00	6.74
High Gas/Oil Resource	4.09	4.40
Low Gas/Oil Resource	7.63	8.50

Note: Discount rate of 5%, consistent with IPM assumptions. The 30-year natural gas price is calculated by applying the price increase from 2039 to 2040 in all subsequent years through 2049.

To achieve a price that exceeds $10/MMBtu on a 20-year levelized basis in 2020 would require a natural gas price projection more than 30% higher than EIA's low resource scenario in all years – see Figure 5-5 below. This elevated natural gas price would result in a $10.15/MMBtu average annual price in 2030 ($16.23/MMBtu nominal) and a $13.66/MMBtu price in 2039 ($27.27/MMBtu nominal).[51]

expect such a price level to be sustained over a period of time that would influence an economic assessment of which type of new capacity offers a better investment.

[51] Nominal prices assuming an annual inflation rate of 2.5%.

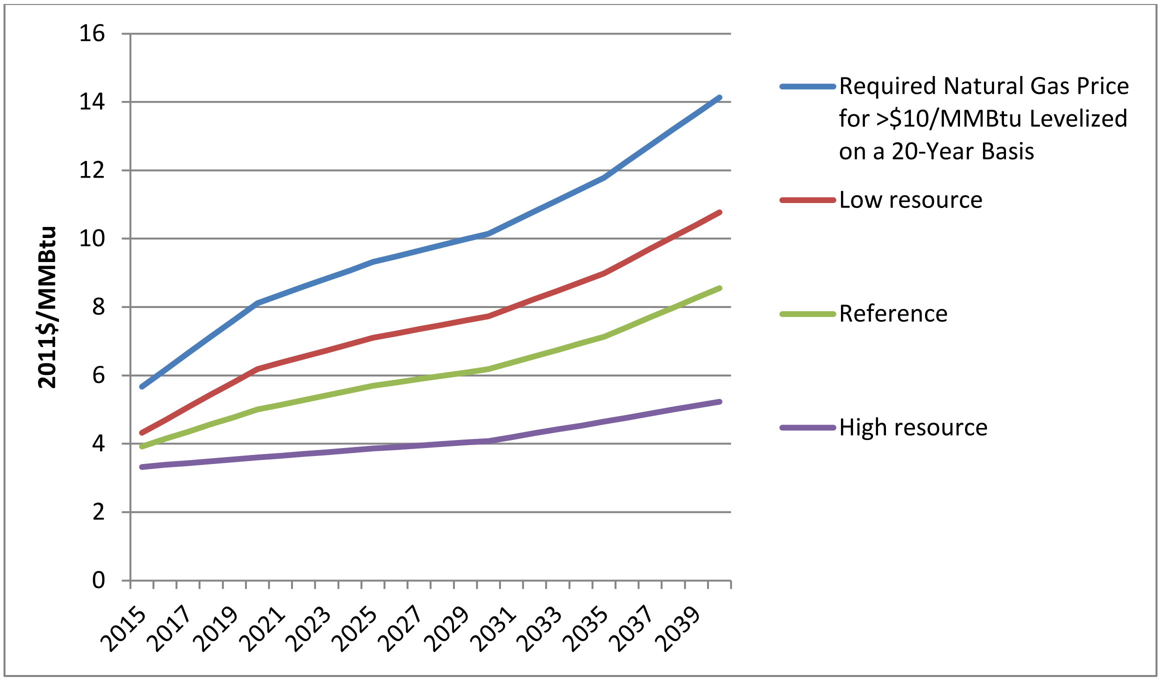

Figure 5-5. Projected Real National Delivered Natural Gas Price for Select AEO 2013 Scenarios and Illustrative Path for > $10/MMBtu Levelized Cost

To conclude the comparison of NGCC with uncontrolled coal-fired alternatives, it is important to note that the LCOE calculations are based on assumptions regarding the average national cost of generation at new facilities. It is known that there is significant spatial variation in the costs of new generation due to design differences, labor wage and productivity differences, and delivered fuel prices among other potential factors.[52]

For example, EIA utilizes capital cost scalars to capture regional differences in labor, material, and construction costs. The minimum and maximum capital cost scalars across all regions in AEO 2013 for SCPC, IGCC, and NGCC build options are presented below in Table 5-7:[53]

Table 5-7. AEO 2013 Regional Capital Cost Scalars by Capacity Type

Capacity Type	Minimum Capital Cost Scalar	Maximum Capital Cost Scalar
SCPC	0.885	1.152
IGCC	0.908	1.136
NGCC	0.893	1.205

[52] http://www.eia.gov/oiaf/beck_plantcosts/pdf/updatedplantcosts.pdf
[53] Excluding the New York City and Long Island areas, as well as those areas of the country that prohibit the development of new, uncontrolled coal-fired facilities.

Applying the regional capital cost scalars displayed above to the base LCOE estimates developed earlier in this section produces only a small change in the relative competitiveness of the technologies as seen in Table 5-8.

Table 5-8. LCOE Estimates with Minimum and Maximum AEO 2013 Regional Capital Cost Scalars (2011$/MWh)

Capacity Type	Reference (w/ 3% CUA)	Minimum Capital Cost Scalar	Maximum Capital Cost Scalar
SCPC	92	86	100
IGCC	112	106	120
NGCC	59	58	62

The LCOE of SCPC in the lowest capital cost region still results in an LCOE that is ~40% higher than an NGCC located in the most expensive capital cost region. IGCC remains more than 70% higher under a similar adjustment. In addition to the relatively small changes in LCOE displayed above, the relative movement in LCOE that can be attributed to regional variations in capital cost is further muted by the fact that a high or low capital cost region for coal-fired build types is projected to be a high or low capital cost region for gas-fired build types. Due to its capital-intensive nature, the most favorable regions for development of new coal-fired capacity over NGCC are the lowest cost areas – an assumption that only narrows NGCC's LCOE advantage by $5/MWh for both SCPC and IGCC. To completely negate the base $33/MWh LCOE advantage of NGCC over SCPC solely with a reduction in coal-fired capital costs, overnight capital costs for SCPC would have to be reduced from $2,452/kW to ~$800/kW; IGCC overnight capital costs would have to be reduced to~$500/kW.

The other primary driver in determining the regional impact on competitiveness of new build options is delivered fuel prices. As part of the AEO, EIA releases electric power projections – including fuel prices – for each of the 22 Electricity Market Module (EMM) regions. The two regions with the highest projected 2020 natural gas prices in the AEO 2013 are the Western Electricity Coordinating Council/Southwest ('Southwest') and the Florida Reliability Coordinating Council (FRCC). The 20-year levelized natural gas and coal price forecasts (2020-2039) in the AEO 2013 reference case are displayed in Figure 5-6 for both regions.

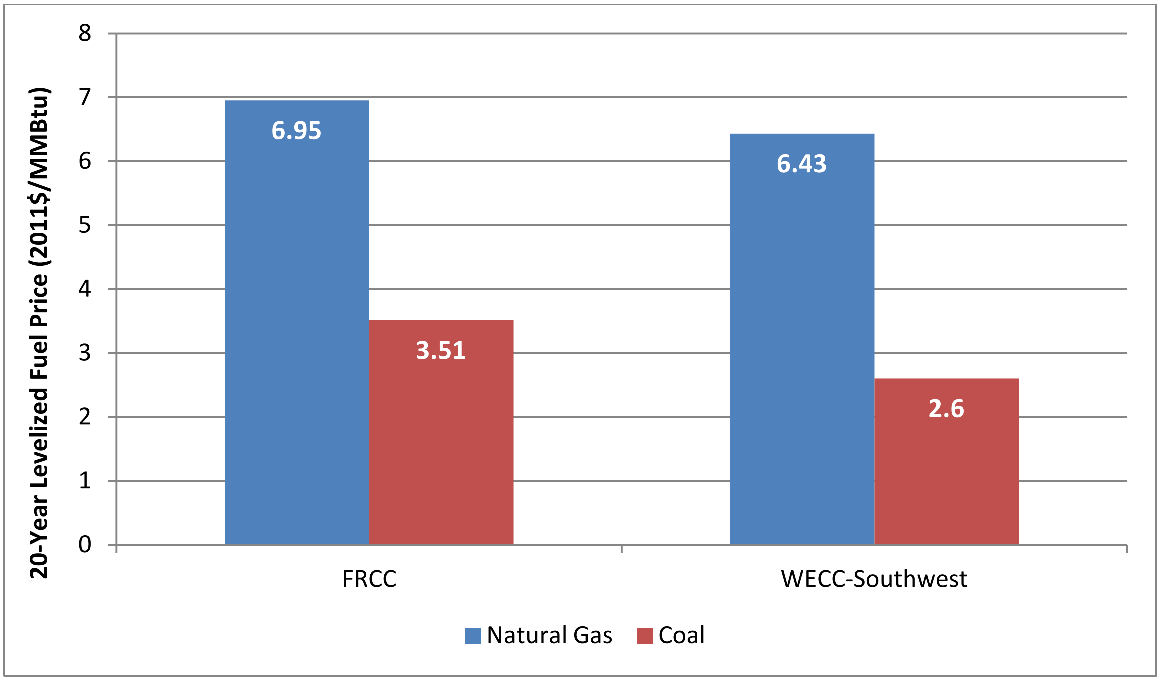

Figure 5-6. Levelized Regional Fuel Price from AEO 2013 Reference Case, 2020-2039 (2011$/MMBtu)[54]

While the FRCC region experiences the highest overall natural gas prices, the Southwest region realizes a greater $/MMBtu differential between coal and natural gas prices under the AEO projections; the impact on the LCOE of SCPC, IGCC, and NGCC is reported in Table 5-9 for both sets of fuel prices.

Table 5-9. LCOE Estimates For Minimum and Maximum AEO 2013 Regional Capital Cost Scalars (2011$/MWh)

Capacity Type	Reference (w/ 3% CUA)	FRCC Fuel Prices	Southwest Fuel Prices
SCPC (w/ 3% CUA)	92	97	89
IGCC (w/ 3% CUA)	112	117	109
NGCC	59	65	62

Due to the greater fuel price differential, the more favorable region for the development of coal-fired facilities from an LCOE perspective is the Southwest, where the regional fuel prices reduce the LCOE advantage of NGCC to $27/MWh over SCPC and $47/MWh over IGCC.

[54] Assuming 5% discount rate.

In conclusion, even the most favorable combination of regional variability in capital costs and delivered fuel prices represented by EIA are insufficient to support new, unplanned, conventional coal-fired capacity in the analysis period.

5.5.5 Levelized Cost of Electricity of Uncontrolled Coal and Coal with Carbon Capture and Storage (CCS)

The power sector continues to move away from the construction of coal-fired power plants in favor of natural gas-fired power plants due, in part, to the significant LCOE differential explored in the previous section. Even so, it is possible that a limited number of conventional coal-fired power plants might be constructed in the analysis period. In these circumstances, EPA believes that any requirement for CCS could be accommodated and would not, based on the incremental cost of the CCS portion of the new unit, preclude the construction of the new coal-fired facility.[55]

One factor in this determination is the availability of ER opportunities for new coal-fired facilities. ER, which includes both EOR and EGR, refers to the injection of fluids into a reservoir to increase oil and/or gas production efficiency. CO_2-EOR has been successfully used at many production fields throughout the United States. The oil and natural gas industry in the United States has over 40 years of experience in injection and monitoring of CO_2. This experience provides a strong foundation for the technologies used in the deployment of CCS on coal-fired electric generating units. Although deep saline formations provide the most CO_2 storage opportunity (2,102 to 20,043 billion metric tons), oil and gas reservoirs are estimated to have 226 billion metric tons of CO_2 storage resource.[56]

The use of CO_2 for EOR can significantly lower the cost of implementing CCS. The opportunity to sell the captured CO_2 rather than paying directly for its long-term storage, greatly improves the economics of the new generating unit. According to the International Energy Agency, of the CCS projects under construction or at an advanced stage of planning, 70% intend to use captured CO_2 to improve recovery of oil in mature fields, including Southern Company's Kemper County Energy Facility, Summit Power's Texas Clean Energy Project, and the Hydrogen Energy California Project.

[55] The preamble provides a complete list of existing sources that have demonstrated CCS as well as new coal-fired facilities that will utilize CCS and are very near to completion.

[56] U.S. Department of Energy National Energy Technology Laboratory (2012). United States Carbon Utilization and Storage Atlas, Fourth Edition.

There are two EOR opportunities presented in Figure 5-16 – 'High' and 'Low.' The high EOR opportunity assumes a CO_2 sale price of $40 per metric ton; the low EOR opportunity assumes a CO_2 sale price of $20 per metric ton.[57] For either opportunity, it is assumed that the facility is only responsible for the costs of transmitting the captured CO_2 to the fence line, as is currently the practice.[58] Costs for the transportation, storage, and monitoring (TSM) of CO2 are included in this analysis. For non-EOR applications, TSM costs of ~$5-$15 dollars per ton of CO_2 are applied based on the level of capture.[59] Figure 5-7 compares the LCOE for uncontrolled coal to coal with partial CCS both with and without EOR. Although this proposal has determined partial CCS is BSER for affected coal-fired facilities, the LCOE associated with full capture is presented as well for illustrative purposes.

[57] The High and Low CO2 sale prices utilized by EPA are consistent with NETL's Base Case and Low Case sale prices, respectively (http://www.netl.doe.gov/energy-analyses/pubs/storing%20co2%20w%20eor_final.pdf). In addition, this range is broadly consistent with the CO2 sale price data collected by the Department of Interior for projects located on federal lands (http://statistics.onrr.gov/ReportTool.aspx). Prices are expressed in 2011$ and the price is expected to be static over time.

[58] For EOR applications the point of sale is typically the facility fence line, in which case the coal facility operator will avoid the TSM cost. Consequently, the economic benefit of EOR may be greater than simply the price paid for CO_2.

[59] This range is broadly consistent with estimates provided by NETL (http://www.netl.doe.gov/energy-analyses/pubs/QGESS_CO2T%26S_Rev2_20130408.pdf) and the Global CCS Institute (http://www.globalccsinstitute.com/publications/economic-assessment-carbon-capture-and-storage-technologies-2011-update).

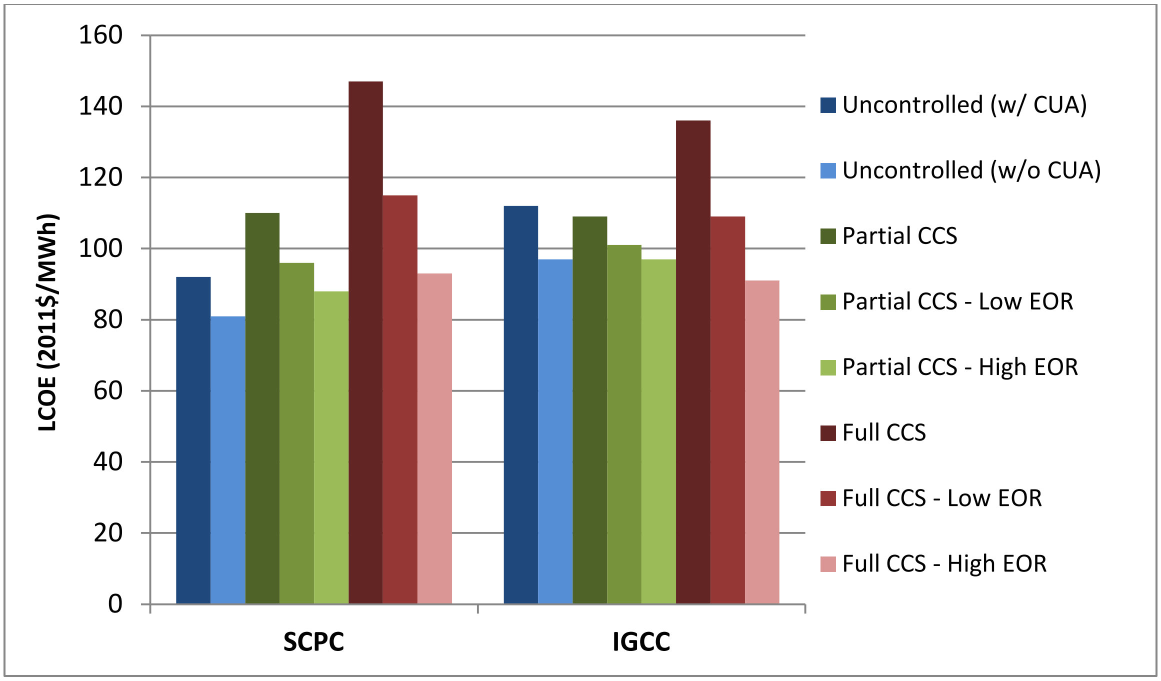

Figure 5-7. Levelized Cost of Electricity, Uncontrolled Coal and Coal with Full and Partial CCS (1,100 lbs/MWh gross)

NOTE: EIA estimated LCOE under AEO 2013 assumptions for full capture SCPC+CCS is estimated at a LCOE of $134 without EOR. No estimate is provided for IGCC+CCS or partial capture technologies.[60]

EPA believes the opportunity to engage in EOR opportunities is not significantly limited by the location of those opportunities or the current CO_2 pipeline infrastructure (12 states currently have existing or under construction CO_2 pipelines). Provision of electric power does not require coal-fired facilities to be co-located with the demand it is intended to serve. Please refer to Chapter 4 for a more detailed discussion of ER, including its geographic availability, expected future growth, and overall impact on the economics of CCS.

5.5.6 Levelized Cost of Electricity of Coal with Carbon Capture and Storage and Nuclear

There are five nuclear units currently under construction in the United States – Vogtle Units 3 and 4, Summer Units 2 and 3, and Watts Bar 2 – as well as nine active applications under U.S. Nuclear Regulatory Commission (NRC) review covering an additional 14 potential units. The addition of Units 3 and 4 at Georgia Power's Plant Vogtle will be the first new nuclear units built in the United States in 30 years. Although it is unlikely that all of the proposed nuclear projects will be built, the renewed interest in new nuclear facilities – despite persistently high capital costs – is driven by a host of factors, including climate and air quality

[60] http://www.eia.gov/forecasts/aeo/electricity_generation.cfm

concern, the value attached to fuel diversity, regional or local base load capacity needs, and supportive regulatory environments.

As shown in Figure 5-8 on an LCOE basis, the cost of new nuclear is similar to the cost of new coal with partial CCS without EOR. Factoring in the revenues associated with the low EOR opportunity ($20 per ton of CO_2 and no transportation storage and monitoring – TSM – obligation) reduces the cost of coal with CCS to levels that are 6-10% lower than new nuclear; assuming a high EOR opportunity ($40 per ton of CO_2 and no TSM obligation) reduces the cost of SCPC with CCS and IGCC with CCS to 18% and 9% below new nuclear, respectively. The current activity related to new nuclear development at a cost that is broadly similar to coal with CCS is a demonstration of the industry's willingness to develop higher cost projects that produce low-emitting base load capacity that contributes to fuel diversity.

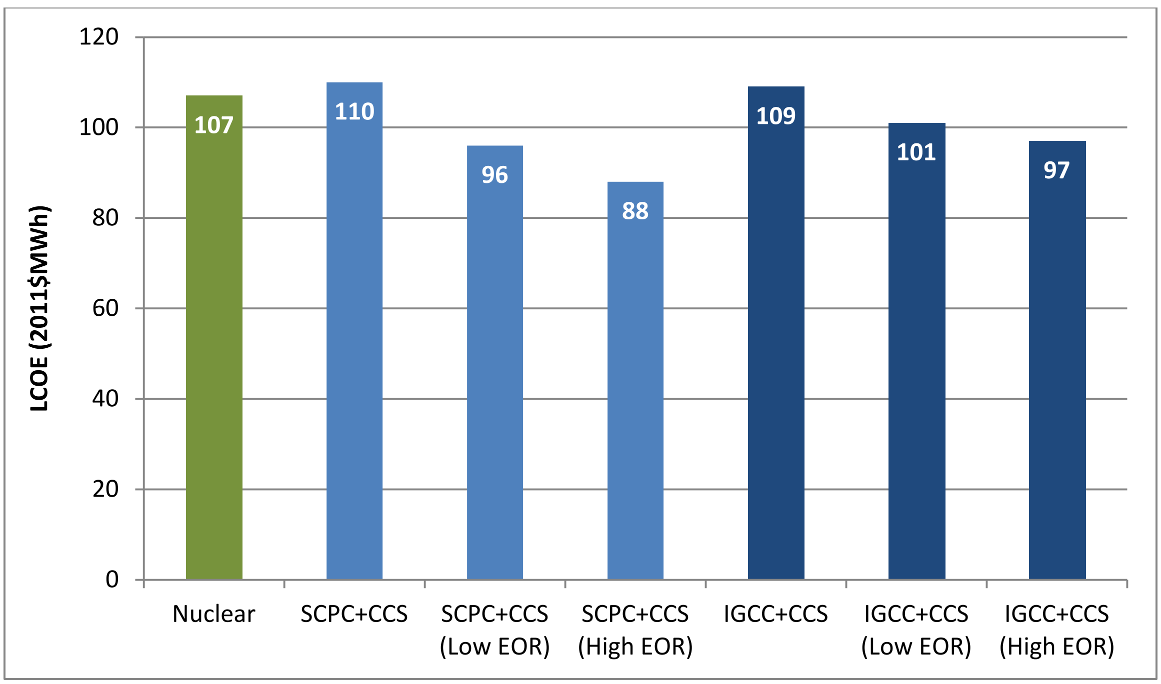

Figure 5-8. Levelized Cost of Electricity, Nuclear and Coal with Partial CCS (1,100 lbs/MWh gross)

5.5.7 Levelized Cost of Simple Cycle Combustion Turbine and Natural Gas Combined Cycle

CTs fulfill a fundamentally different function in power sector operations than that of NGCC and coal-fired facilities. CTs are designed to start quickly in order to meet demand for electricity during peak operating periods and are generally less expensive to build (on a capital cost basis) but are also less fuel efficient than combined cycle technology, (which employs heat recovery systems). Due to lower fuel efficiencies, CTs produce a significantly higher cost of electricity (cost per kWh) at higher capacity factors and consequently are typically utilized at levels well below the proposed threshold for sources affected by the proposed EGU New Source GHG Standards (1/3 of potential electric output). Instead, these units are most often built to ensure reserve margins are met during peak periods (typically in the summer), and in some instances are able to generate additional revenues by selling capacity into power markets. Thus, in practice, EPA expects that potential CT units would not meet the applicability threshold in this proposed action and would not be subject to any standard.

Mirroring real world behavior, relatively low levels of CT generation are projected in both EPA and EIA modeling frameworks. AEO 2013 projects a capacity factor for CTs of less than 20% in all regions and in all years. EPA's IPM modeling projects a capacity factor for individual new CTs of 8.5% or less in all simulation years. Thus, these potential new units do not meet the applicability threshold for this proposal, and there is no projected cost or emissions impact on new CT units.

To illustrate the economic impracticality of utilizing combustion turbines in an intermediate and base load mode of operation, Figure 5-18 displays the LCOE estimates for a CT and NGCC at increasing capacity factors. The estimates utilize the AEO2013 Reference Case natural gas price for 2014 (representative of the lowest – and therefore most favorable to the relative levelized cost of a CT – natural gas price during the analysis period).

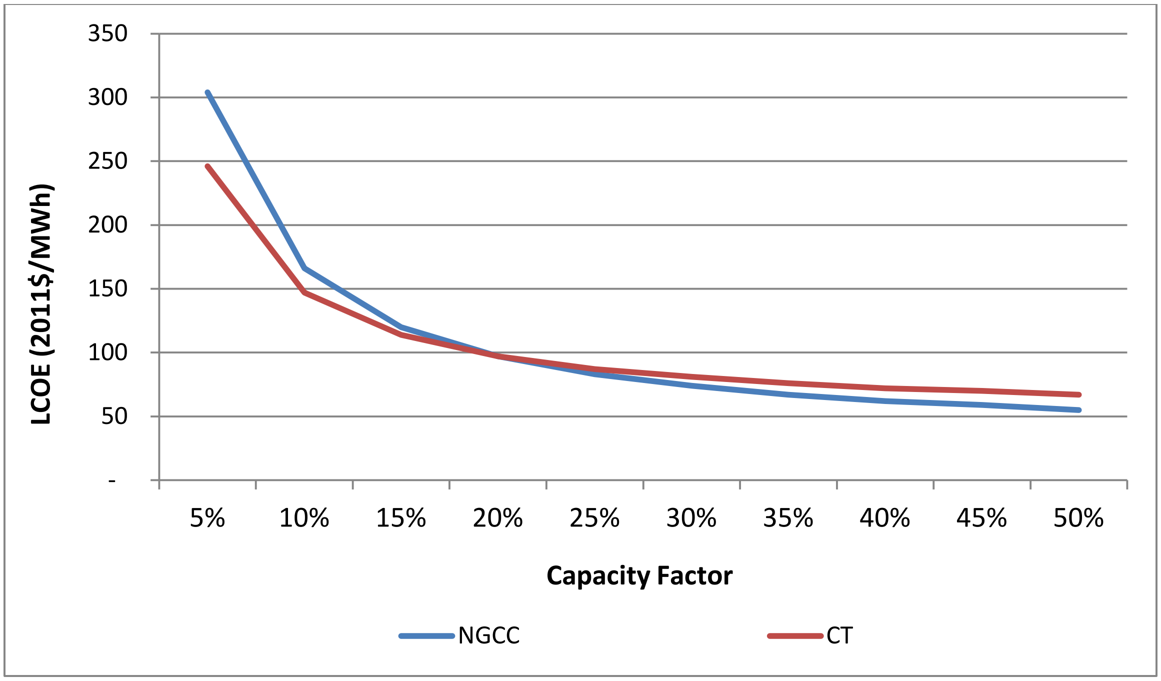

Figure 5-9. Levelized Cost of Electricity Across a Range of Capacity Factors, CT and NGCC ($2011/MWh at $3.84/MMBtu Levelized Natural Gas Price)

In the LCOE figure above, utilizing a CT for generation is less expensive than an NGCC only at capacity factors of less than 20%.[61] If expected utilization is greater than 20%, it can reasonably be expected that a utility or developer would seek to deploy NGCC over CT for a host of economic, environmental, and technical reasons. Unanticipated short term utilization of CTs above a 33% capacity factor would not be expected to alter this dynamic as utilization is evaluated over a 3-year averaging period to determine the applicability of the proposed standards.

5.6 Comparison of Emissions from Generation Technologies

As discussed earlier in this chapter, NGCC units are on average expected to be more economical to build and operate than new coal units. These natural gas units also have lower emission profiles for CO_2 and criteria air pollutants than new coal units. While the proposed EGU New Source GHG Standards is anticipated to have negligible costs or quantified benefits under a range of likely market conditions, it is instructive to consider the differences in emissions of CO_2 and other air pollutants between the two types of units.

[61] CT cost, performance, and financial assumptions from AEO 2013.

As Table 5-19 below shows, emissions from a typical new NGCC unit are significantly lower than those from a new coal unit.[62] For example, a typical new supercritical pulverized coal facility that burns bituminous coal in compliance with new utility regulations (e.g., MATS) would have considerably greater CO_2, SO_2, NO_x, toxic metals, acid gases, and particulate emissions than a comparable natural gas combined cycle facility. A typical natural gas combined cycle unit emits two million metric tons less CO_2 per year than a typical new conventional coal unit, as well as 2,000 fewer short tons SO_2 and about 1,200 fewer short tons of NO_x each year. Importantly, these differences in emissions assume a new coal unit that complies with all applicable final regulations, including MATS. Reductions in SO_2 emissions are a particularly significant driver for monetized health benefits, as SO_2 is a precursor to the formation of particulates in the atmosphere, and particulates are associated with premature death and other serious health effects. Further information on these pollutants' health effects is included in the next subsection.

Table 5-10. Illustrative Emissions Profiles, New Coal and Natural Gas-Fired Generating Units

	Natural Gas CC		***SCPC***		***SCPC+CCS (1,100 lbs/MWh Gross)***		***IGCC***		***IGCC+CCS (1,100 lbs/MWh Gross)***	
	Emissions (tons/ year)	Emission Rate (lbs/ MWh net)	Emissions (tons/ year)	Emission Rate (lbs/ MWh net)	Emissions (tons/ year)	Emission Rate (lbs/ MWh net)	Emissions (tons/ year)	Emission Rate (lbs/ MWh net)	Emissions (tons/year)	Emission Rate (lbs/ MWh net)
SO_2	10	0.0041	1,700	0.74	1,100	0.48	23	0.010	30	0.013
NO_x	130	0.060	1,400	0.61	1,500	0.69	1,200	0.52	1,200	0.52
CO_2	1.7 million	800	4.0 million	1,800	2.7 million	1,200	3.8 million	1,700	3.0 million	1,400

Notes: SO_2 and NO_x in short tons, CO_2 in metric tons. Values rounded to two significant digits. Emission characteristics are based on, and thus consistent with the cost and performance assumptions of, the illustrative units described in LCOE analysis above (e.g., that these are base load units running at 85 percent capacity factor, all coal units are assumed to be using bituminous coal with a sulfur content of 2.8% dry, etc.). Here we further assume all units are of the same capacity (600 MW net). Utilizing a consistent net capacity metric across plant types requires a higher gross capacity for those types with greater need for auxiliary power. The tons of emissions associated with a facility are driven by gross capacity.

5.7 Benefits of Reducing GHGs and Other Pollutants

Society is not only affected by differences in the private generating costs of different technologies, it also experiences the benefit or the burden of relative differences in emissions

[62] Estimated emissions of CO_2, SO_2, and NO_X for the illustrative new coal and natural gas combined cycle units could vary depending on a variety of assumptions including heat rate, fuel type, and emission controls, to name a few.

produced by these generation technologies. As such, the appropriate social welfare comparison should also account for the health, ecological and other emissions impacts of different generation technologies. In particular, emissions of CO_2 and other pollutants lead to additional social costs of these technologies. Any relative differences in these emissions between newly built electric generating technologies would translate into relative climate-related and human health benefits. This section provides a general discussion about how the climate-related and human health benefits of emission reductions are estimated.

5.7.1 Social Cost of Carbon

The social cost of carbon (SCC) is a metric that estimates the monetary value of impacts associated with marginal changes in CO_2 emissions in a given year. It is intended to include (but is not limited to) changes in net agricultural productivity, human health, property damages from increased flood risk, and the value of ecosystem services due to climate change. It is typically used to assess the avoided damages, i.e. benefits, of rulemakings that achieve marginal reductions in CO_2 emissions. This analysis applies SCC to illustrate the value of the difference in CO_2 emissions among different generation technologies discussed in Section 5.5.

The federal government typically uses the SCC to estimate the social benefits of CO_2 reductions from regulatory actions that impact cumulative global emissions. An interagency process that included the EPA and other executive branch entities used three integrated assessment models (IAMs) to develop SCC estimates and selected four global values for use in regulatory analyses. Three values are based on the average SCC from the three IAMs, at discount rates of 5, 3, and 2.5 percent. SCCs at several discount rates are included because the literature shows that the SCC is quite sensitive to assumptions about the discount rate, and because no consensus exists on the appropriate rate to use in an intergenerational context (where costs and benefits are incurred by different generations). The fourth value is the 95th percentile of the SCC from all three models at a 3 percent discount rate. It is included to represent higher-than-expected impacts from temperature change further out in the tails of the SCC distribution (representing less likely, but potentially catastrophic, outcomes). The SCC Technical Support Document (SCC TSD) provides a complete discussion of the methods used to develop these estimates.[63]

[63] Docket ID EPA-HQ-OAR-2009-0472-114577, *Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866, Interagency Working Group on Social Cost of Carbon*, with participation by Council of Economic Advisers, Council on Environmental Quality, Department of Agriculture, Department of Commerce, Department of Energy, Department of Transportation, Environmental Protection Agency, National Economic Council, Office of Energy and Climate Change, Office of Management and Budget,

The federal government recently updated these estimates, using new versions of each integrated assessment model and published them in May 2013. The 2013 process did not revisit the 2010 interagency modeling decisions (e.g., with regard to the discount rate, reference case socioeconomic and emission scenarios or equilibrium climate sensitivity). Rather, improvements in the way damages are modeled are confined to those that have been incorporated into the latest versions of the models by the developers themselves and used in peer-reviewed publications. The model updates that are relevant to the SCC estimates include: an explicit representation of sea level rise damages in the Dynamic Integrated Climate and Economy (DICE) and Policy Analysis of the Greenhouse Effect (PAGE) models; updated adaptation assumptions, revisions to ensure damages are constrained by GDP, updated regional scaling of damages, and a revised treatment of potentially abrupt shifts in climate damages in the PAGE model; an updated carbon cycle in the DICE model; and updated damage functions for sea level rise impacts, the agricultural sector, and reduced space heating requirements, as well as changes to the transient response of temperature to the buildup of GHG concentrations and the inclusion of indirect effects of methane emissions in the Climate Framework for Uncertainty, Negotiation, and Distribution (FUND) model.[64]

The SCC estimates from the updated versions of the models are higher than those reported in the 2010 TSD, which were used in the April 2012 EGU New Source GHG Standards RIA. By way of comparison, the four 2020 SCC estimates reported in the 2010 TSD and used in the April 2012 EGU New Source GHG Standards proposal were $7, $28, $44 and $86 per metric ton (2011$). The corresponding four updated SCC estimates for 2020 are $13, $46, $69, and $138 per metric ton (2011$).[65,66]

Office of Science and Technology Policy, and Department of Treasury (February 2010). Also available at http://www.whitehouse.gov/sites/default/files/omb/inforeg/for-agencies/Social-Cost-of-Carbon-for-RIA.pdf

[64] Docket ID EPA-HQ-OAR-2013-0495, *Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866, Interagency Working Group on Social Cost of Carbon*, with participation by Council of Economic Advisers, Council on Environmental Quality, Department of Agriculture, Department of Commerce, Department of Energy, Department of Transportation, Environmental Protection Agency, National Economic Council, Office of Energy and Climate Change, Office of Management and Budget, Office of Science and Technology Policy, and Department of Treasury (May 2013). Also available at http://www.whitehouse.gov/sites/default/files/omb/inforeg/social_cost_of_carbon_for_ria_2013_update.pdf

[65] The 2010 and 2013 TSDs present SCC in $2007. The estimates were adjusted to $2011 using GDP Implicit Price Deflator, http://www.gpo.gov/fdsys/pkg/ECONI-2013-02/pdf/ECONI-2013-02-Pg3.pdf.

[66] The 2010 SCC TSD concluded that a global measure of the benefits from reducing U.S. emissions is preferable. The development of a domestic SCC is greatly complicated by the relatively few region- or country-specific estimates of SCC in the literature. See Interagency Working Group on Social Cost of Carbon. 2010. Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866.

When attempting to assess the incremental economic impacts of carbon dioxide emissions, the analyst faces a number of serious challenges. A report from the National Academies of Science (NRC 2009) points out that any assessment will suffer from uncertainty, speculation, and lack of information about (1) future emissions of greenhouse gases, (2) the effects of past and future emissions on the climate system, (3) the impact of changes in climate on the physical and biological environment, and (4) the translation of these environmental impacts into economic damages.[67] As a result, any effort to quantify and monetize the harms associated with climate change will raise serious questions of science, economics, and ethics and should be viewed as provisional.

The 2010 SCC TSD noted a number of limitations to the SCC analysis, including the incomplete way in which the integrated assessment models capture catastrophic and non-catastrophic impacts, their incomplete treatment of adaptation and technological change, uncertainty in the extrapolation of damages to high temperatures, and assumptions regarding risk aversion. Current integrated assessment models do not assign value to all of the important physical, ecological, and economic impacts of climate change recognized in the climate change literature because of a lack of precise information on the nature of damages and because the science incorporated into these models understandably lags behind the most recent research. The limited amount of research linking climate impacts to economic damages makes the interagency modeling exercise even more difficult.

While the new versions of the models used to estimate the values presented below offer some improvements in these areas, further work remains warranted. Accordingly, the EPA and other agencies continue to engage in research on modeling and valuation of climate impacts with the goal to improve these estimates. Additional details are provided in the SCC TSDs.

Table 5-11 presents the updated global SCC estimates for the years 2015 to 2050. In order to calculate the dollar value for emission reductions, the SCC estimate for each emissions year would be applied to changes in CO_2 emissions for that year, and then discounted back to the analysis year using the same discount rate used to estimate the SCC.[68] The SCC increases

[67] National Research Council (2009). *Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use*. National Academies Press. See docket ID EPA-HQ-OAR-2009-0472-11486.

[68] This analysis considered the climate impacts of only CO_2 emission change, as the U.S. Interagency Working Group on the Social Cost of Carbon has thus far only considered estimates for the social cost of CO_2. While CO_2 is the dominant GHG emitted by the sector, we recognize the representative facilities within these comparisons may also have different emission rates for other climate forcers which will serve a minor role in determining the overall social cost of generation.

over time because future emissions are expected to produce larger incremental damages as physical and economic systems become more stressed in response to greater climate change. Note that the interagency group estimated the growth rate of the SCC directly using the three integrated assessment models rather than assuming a constant annual growth rate. This helps to ensure that the estimates are internally consistent with other modeling assumptions.

Table 5-11. Social Cost of CO_2, 2015-2050[a] (in 2011$)

	Discount Rate and Statistic			
Year	5% Average	3% Average	2.5% Average	3% 95^{th} percentile
2015	$13	$41	$62	$116
2020	$13	$46	$69	$138
2025	$15	$51	$75	$154
2030	$17	$55	$81	$170
2035	$20	$61	$86	$188
2040	$22	$66	$93	$205
2045	$26	$70	$98	$220
2050	$29	$76	$105	$236

[a] The SCC values vary depending on the year of CO_2 emissions and are defined in real terms. These SCC values are stated in $/metric ton.

5.7.2 Health Co-Benefits of SO_2 and NO_x Reductions

Reducing power sector CO_2 under this rule would also result in reductions of SO_2 and NO_X emissions, which in turn would yield health benefits (we refer to these additional benefits as "co-benefits"). SO_2 is a precursor for fine particulate matter ($PM_{2.5}$) formation while NO_X is a precursor for $PM_{2.5}$ and ground-level ozone formation. As such, reductions of SO_2 and NO_X would in turn lower overall ambient concentrations of $PM_{2.5}$ and ozone. Reducing exposure to $PM_{2.5}$ and ozone is associated with significant human health benefits including avoided mortality and morbidity. Researchers have associated $PM_{2.5}$ and ozone exposure with adverse health effects in numerous toxicological, clinical, and epidemiological studies (U.S. EPA, 2009; U.S. EPA, 2013b). Health effects associated with exposure to $PM_{2.5}$ include premature mortality for adults and infants, cardiovascular morbidity such as heart attacks and hospital admissions, and respiratory morbidity such as asthma attacks, bronchitis, hospital and emergency room visits, work loss days, restricted activity days, and respiratory symptoms. Health effects associated with exposure to ozone include premature mortality and respiratory morbidity such as hospital admissions, emergency room visits, and school loss days. In addition to human health co-benefits associated with $PM_{2.5}$ and ozone exposure, reducing SO_2 and NO_X emissions under this rule would result in reduced health impacts from direct exposure to these pollutants.

Reducing SO_2 and NO_X emissions would also result in other human welfare (non-health) improvements including improvements in ecosystem services. SO_2 and NO_X emissions can adversely impact vegetation and ecosystems through acidic deposition and nutrient enrichment, and can affect certain manmade materials, visibility, and climate (U.S. EPA, 2009; U.S. EPA, 2008).

For a full discussion of the human health, ecosystem and other benefits of reducing SO_2 and NO_X emissions from power sector sources, please refer to the RIA for MATS (U.S. EPA, 2011).

The avoided incidences of health effects and monetized value of health or non-health improvements that result from SO_2 and NO_x emissions reductions depend on the location of those reductions. However, when assessing the co-benefits of differences in emissions from different generation technologies in the following sections, the EPA does not assert a specific location for the new unit. As a result, the EPA does not have the data to perform a full health impact assessment for a specific modeled scenario.[69] Instead, the EPA relied on a national-average benefit per-ton (BPT) method to estimate $PM_{2.5}$-related health impacts of SO_2 and NO_X emissions. The BPT approach provides an estimate of the total monetized human health benefits (the sum of premature mortality and morbidity) of reducing one ton of $PM_{2.5}$ precursor (i.e., NO_X and SO_2) from the sector. To develop the BPT estimates used in this analysis the EPA utilized detailed air quality modeling of power sector SO_2 and NO_X emissions along with the BenMAP model[70] to estimate the benefits of air quality improvements using projected 2020 population, baseline incidence rates, and economic factors.

The SO_2- and NO_X-related BPT estimates utilized in this analysis are derived from the Technical Support Document (TSD) on estimating the BPT of reducing $PM_{2.5}$ and its precursors (U.S. EPA, 2013a). These BPT values are estimated in a methodologically consistent manner with those reported in Fann et al. (2012). They differ from those reported in Fann et al. (2012) as they reflect the health impact studies and population data updated in the benefits analysis of the final PM NAAQS RIA (U.S. EPA, 2012). The recalculation of the Fann et al. (2012) BPT values based on the updated data from the PM NAAQS RIA (U.S. EPA, 2012) is described in the TSD (U.S. EPA, 2013a).

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[69] If the EPA conjectured a location for a particular new unit it may be possible to perform a full health impact assessment of different technologies at that location. Doing so for a number of locations is beyond the scope of this analysis and would be better captured in sector-wide modeling. For more information on the EPA's methods for conducting health impact assessments, please refer to Chapter 5 of the final PM NAAQS RIA. (U.S. EPA, 2012)

[70] Available at http://www.epa.gov/air/benmap.

Despite our attempts to quantify and monetize as many of the co-benefits of reducing emissions from electricity generating sources as possible, not all known health and non-health co-benefits from reducing SO_2 and NO_x are accounted for in this assessment. For more information about unquantified health and non-health co-benefits of SO_2 and NO_x please refer to tables 5-2 and 6-2 of the PM NAAQS RIA (U.S. EPA, 2012), respectively. Furthermore, the analysis that follows does not account for known differences in the emissions of other air and water pollutants between the different generating technologies, including, for example, directly-emitted PM.

As we do not conjecture a specific location for the new units being compared, this RIA is unable to include the type of detailed uncertainty assessment found in the PM NAAQS RIA (U.S. EPA, 2012). However, the results of the uncertainty analyses presented in the PM NAAQS RIA can provide some information regarding the uncertainty inherent in the benefits results presented in this analysis. In addition to these uncertainties, use of BPT estimates come with additional uncertainty. Specifically, all national-average BPT estimates reflect a specific geographic distribution of SO_2 and NO_X reductions resulting in a specific reduction in $PM_{2.5}$ exposure and may not fully reflect local or regional variability in population density, meteorology, exposure, baseline health incidence rates, or other factors that might lead to an over-estimate or under-estimate of the actual benefits associated with $PM_{2.5}$ precursors in a specific location. These estimates are purely illustrative as the EPA does not assert a specific location for the illustrative electricity generation technologies and is therefore unable to specifically determine the population that would be affected by their emissions. Therefore, the benefits for any specific unit can be different than the estimates shown here.

Notwithstanding these limitations, reducing one thousand tons of annual SO_2 from U.S. power sector sources has been estimated to yield between 4 and 9 incidences of premature mortality avoided and monetized $PM_{2.5}$-related health benefits (including these incidences of premature mortality avoided) between $38 million and $85 million in 2020 (2011$) using a 3% discount rate or between $34 million and $76 million (2011$) using a 7% discount rate. Additionally, reducing one thousand tons of annual NO_X from U.S. EGUs has been estimated to yield up to 1 incidence of premature mortality avoided and monetized $PM_{2.5}$-related health benefits (including these incidences of premature mortality avoided) of between $5.5 million and $12 million in 2020 (2011$) using a 3% discount rate or between $5.0 million and $11 million (2011$) using a 7% discount rate. For each pollutant, the range of estimated benefits for each discount rate is due to the EPA's use of two alternative primary estimates of $PM_{2.5}$-related mortality impacts: a lower primary estimate based on Krewski et al. (2009) and a higher primary estimate based on Lepeule et al. (2012).

Table 5-12. Monetized Health Co-Benefits Per Ton of $PM_{2.5}$ Precursor Reductions in 2020[a] (in 2011$)

	$PM_{2.5}$ Precursor	
	SO_2	NO_X
3% Discount Rate		
Krewski et al. (2009)	$38,000	$5,5000
Lepeule et al. (2012)	$85,000	$12,000
7% Discount Rate		
Krewski et al. (2009)	$34,000	$5,000
Lepeule et al. (2012)	$76,000	$11,000

[a] As described in Section 5.7.2, the SO2- and NOX-related BPT estimates are from the Technical Support Document on Estimating the Benefit Per Ton of Reducing PM2.5 from 17 Sectors (U.S. EPA, 2013a) and are adjusted to 2011$.

5.8 Comparison of Health and Welfare Impacts from Generation Technologies

As previously discussed in this chapter, the emissions of GHGs and other pollutants associated with new sources of electricity generation are greater for coal-fired units than for natural gas combined cycle units (even when accounting for compliance with MATS). Reducing the emissions associated with electricity generation results in both climate and human health and non-health benefits.

To consider the social benefits associated with the adoption of lower emitting new generation technologies, we determine the differences in emissions in the illustrative emission profiles between technologies in Table 5-10 and apply the 2020 social benefit values discussed in Section 5.7. Specifically, we multiply the difference in CO_2 emissions between two technologies by the estimates of the SCC, multiply the difference in SO_2 and NO_X emissions by the $PM_{2.5}$-related SO_2 and NO_X BPT estimates, and add those values to get a measure of 2020 social benefits of the adoption of lower emitting generation technology. We subsequently divide by the number of MWh underlying the emission estimates to derive the social benefits per unit of generation.

Only the direct emissions of CO_2, SO_2, and NO_X are considered in this illustrative exercise. Other air and water pollutants emitted by these technologies and emissions from the extraction and transport of the fuels used by these technologies are not considered. For example, coal has higher mercury emissions than natural gas, but the relative benefits from the difference in mercury emissions are not considered. Furthermore, there may be differences in upstream greenhouse gas emissions (in particular, methane) from different technologies but those were not quantified for this assessment.

Table 5-13 reports the 2020 incremental climate and health benefits associated with an illustrative new NGCC plant relative to illustrative new SCPC and IGCC coal plants, given different mortality risk studies and assumptions about the discount rate. These incremental benefits should be relatively invariant across natural gas prices and other economic factors. Depending on the discount rate and mortality risk study used, 2020 incremental benefits associated with generation from a representative new natural gas combined cycle unit relative to a new coal unit are \$6.6 to \$95 per MWh (2011\$).[71]

The precise social benefits associated with reduced CO_2 emissions, which are the focus of this rule, depend on the specific fuels used but do not depend on the location of generation because the location of CO_2 emissions does not influence their impact on the evolution of global climate conditions. As with the relative investment costs of a new coal unit and a new natural gas combined cycle system, the precise incremental health co-benefits associated with lower emissions depend on the location under consideration and the specific fuels that would be used. An ideal benefit-cost analysis would account for these local circumstances (and consider alternative sources of generation).

However, these factors will not change the qualitative conclusion. There will always be incremental climate and human health benefits associated with a new natural gas combined cycle unit relative to a new coal unit, independent of the location.

[71] Different discount rates are applied to SCC than to the other benefit estimates because CO_2 emissions are long-lived and subsequent damages occur over many years. Moreover, several rates are applied to SCC because the literature shows that it is sensitive to assumptions about discount rate and because no consensus exists on the appropriate rate to use in an intergenerational context. The SCC interagency group centered its attention on the 3 percent discount rate but emphasized the importance of considering all four SCC estimates. See the 2010 SCC TSD. Docket ID EPA-HQ-OAR-2009-0472-114577 or http://www.whitehouse.gov/sites/default/files/omb/inforeg/for-agencies/Social-Cost-of-Carbon-for-RIA.pdf for details.

Table 5-13. 2020 Incremental Benefits ($/MWh, 2011$) of Emission Reductions from Illustrative New Natural Gas Combined Cycle Generation *Relative to* New SCPC or IGCC Coal Generation without CCS[72]

	SCPC		IGCC	
CO_2-Related Benefits using SCC				
5% Discount Rate	$5.6		$5.4	
3% Discount Rate	$20		$19	
2.5% Discount Rate	$31		$29	
3% Discount Rate (95th percentile)	$61		$58	
$PM_{2.5}$-Related Co-Benefits from SO_2 and NO_X Reductions				
3% discount rate				
Krewski et al. (2009)	$15		$1.4	
Lepeule et al. (2012)	$35		$3.1	
7% discount rate				
Krewski et al. (2009)	$14		$1.2	
Lepeule et al. (2012)	$31		$2.8	
Combined CO_2-Related and $PM_{2.5}$-Related Benefits				
	Discount Rate Applied to $PM_{2.5}$-Related Benefits (range based on adult mortality function)			
SCC Discount Rate	3%	7%	3%	7%
5% Discount Rate	$21 to $40	$20 to $37	$6.7 to $8.5	$6.6 to $8.2
3% Discount Rate	$36 to $55	$34 to $52	$21 to $22	$20 to $22
2.5% Discount Rate	$46 to $65	$44 to $62	$30 to $32	$30 to $32
3% Discount Rate (95th percentile)	$76 to $95	$75 to $92	$59 to $61	$59 to $60

Notes: The emission rates and operating characteristics of the units being compared in this table are reported in Table 5.10. Benefits are estimated for a 2020 analysis year. The range of benefits within each SCC value and discount rate for $PM_{2.5}$-related benefits pairing reflects the use of two core estimates of $PM_{2.5}$-related premature mortality.[73] The EPA has evaluated the range of potential impacts per MWh by combining all SCC values with health benefits values at the 3 percent and 7 percent discount rates. To be consistent with concepts of intergenerational discounting, values for health benefits, which occur within a generation, would only be combined with SCC values using a lower discount rate, e.g. the 7 percent health benefit estimates would be combined with 5 percent or lower SCC values, but the 3 percent health benefit would not be combined with the 5 percent SCC value. While the 5 percent SCC and 3 percent health benefit estimate falls within the range of values we analyze, this individual estimate should not be used independently in an analysis, as it is represents a combination of discount rates that is unlikely to occur. Combining the 3 percent SCC values with the 3 percent health benefit values assumes that there is no difference in discount rates between intragenerational and intergenerational impacts.

[72] The benefits presented here are estimated on an output basis to enable easier comparisons and to illustrate the potential impacts of moving from new coal without CCS to new NGCC. This analysis assumes representative new units and does not reflect the full array of new generating sources that could potentially be built (e.g., a comparison of a small new conventional coal plant with a small natural gas plant, or a comparison of a waste coal or petroleum coke facility to a natural gas plant of a comparable size and capacity factor). However, the incremental benefits associated with other facilities that could be built, and which would be subject to this proposal, would not change noticeably (i.e., these new facilities would be subject to emissions standards for other pollutants and would emit similar levels of SO_2, NO_X, and CO_2, on an output basis) except for differences in local conditions, as discussed previously.

[73] The range of estimated benefits for each discount rate is due to the EPA's use of two alternative primary estimates of $PM_{2.5}$-related mortality impacts: a lower primary estimate based on Krewski et al. (2009) and a higher primary estimate based on Lepeule et al. (2012).

The conclusion from this analysis is that there are significant environmental and health benefits associated with electricity generation from a representative new NGCC unit relative to a new conventional coal unit. Other studies of the social costs of coal and natural gas fired generation provide similar findings (Muller et. al., 2011; NRC, 2009).[74]

As explained previously, the power sector continues to move away from the construction of coal-fired power plants in favor of natural gas-fired power plants due, in part, to the significant cost differential. Even so, it is possible that a limited number of unplanned coal-fired power plants will be constructed during the analysis period. In these circumstances, units built with CCS in place of conventional coal-fired units would result in relative climate and human health and non-health benefits. Table 5-14 reports the 2020 incremental benefits associated with an illustrative new coal-fired plant with CCS relative to illustrative new SCPC and IGCC coal plants, given different mortality risk studies and assumptions about the discount rate. Depending on the coal-fired generation type, discount rate, and mortality risk study used, 2020 incremental benefits associated with generation from a representative new coal-fired unit with CCS relative to a new coal unit without CCS are \$2.0 to \$45 per MWh (2011\$).[75]

[74] Muller et al. 2011 conclude that, "coal-fired power plants have air pollution damages larger than their value added", while the same is not true for natural gas plants (see Table 5). However, these comparisons are based on typical existing coal and natural gas units, including natural gas boilers, and are not sensitive to location (although the underlying analysis in the study does account for differences in the location of existing units when estimating damages). The NRC 2009 study shows that only the most polluting natural gas units may cause greater damages than even the least polluting existing coal plants (compare Tables 2-9 and 2-15). However, the NRC comparison does not compare new units located in the same place, and so some of the natural gas units with the greatest damages may be attributable to their location, and includes natural gas steam boilers, which have a higher emission rates per unit of generation than natural gas combined cycle units.

[75] Different discount rates are applied to SCC than to the other benefit estimates because CO_2 emissions are long-lived and subsequent damages occur over many years. Moreover, several rates are applied to SCC because the literature shows that it is sensitive to assumptions about discount rate and because no consensus exists on the appropriate rate to use in an intergenerational context. The SCC interagency group centered its attention on the 3 percent discount rate but emphasized the importance of considering all four SCC estimates. See the 2010 SCC TSD for details. Docket ID EPA-HQ-OAR-2009-0472-114577 or http://www.whitehouse.gov/sites/default/files/omb/inforeg/for-agencies/Social-Cost-of-Carbon-for-RIA.pdf.

Table 5-14. 2020 Incremental Benefits ($/MWh, 2011$) of Emission Reductions from Coal-Fired Generation with CCS meeting 1,100 lbs/MWh *Relative* to New Coal-Fired Generation Without CCS

	SCPC		IGCC	
CO2-Related Benefits using SCC				
5% Discount Rate	$3.2		$2.1	
3% Discount Rate	$11		$7.5	
2.5% Discount Rate	$17		$11	
3% Discount Rate (95th percentile)	$34		$23	
PM2.5-Related Benefits from SO2 and NOX Reductions				
3% discount rate				
Krewski et al. (2009)	$4.7		*	
Lepeule et al. (2012)	$11		*	
7% discount rate				
Krewski et al. (2009)	$4.2		*	
Lepeule et al. (2012)	$9.5		*	
Combined CO2-Related and PM2.5-Related Benefits				
	Discount Rate Applied to PM2.5-Related Benefits (range based on adult mortality function)			
SCC Discount Rate	3%	7%	3%	7%
5% Discount Rate	$7.9 to $14	$7.4 to $13	$2.0 to $2.0	$2.0 to $2.1
3% Discount Rate	$16 to $22	$16 to $21	$7.4 to $7.5	$7.4 to $7.5
2.5% Discount Rate	$22 to $28	$22 to $27	$11 to $11	$11 to $11
3% Discount Rate (95th percentile)	$39 to $45	$39 to $44	$22 to $23	$22 to $23

*IGCC with CCS results in a small SO_2 emissions increase when compared to IGCC without CCS. As a result, there would be a negligible health disbenefit associated with these emissions increases.

Notes: Benefits are estimated for a 2020 analysis year. The range of benefits within each SCC value and discount rate for $PM_{2.5}$-related benefits pairing reflects the use of two core estimates of $PM_{2.5}$-related premature mortality.[76] The EPA has evaluated the range of potential impacts per MWh by combining all SCC values with health benefits values at the 3 percent and 7 percent discount rates. To be consistent with concepts of intergenerational discounting, values for health benefits, which occur within a generation, would only be combined with SCC values using a lower discount rate, e.g. the 7 percent health benefit estimates would be combined with 5 percent or lower SCC values, but the 3 percent health benefit would not be combined with the 5 percent SCC value. While the 5 percent SCC and 3 percent health benefit estimate falls within the range of values we analyze, this individual estimate should not be used independently in an analysis, as it is represents a combination of discount rates that is unlikely to occur. Combining the 3 percent SCC values with the 3 percent health benefit values assumes that there is no difference in discount rates between intragenerational and intergenerational impacts.

5.9 Illustrative Analysis – Benefits and Costs across a Range of Gas Prices

As the analysis in Sections 5.4 and 5.5 demonstrated, under a wide range of likely electricity market conditions – including the EPA and EIA baseline scenarios as well as multiple alternative scenarios – the EPA projects that the industry will choose to construct new units

[76] The range of estimated benefits for each discount rate is due to the EPA's use of two alternative primary estimates of $PM_{2.5}$-related mortality impacts: a lower primary estimate based on Krewski et al. (2009) and a higher primary estimate based on Lepeule et al. (2012).

that already meet the standards of this proposed rulemaking, regardless of this proposal. In this section, we consider the unlikely scenario where construction of new supercritical coal capacity without CCS occurs during the analysis period in the absence of the rule. The analysis in this section indicates that in this scenario, which implies that the proposed EGU New Source GHG Standards would result in costs to the investor, but would lead to greater climate and human health benefits and is highly likely to provide net benefits to society as a whole. [77]

The starting point for this analysis is the illustrative comparison (presented in Section 5.5.4) of the relative LCOE of representative new SCPC and IGCC coal EGUs and representative NGCC units.[78] This comparison demonstrates a significant difference in the LCOE between the coal-fired and natural gas-fired generating technologies. The estimated LCOE for a representative NGCC unit is roughly \$33 and \$38 per MWh less than for a representative new SCPC or IGCC coal unit, respectively (see Figure 5-3).[79] This is consistent with the EPA's projection, discussed at length in this chapter, that the proposed EGU New Source GHG Standards are not projected to impose any costs (or generate quantified net benefits) under current and likely future market conditions.

To supplement this determination, this section presents an analysis of three relevant ranges within the distribution of future natural gas prices that can be classified as likely gas prices, unexpectedly high natural gas prices, and unprecedented natural gas prices. Because the cost of natural gas is a significant share of the LCOE for NGCC, we evaluate how changes in natural gas prices affect differences in private and social cost of new technologies. In general, this analysis shows that there would likely be a net social benefit,[80] even under scenarios with higher than expected gas prices, if new NGCC units were built in place of new coal-fired units as a result of this policy. Under some conditions, higher natural gas prices may result in a net social cost, holding all other parameters constant and disregarding social benefits that we are

[77] EO 13563 states that each agency must "propose or adopt a regulation only upon a reasoned determination that its benefits justify its costs (recognizing that some benefits are hard to quantify)." While the presence of net social benefits for a given regulatory option is not the only condition necessary for optimal regulatory design, it does signify that the regulatory option is welfare improving for society.

[78] By fixing generation in this comparison, we are assuming that both technologies generate the same benefits in the form of electricity generating services. We assume in the discussion that the benefit of electricity production to consumers outweighs the private and social investment cost. However, at particularly high fuel prices this might not be the case. For a discussion of when comparing the levelized costs of different generating technologies provides informative results and when it does not see, for example, Joskow 2010 and 2011.

[79] LCOE of NGCC relative to SCPC with 3% CUA and IGCC without 3% CUA.

[80] The benefits estimated in this section are based on a single year (2020) of emissions from different generating technologies. Due to data limitations, we are not able to estimate annualized benefits from the stream of emissions over the lifetime of the generating technologies. This results in a conservative comparison of benefits to costs where LCOE represents annualized lifetime costs of generating technologies.

unable to monetize.[81] Additionally, given certain market conditions, some operators may choose to construct a new coal-fired unit with CCS. The relative private costs and social benefits of a new coal-fired unit with CCS are discussed in Section 5.10.

5.9.1 Likely Natural Gas Prices

As shown earlier, it is only when natural gas prices reach $10.94/MMBtu on a levelized basis (in 2011 dollars) that new coal-fired generation without CCS becomes competitive in terms of its cost of electricity. None of the EPA sensitivities or AEO2013 scenarios approach this natural gas price level on either a forward looking 20-year levelized price basis or on an average annual price basis at any point during the analysis period.[82]

5.9.2 Unexpectedly High Natural Gas Prices

At natural gas prices above $10.94/mmBtu, the private levelized cost of electricity for a representative new SCPC unit falls below that of a new NGCC unit. Therefore, at anticipated levelized fuel prices above that price level some new SCPC coal units might be constructed in the absence of this proposed rulemaking, provided there is sufficient demand and new coal without CCS is competitive with other generating technologies.[83] In this scenario, there would be some compliance cost if a new NGCC unit or a coal-fired unit with CCS were built as a result of the standard. However, generation from either a new NGCC unit or a coal-fired unit with CCS would also have incremental environmental and health benefits by reducing global warming pollution and particulate matter (as a result of SO_2 and NO_x emissions) relative to generation from a new coal unit.

For average annual natural gas prices greater than $10.94/mmBtu, the resulting emission reduction benefits of building NGCC will outweigh the costs of constructing an NGCC unit in lieu of a coal plant without CCS – indicating that the standard would yield net benefits

[81] The net cost scenario is unlikely to occur over our analysis period and for a significant period beyond. For example, high economic growth would increase both natural gas and coal prices at the same time - making it harder to alter the underlying cost advantage of NGCC generation. It is important to note that this analysis is limited in the types of benefits and costs considered, given that it does not address the life-cycle pollution associated with fossil fuels along with the limitations of current SCC estimates. As previously discussed, the current SCC estimates do not capture all important all of the physical, ecological, and economic impacts of climate change recognized in the climate change literature. Despite our attempts to quantify and monetize as many of the co-benefits as possible, the health and welfare co-benefits are not fully quantified or monetized in this assessment. For more information about unquantified health and welfare co-benefits please refer to tables 5-2 and 6-2 of the PM NAAQS RIA (U.S. EPA, 2012), respectively.

[82] EIA's projected natural gas price for 2022 in its reference scenario for AEO2013 is $5.31 (in 2011 dollars). EIA's "Low oil and gas resource" scenario projects an average delivered electricity sector gas price of $6.64/mmBtu (in 2011 dollars) in 2022.

[83] See section 5.5 for a discussion of how local conditions and other factors may influence the LCOE comparison.

for the analysis year. For example, at an average annual gas price of $11/MMBtu, the illustrative NGCC unit would generate power for approximately $1/MWh more than an SCPC coal unit on a levelized basis,[84] and result in incremental benefits from emissions of $20 to $95/MWh (see analysis of 2020 relative benefits of NGCC: table 5-13).[85] The net benefit of this scenario would be $19 to $95/MWh.[86] As illustrated in section 5.10, if an SCPC coal unit with CCS (as opposed to an NGCC unit) were built instead of an SCPC coal unit without CCS, the CCS equipped unit would result in an incremental cost of $18/MWh and incremental benefits from emissions of $7.4 to $45/MWh relative to an SCPC unit without CCS (see analysis of 2020 relative benefits of CCS: table 5-14). The net impact of this scenario would range from a net cost of $11/MWh to a net benefit of $27/MWh.

For context, a natural gas price level of $10/MMBtu (in 2011 dollars) is higher than any annual natural gas price to the electric power sector since at least 1996, when the EIA data series stops.[87] In addition, the highest projected average annual natural gas price during the analysis period in any of the AEO2013 scenarios cited in this chapter is $6.64/MMBtu in the Low Oil and Gas Resource scenario. Further, the continued development of unconventional natural gas resources in the U.S. suggests that gas prices would actually tend to be towards the lower end of the historical range. As discussed above, none of the EIA sensitivity cases (which account for future fuel prices for both gas and coal) show scenarios where noncompliant coal becomes more economic than NGCC before 2020.

5.9.3 Unprecedented Natural Gas Prices

At extremely high natural gas prices, the generating costs of coal without CCS would be sufficiently lower than the cost of new natural gas that the net benefit of the standard in a given year could be negative (i.e., a net cost) under some ranges of benefit estimates. For example, at gas prices of $14/MMBtu, the illustrative NGCC unit would generate power for roughly $21 and $16/MWh more than conventional SCPC and IGCC coal units, respectively but result in social benefits from lower emissions of $20 to $95/MWh and $6.6 to $61/MWh relative to the SCPC and IGCC coal units, respectively (see analysis of 2020 relative benefits of NGCC: table 5-13). If an NGCC unit were built as a result of the standard, the resulting net

[84] Assuming an increase of $6.80/MWh in the cost of gas generation for every $1/MMBtu increase in natural gas prices.
[85] Assuming that coal prices do not increase along with natural gas prices as they historically have.
[86] The higher value of net benefits calculated here is equal to the higher value of incremental benefits due to rounding.
[87] See: http://www.eia.gov/dnav/ng/hist/n3045us3A.htm. EIA reports average annual delivered natural gas prices to the electricity sector for the past 16 years (since 1997).

impact would range from a net social cost of $1.5/MWh to a net social benefit of $74/MWh relative to SCPC and from a net social cost of $9.5/MWh to a net social benefit of $45/MWh relative to IGCC.

As noted in the previous subsection, natural gas prices at these levels would be unprecedented as they have not been observed as long as EIA has collected data on natural gas prices. As a result, the EPA believes that the probability of natural gas prices reaching average annual levels at which this standard would generate net social costs under some ranges of benefit estimates is extremely small.

We emphasize that differences in generating costs, plant design, local factors, and the relative differences between fuels costs can all have major impacts on the precise circumstances under which this standard would be projected to have no costs, net social benefits or net social costs. However, based on historical and expected average annual gas prices, we project that this standard is most likely to have negligible costs, and, if it does result in costs, it is also likely to produce positive, although modest, net social benefits. The probability that this proposed standard would result in net social costs is exceedingly low.

5.10 Illustrative Analysis – Benefits and Costs of CCS Compared with Conventional Coal

The previous section evaluated the social benefit of an investor constructing a new NGCC unit in lieu of an uncontrolled unit in response to the proposed rule. If an operator chose to construct a new coal unit, this proposed rule would result in some costs in order to build a unit with partial CCS. However, there would also be climate and other benefits resulting from reductions in CO_2, SO_2, and NO_X emissions.[88] For each coal-fired generation type, SCPC and IGCC, the EPA analyzed the cost and 2020 emission impacts for the proposed emission limit using partial capture, plus a more stringent full capture scenario. Consistent with the LCOE estimates provided earlier in this chapter, the partial capture CCS scenarios achieve the proposed emissions rate of 1,100 lb CO_2/MWh gross output. The full capture CCS scenarios achieve an emissions rate of 200 lb CO_2/MWh and 150 lb CO_2/MWh for SCPC and IGCC, respectively. Tables 5-15 and 5-16 show the costs and 2020 net benefits per MWh of each of these scenarios relative to a no capture scenario.

In the near term, any new coal-fired EGU with CCS would most likely be located in areas amenable to using the captured CO_2 in EOR operations. This is because EOR provides a revenue

[88] When comparing the private costs of different technologies, we account for the CUA in the investor decision making, but when we compare the difference in the social costs of these technologies (i.e., the private cost plus the cost associated with their emissions) the CUA is not included.

stream that is not available for other forms of geologic storage. For example, the Texas Clean Energy project[89] is planning to capture 90% of the CO_2 and sell it for EOR. To evaluate the potential revenues from EOR we estimate the revenue in each scenario if CO_2 could be sold for $20 to $40/ton based on assumptions used by NETL in evaluating the EOR opportunities.[90]

Table 5-15. Illustrative Costs and 2020 Social Benefits for SCPC with Partial Capture and Full Capture CCS Relative to SCPC without CCS (per MWh 2011$)

	Partial CCS	Full CCS
Additional LCOE of CCS[a]	$29	$66
Revenue from EOR (Low - High EOR)	$14 to $22	$32 to $54
Additional LCOE, net of EOR	$15 to $7	$34 to $12
Value of Monetized Benefits for 2020 Emissions		
SCC 5% with Krewski 3% to SCC 3% (95th) with Lepeule 3%[b]	$7.9 to $45	$22 to $120
Net Monetized Benefits for 2020 Emissions		
Without EOR Revenue	-$21 to $16	-$44 to $59
With EOR Revenue	-$7.1 to $38	-$12 to $110

[a] LCOE of SCPC without CCS does not include 3% CUA.
[b] Benefits are estimated for a 2020 analysis year. Values shown are calculated using different discount rates. Four estimates of the SCC in the year 2020 were used: $13, $46, and $69 per metric ton (average SCC at discount rates of 5, 3, and 2.5 percent, respectively) and $138 per metric ton (95th percentile SCC at 3 percent). The average SCC at 5 percent produced the lowest estimate and the 95th percentile estimate at 3 percent produced the highest estimate. See RIA 5.7.1 for complete discussion about these estimates.

Table 5-16. Illustrative Costs and 2020 Social Benefits for IGCC with Partial Capture and Full Capture CCS Relative to IGCC without CCS (per MWh 2011$)

	Partial CCS	Full CCS
Additional LCOE of CCS[a]	$12	$39
Revenue from EOR (Low - High EOR)	$8 to $12	$27 to $45
Additional LCOE, net of EOR	$4 to $0	$12 to -$6
Value of Monetized Benefits for 2020 Emissions		
SCC 5% with Krewski 3% to SCC 3% (95th) with Lepeule 3%[b]	$2 to $22	$8.3 to $94
Net Monetized Benefits for 2020 Emissions		
Without EOR Revenue	-$10 to $11	-$31 to $55
With EOR Revenue	-$2 to $23	-$3.7 to $100

[a] LCOE of IGCC without CCS does not include 3% CUA.
[b] Benefits are estimated for a 2020 analysis year. Values shown are calculated using different discount rates. Four estimates of the SCC in the year 2020 were used: $13, $46, and $69 per metric ton (average SCC at discount rates of 5, 3, and 2.5 percent, respectively) and $138 per metric ton (95th percentile SCC at 3 percent). The average SCC at 5 percent produced the lowest estimate and the 95th percentile estimate at 3 percent produced the highest estimate. See RIA 5.7.1 for complete discussion about these estimates.

[89] http://www.texascleanenergyproject.com/
[90] http://www.netl.doe.gov/energy-analyses/pubs/storing%20co2%20w%20eor_final.pdf

The EPA estimated the benefits associated with avoided CO_2, SO_2, and NO_X emissions using the methods described previously in this chapter. Similarly, the cost estimates EPA used are described previously in this chapter. As before, it is important to note that these comparisons omit additional benefits that may be associated with the abatement of greenhouse gas emissions.

5.11 Impact of the Proposed Rule on Option Costs

Consistent with EPA's practice in evaluating the benefits and costs of significant rules, Section 5.5 of this chapter uses detailed electricity sector modeling of expected market conditions, along with alternative scenario analysis, to demonstrate, that under a broad range of conditions, new EGUs expected to be built in the period of analysis would be in compliance with this proposed rule, even in the absence of this rule. As a result, the quantifiable benefits and costs of the proposed EGU New Source GHG Standards are zero in the analysis period. This analysis is extended in Sections 5.9 through 5.10 to acknowledge unexpected conditions that could occur during the period of analysis in which the construction of a new coal unit without CCS would be desirable from the perspective of an individual investor and evaluates the costs and benefits of constructing a generating technology that complies with the proposed rule instead. This section further extends, and draws on, those analyses to discuss, qualitatively, how EPA views the potential social benefits and costs of the proposed EGU New Source GHG Standards.

When there is uncertainty about future conditions that could impact an investment decision, investors place a value on retaining the ability to choose from a range of different investments. This is referred to as "option value." Any cost of this proposed rule is the investor's loss of the option value associated with the ability to build new coal units without CCS. In the future, as uncertainty in market conditions is resolved investors will respond to expected electricity demand based on the available choice set, taking as given other market and regulatory constraints. The cost that society incurs when the choices available to the investors are restricted is represented by the least cost option value associated with the choices that are eliminated (Dixit and Pindyck, 1994; Trigeorgis, 1996). This option value is determined by the likelihood that the restricted choices would be exercised absent the policy, the social cost of substitutes, and the value of being able to adjust diversity of fuels that can be used by the generating fleet.[91] If it is highly unlikely that the restricted choices would be exercised in the

[91] The option value associated with constructing new coal-fired capacity without partial CCS as part of a portfolio that hedges against uncertainty in future fuel prices will be conditional upon the current composition of the fleet. If the current stock was constructed in expectation of relative fuel prices that more strongly favored

absence of the policy, or substitutes are available at a minimal incremental cost, then the option value will be negligible, and therefore so to will be the social cost of the restriction.

In the case of this proposal, the choice set for firms that generate and sell electricity is not being significantly restricted. The proposal eliminates the option to construct new uncontrolled coal units, for which there are other generating substitutes, including renewables, natural gas, and coal with CCS.[92] The value of this option is conditional upon the likelihood that it would be exercised during the analysis period and the cost of available substitutes. As discussed in Section 5.9 it is highly unlikely that over the analysis period there will be enough expansion in relative fuel prices (i.e. natural gas prices relative to coal) to make new coal-fired EGUs cost competitive. Therefore, the option value, from the perspective of society, associated with allowing investors to construct a new coal fired EGU is currently expected to be minimal. As a result, any impact this proposal may have on the option value will be minimal as well.

If current conditions were significantly different and there existed a higher probability that the option to build a new coal-fired unit without SCC might be exercised during the analysis period, the impact on the option value will be primarily driven by the incremental cost of increasing utilization at existing units, investing in cost-saving energy efficiency or constructing a new unit with a substitute fuel (e.g., renewables, natural gas, etc.). Because investors retain the ability to construct coal with CCS, the effect on the option value will be equal to the incremental cost of CCS.[93] Additionally, this is based not on the cost of CCS today, but the expected cost of CCS in the future. If market conditions were to deviate significantly from expectations such that the likelihood of investors constructing new coal units with CCS increased, so would research and development spending on the technology, thereby driving down its expected costs.

It is difficult to precisely estimate the option cost of this proposed rule given the numerous sources of uncertainty that influence investment decisions in the electricity sector and existing modeling tools. However, the analysis reported in this chapter has considered important variables that influence investment decisions in the electricity sector and found that across a wide range of potential outcomes this rule would have no quantifiable costs. Furthermore, considering the additional analysis in sections 5.9 and 5.10 and the discussion

higher emitting fuels, then the composition of the generating fleet may already be too heavily weighted toward the ability to use those fuels, given the current expected distribution of relative fuel prices.

[92] By definition the option value associated with coal without partial CCS will be less than the option value associated with the ability to construct and operate any type of new coal fired unit..

[93] Including any additional costs associated with differences in electricity transmission, coal delivery, etc. associated with a coal unit with CCS being constructed in lieu of the construction of a non-compliant unit.

above, the option cost of the rule is concluded to be small and bounded by the cost of CCS. Additionally, if conditions arise that would have lead to the construction of coal-fired units without CCS absent the proposed rule, the quantifiable social benefits of limiting the construction of those units likely exceed the cost. However, as discussed throughout this RIA, when considering the most likely outcomes, the proposed rule is anticipated to yield no monetized benefits and impose negligible costs over the analysis period.

5.12 Summary of Costs, Benefits, and Energy Impacts

Under a wide range of electricity market conditions – including EPA's baseline scenario as well as multiple sensitivity analyses – EPA projects that the industry will choose to construct new units that already meet these standards, regardless of this proposal. As a result, EPA anticipates that the proposed EGU New Source GHG Standards will result in negligible CO_2 emission changes, energy impacts, benefits or costs for new units constructed by 2020. Likewise, the Agency does not anticipate any notable impacts on the price of electricity or energy supplies. Additionally, for the reasons described above, the proposed rule is not expected to raise any reliability concerns, since reserve margins will not be impacted and the rule does not impose any requirements on existing facilities.

5.13 Macroeconomic and Employment Impacts

These proposed EGU New Source GHG Standards is not anticipated to change GHG emissions for newly constructed electric generating units, and is anticipated to impose negligible costs or monetized benefits. EPA typically presents the economic impacts to secondary markets (e.g., changes in industrial markets resulting from changes in electricity prices) and impacts to employment or labor markets associated with proposed rules based on the estimated compliance costs and other energy impacts, which serve as an input to such analyses. However, since the EPA does not forecast a change in behavior relative to the baseline in response to this proposed rule, there are no notable macroeconomic or employment impacts expected as a result of this proposed rule.

5.14 References

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EXHIBIT 24

Regulatory Impact Analysis

Petroleum Refineries
New Source Performance Standards Ja

June 2012

U.S. Environmental Protection Agency
Office of Air and Radiation
Office of Air Quality Planning and Standards
Research Triangle Park, NC 27711

1. EXECUTIVE SUMMARY

1.1 Introduction

On June 24, 2008, EPA promulgated amendments to the Standards of Performance for Petroleum Refineries and new standards of performance for petroleum refinery process units constructed, reconstructed, or modified after May 14, 2007. EPA subsequently received three petitions for reconsideration of these final rules. On September 26, 2008, EPA granted reconsideration and issued a stay for the issues raised in the petitions regarding process heaters and flares. On December 22, 2008, EPA addressed those specific issues by proposing amendments to certain provisions for process heaters and flares. This final regulation includes emissions limits for new and modified/reconstructed sources, and these limits are set for sulfur dioxide (SO_2), nitrogen oxides (NO_x), volatile organic compounds (VOC), and other pollutants.

The petroleum refining industry comprises establishments primarily engaged in refining crude petroleum into refined petroleum. Examples of refined petroleum products include gasoline, kerosene, asphalt, lubricants, solvents, and a variety of other products. Petroleum refining falls under the North American Industrial Classification System (NAICS) 324110.

This regulatory impact analysis (RIA) was prepared in response to requirements under Executive Order 12866. The RIA presents the results of analyses undertaken in support of this final rule including compliance costs, benefits, economic impacts, and impacts to small businesses. This RIA is organized as follows:

- Section 1: Executive Summary,
- Section 2 and an Appendix A: Profile of the Petroleum Refining Industry,
- Section 3: NSPS Regulatory Alternatives, and Costs and Emission Reductions From Complying with the NSPS,
- Section 4: Economic Impact Analysis: Methods and Results,
- Section 5: Executive Orders,
- Section 6: Benefits of the NSPS, and
- Section 7: Comparison of Benefits and Costs.

1.2 Results

EPA has characterized the facilities and companies potentially affected by the NSPS by examining existing refineries and the companies that own them. EPA projects that new refineries and processes will be similar to existing ones, and that the companies owning new sources will also be similar to the companies owning existing refineries. EPA has collected data on 148 existing refineries, owned by 64 companies. Of the affected parent companies, thirty-six are identified as small entities based on the Small Business Administration size standard criteria for NAICS 324110, for they employ 1,500 or fewer employees.

The total annualized engineering compliance costs of the NSPS are estimated at $96 million. The total annual savings from offset natural gas purchases and product recovery credits that arise as a result of complying with the rule are estimated at $180 million. EPA estimates that complying with the final NSPS will yield an annualized cost savings of approximately $79 million per year (2006 dollars) in 2017. The estimated nationwide 5-year incremental emissions reductions and cost impacts for the final standards are summarized in Table 1-1 below. Given that there are cost savings, EPA anticipates that the NSPS will have no negative impacts on the market for petroleum products. Based on sales data obtained for the affected small entities, as well as expected annualized cost savings, EPA estimates that the NSPS will not result in a SISNOSE (significant economic impact on a substantial number of small entities).

Table 1-1. National Incremental Cost Impacts, Emission Reductions, and Cost Effectiveness for Petroleum Refinery Flares Subject to Amended Standards Under 40 CFR part 60, subpart Ja (Fifth Year After Effective Date of Final Rule Amendments)[1]

	Subpart Ja Requirements	Total capital cost (millions)	Total annual cost without credit (millions/yr)	Natural gas offset/ product recovery credit (millions)	Total annual cost (millions/yr)	Annual emission reductions (tons SO_2/yr)	Annual emission reductions (tons NO_X/yr)	Annual emission reductions (tons VOC/yr)	Cost effective-ness ($/ton emissions reduced)	Annual emission reductions (metric tons CO_2/yr)[2]	Monetized Benefits (millions, 3% discount rate for health and climate benefits)			Monetized Benefits (millions, 3% discount rate for health and 7% for climate benefits)		
Small Flares	Flare Monitoring	$72	$12	$0	$12	0	0	0		0	$0	to	$0	$0	to	$0
	Flare gas recovery	$0	$0	$0	$0	0	0	0		0	$0	to	$0	$0	to	$0
	Flare Management	$0	$0.79	$0	$0.79	0	0	270	$2,900	0	$0	to	$0	$0	to	$0
	SO2 RCA/CA	$0	$1.9	$0	$1.9	2,600	0	0	$760	0	$170	to	$410	$150	to	$370
	Flowrate RCA/CA	$0	$0.90	-$6.7	-$5.8	3.4	50	390	-$13,000	98,000	$2.9	to	$3.7	$2.9	to	$3.6
	Total	**$72**	**$16**	**-$6.7**	**$9.0**	**2,600**	**50**	**660**	**$2,700**	**98,000**	**$170**	**to**	**$410**	**$150**	**to**	**$370**
Large Flares	Flare Monitoring	$12	$2.0	$0	$2.0	0	0	0		0	$0	to	$0	$0	to	$0
	Flare gas recovery	$380	$78	-$170	-$90	380	1,100	2,700	-$22,000	1,800,000	$74	to	$120	$71	to	$110
	Flare Management	$0	$0.088	$0	$0.088	0	0	30	$2,900	0	$0	to	$0	$0	to	$0
	SO2 RCA/CA	$0	$0.22	$0	$0.22	290	0	0	$760	0	$18	to	$45	$17	to	$41
	Flowrate RCA/CA	$0	$0.10	-$0.74	-$0.64	0	6	43	-$13,000	11,000	$0	to	$0	$0	to	$0
	Total	**$390**	**$81**	**-$170**	**-$88**	**660**	**1,100**	**2,800**	**-$20,000**	**1,800,000**	**$93**	**to**	**$160**	**$88**	**to**	**$150**
All Flares	Flare Monitoring	$84	$14	$0	$14	0	0	0		0	$0	to	$0	$0	to	$0
	Flare gas recovery	$380	$78	-$170	-$90	380	1,100	2,700	-$22,000	1,800,000	$74	to	$120	$71	to	$110
	Flare Management	$0	$0.88	$0	$0.88	0	0	300	$2,900	0	$0	to	$0	$0	to	$0
	SO2 RCA/CA	$0	$2.2	$0	$2.2	2,900	0	0	$760	0	$180	to	$450	$170	to	$410
	Flowrate RCA/CA	$0	$1.00	-$7.4	-$6.4	3.4	56	430	-$13,000	110,000	$3.2	to	$4.0	$3.1	to	$3.9
	Total	**$460**	**$96**	**-$180**	**-$79**	**3,200**	**1,100**	**3,400**	**-$10,000**	**1,900,000**	**$260**	**to**	**$580**	**$240**	**to**	**$520**

[1] All estimates are for the implementation year (2017), and are rounded to two significant figures.

[2] The emission reductions of CO_2 reflect the anticipated emission increases associated with the energy disbenefits from additional electricity consumption.

EPA estimates that the total monetized benefits of the final NSPS are \$260 million to \$580 million and \$240 million to \$520 million, at 3% and 7% discount rates, respectively (Table 1-2). All estimates are in 2006 dollars for the year 2017. Using alternate relationships between $PM_{2.5}$ and premature mortality supplied by experts, higher and lower benefits estimates are plausible, but most of the expert-based estimates fall between these estimates. In addition, direct exposure to SO_2 and NOx benefits, ozone benefits, ecosystem benefits, and visibility benefits have not been monetized in this analysis.

EPA estimates the net benefits of the final NSPS are \$340 million to \$660 million and \$320 million to \$600 million, at 3% and 7% discount rates, respectively (Table 1-2). All estimates are in 2006 dollars for the year 2017.

Table 1-2. Summary of the Monetized Benefits, Social Costs, and Net Benefits for the Final Petroleum Refineries NSPS in 2017 (millions of 2006\$)[1]

	3% Discount Rate			7% Discount Rate		
			Final Major Source NSPS			
Total Monetized Benefits[2]	\$260	to	\$580	\$240	to	\$520
Total Compliance Costs[3]		-\$79			-\$79	
Net Benefits	\$340	to	\$660	\$320	to	\$600
Non-monetized Benefits	Health effects from SO_2, NO_2, and ozone exposure Health effects from PM exposure from VOCs Ecosystem effects Visibility impairment					

[1] All estimates are for the implementation year (2017), and are rounded to two significant figures.

[2] The total monetized benefits reflect the human health benefits associated with reducing exposure to $PM_{2.5}$ through reductions of $PM_{2.5}$ precursors such as NOx and SO_2 as well as CO_2 benefits. It is important to note that the monetized benefits do not include the reduced health effects from direct exposure to SO_2 and NOx, ozone exposure, ecosystem effects, or visibility impairment. Human health benefits are shown as a range from Pope et al. (2002) to Laden et al. (2006). These models assume that all fine particles, regardless of their chemical composition, are equally potent in causing premature mortality because the scientific evidence is not yet sufficient to allow differentiation of effects estimates by particle type. The net present value of reduced CO_2 emissions is calculated differently than other benefits. This table includes monetized climate benefits using the global average social cost of carbon (SCC) estimated at a 3 percent discount rate because the interagency workgroup deemed the SCC estimate at a 3 percent discount rate to be the central value.

[3] The engineering compliance costs are annualized using a 7 percent discount rate.

Alternatively, if no refineries install flare gas recovery systems, EPA estimates the costs would be \$10.7 million with monetized benefits of \$190 to \$460 million and \$170 to \$410 million at a discount rates of 3% and 7% respectively. Thus, net benefits without flare gas recovery systems would be \$180 million to \$450 million and \$160 million to \$400 million, at 3% and 7% discount rates, respectively. All estimates are in 2006 dollars for the year 2017.

For small flares, we estimate the monetized benefits are \$170 million to \$410 million (3-percent discount rate) and \$150 million to \$370 million (7% discount rate for health benefits and 3% discount rate for climate benefits). For large flares, we estimate the monetized benefits are \$93 million to \$160 million (3% discount rate) and \$88 million to \$150 million (7% discount rate for health benefits and 3-percent discount rate for climate benefits). All estimates are in 2006 dollars for the year 2017.

1.3 References

Laden, F., J. Schwartz, F.E. Speizer, and D.W. Dockery. 2006. Reduction in Fine Particulate Air Pollution and Mortality. *American Journal of Respiratory and Critical Care Medicine.* 173: 667-672.

Office of Management and Budget. Circular A-4, September 17, 2003. Available on the Internet at http://www.whitehouse.gov/omb/circulars_a004_a-4.

Pope, C.A., III, R.T. Burnett, M.J. Thun, E.E. Calle, D. Krewski, K. Ito, and G.D. Thurston. 2002. "Lung Cancer, Cardiopulmonary Mortality, and Long-term Exposure to Fine Particulate Air Pollution." *Journal of the American Medical Association* 287:1132-1141.

4 ECONOMIC IMPACT ANALYSIS: METHODS AND RESULTS

4.1 Introduction

The economic impact analysis (EIA) is designed to inform decision makers about the potential economic consequences of a regulatory action. An economic welfare analysis estimates the social costs and consumer and producer surplus changes associated with a regulatory program. The welfare analysis identifies how the regulatory costs are distributed across the two broad classes of stakeholders -- consumers and producers. As defined in EPA's (2010) *Guidelines for Preparing Economic Analyses,*[9] social costs are the value of the goods and services lost by society resulting from using resources to comply with and implement a regulation. In addition, national engineering compliance cost estimates can be used to approximate the welfare impacts of a regulatory program.

Because the proposed amendments apply to new or modifying sources, we are not able to predict which specific sources will trigger applicability. Also, assuming no refineries install fuel gas recovery systems, the estimated, incremental annual costs would be about $10.7 million (2006 dollars), which represents substantially less than 0.001% of total refinery industry revenues in 2010. If we assume a full cost pass through, we do not anticipate any resulting price increases. As such, we did not employ a detailed economic model to estimate the social costs of the proposed amendments, nor to estimate the social cost distribution across stakeholders. For this rule, based on our analysis and an estimated annual cost savings of $79 million (2006 dollars) expected in the fifth year, no national-level negative economic impacts are expected. The remainder of this section includes a discussion of why firms may consider installing flare gas recovery systems, as well as the small business impact analysis.

4.2 Compliance Costs Estimates

As indicated in Section 3, we estimate there are approximately 500 flares industry-wide, and about 80 percent, or 400 flares, would be subject to the proposed amendments over the next five years. We further estimate that it would be cost-effective to install compressors and

[9] These guidelines are currently under review by the Agency.

recovery systems at 10 percent of the 400 flares, or at approximately 40 flares. We assume that a flare gas recovery system would be considered for flares with average releases greater than 500,000 scf per 24-hour period. And while we do not have current data on where all of the potential 40 flares are located, data from the 2002 National Emissions Inventory indicate the flares are likely located at large refineries.[10]

The total annualized engineering compliance costs are estimated at $96 million, and the estimated annual savings from offset natural gas purchases and product recovery credits are estimated at $180 million, giving rise to the net annual savings of $79 million discussed in Section 3. These costs can be broken down into costs required by the rule and costs that are not required by the rule. The annualized compliance costs for actions required by the rule are estimated at $18 million, and the estimated savings from product recovery credits is $7.4 million. Using these figures, we estimate the implied rate of return for actions required by the rule to be about -60 percent. Meanwhile, the annualized compliance costs for actions not required by the rule are estimated at $78 million, and the estimated savings from offset natural gas purchases is $168 million. Using these figures, we estimate the implied rate of return for actions not required by the rule to be about 120 percent and the overall rate of return to be about 90 percent. The actual industry-level rate of return varies greatly over time because of industry and economic factors. See Table 4-1 for refinery rates of return on investment from 2000 through 2009. It is readily observed that the rate of return related to the pollution control equipment and activities by this rule exceeds that of the rate of return associated with investments in the refining sector.

Table 4-1 Rates of Return on Investment for Refineries

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Rate of Return on Investment	9.6	14.5	(1.7)	9.3	18.4	23.2	25.3	21.2	2.4	(6.6)

(EIA 2009)

[10] For details on where flares of this size were located as of the 2002 National Emissions Inventory, see Appendix A of the January 25, 2012 memorandum entitled “Impact Estimates for Fuel Gas Combustion Device and Flare Regulatory Options for Amendments to the Petroleum Refinery NSPS.”

Assuming financially rational producers, standard economic theory suggests that refineries would incorporate all cost-effective improvements, which they are aware of, without government intervention. The cost analysis of this RIA nevertheless is based on the observation that process actions (i.e., installation of a flare gas recovery system) that appear to be profitable in our analysis have not been widely adopted. One explanation for why there appears to be negative cost control technologies that are not generally adopted is imperfect information. If process improvements in the refining sector are not well understood, firms may underestimate the potential financial returns to those improvements. Another explanation is the cost associated with the irreversibility of implementing these process improvements is not reflected in the engineering cost estimates. Because of the high volatility of natural gas prices, it is important to recognize the value of flexibility taken away from firms when requiring them to install and use a particular process technology.

If a firm has not adopted the technology on its own, then a regulation encouraging its use means the firm may require reprioritizing other non-environmental investments. Although the rule does not specifically require installation of flare gas recovery systems, we anticipate that owners and operators of flares receiving high waste gas flows will conclude, upon installation of monitors, implementation of their flare management plans, and implementation of root causes analyses, that installing flare gas recovery would result in fuel savings by using the recovered flare gas where purchased natural gas is now being used to fire equipment such as boilers and process heaters. The flare management plan requires refiners to conduct a thorough review of the flare system so that flare gas recovery systems are installed and used where these systems are warranted. As part of the development of the flare management plan, refinery owners and operators must provide rationale and supporting evidence regarding the flare waste gas reduction options considered, the quantity of flare gas that would be recovered or prevented by the option, the BTU content of the flare gas and the ability or inability of the reduction option to offset natural gas purchases. In addition, regulatory requirements imply firms are unable to suspend use of the technology if it becomes unprofitable in the future. Therefore, the true cost of the regulation should include the lost option value, as well as the engineering costs. In the absence of quantitative estimates of this option value, the costs presented in this RIA may underestimate the full costs faced by the affected firms.

4.3 Small Business Impact Analysis

The Regulatory Flexibility Act (RFA) as amended by the Small Business Regulatory Enforcement Fairness Act (SBREFA) generally requires an agency to prepare a regulatory flexibility analysis of any rule subject to notice and comment rulemaking requirements under the Administrative Procedure Act or any other statute, unless the agency certifies that the rule will not have a significant economic impact on a substantial number of small entities. Small entities include small businesses, small governmental jurisdictions, and small not-for-profit enterprises. The petroleum refining industry (NAICS code 324110) does not include small governmental jurisdictions or small not-for-profit enterprises. For this analysis we applied the Small Business Administration's small refiner definition of a refinery with no more than 1,500 employees (SBA, 2011). For additional discussion of the Agency's application of the definition for small refiner, see the June 24, 2008 Federal Register Notice for 40 CFR Part 60, Standards of Performance for Petroleum Refineries (Volume 73, Number 122, page 35858).[11]

4.3.1 Small Entity Economic Impact Measures

The analysis provides EPA with an estimate of the magnitude of impacts that the provisions of the proposed standards may have on the ultimate domestic parent companies that own the small refineries. This section references the data sources used in the screening analysis and presents the methodology we applied to develop estimates of impacts, the results of the analysis, and conclusions drawn from the results.

The small business impacts analysis for Subpart Ja New Source Performance Standards amendments rely upon data collected through the March 2011 Information Collection Request (ICR -- OMB Control No. 2060-0657). Information collected through component 1 of the ICR includes facility location, products produced, capacity, throughput, process and emissions, and employment and sales receipt data. EPA performed a screening analysis for impacts on all affected small refineries by comparing compliance costs to revenues at the parent company level. This is known as the cost-to-revenue or cost-to-sales ratio, or the "sales test." The "sales test" is

[11] Refer to http://www.sba.gov/sites/default/files/Size_Standards_Table.pdf for more information on SBA small business size standards.

the impact methodology EPA employs in analyzing small entity impacts as opposed to a "profits test," in which annualized compliance costs are calculated as a share of profits. The sales test is frequently used because revenues or sales data are commonly available for entities impacted by EPA regulations, and profits data normally made available are often not the true profit earned by firms because of accounting and tax considerations. The use of a "sales test" for estimating small business impacts for a rulemaking is consistent with guidance offered by EPA on compliance with the RFA[12] and is consistent with guidance published by the U.S. SBA's Office of Advocacy that suggests that cost as a percentage of total revenues is a metric for evaluating cost increases on small entities in relation to increases on large entities (U.S. SBA, 2010).[13]

4.3.2 Small Entity Economic Impact Analysis

As discussed in Section 2 of this RIA, as of January 2011 there were 148 petroleum refineries operating in the continental United States and US territories with a cumulative capacity of processing over 17 million barrels of crude per calendar day (EIA, 2011b). Sixty-four (64) parent companies own these refineries, and EPA has employment and sales data for 61 (95%) of the parent companies. Thirty-six (36) companies (59% of the 61 total) employ fewer than 1,500 workers and are considered small businesses. These firms earned an average of $1.36 billion of revenue per year, while firms employing more than 1,500 employees earned an average of $82.5 billion of revenue per year.[14]

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[12] The RFA compliance guidance to EPA rule writers regarding the types of small business analysis that should be considered can be found at <http://www.epa.gov/sbrefa/documents/rfaguidance11-00-06.pdf>

[13] U.S. SBA, Office of Advocacy. A Guide for Government Agencies, How to Comply with the Regulatory Flexibility Act, Implementing the President's Small Business Agenda and Executive Order 13272, June 2010.

[14] The U.S. Census Bureau's Statistics of U.S. Businesses include the following relevant definitions: (i) **establishment** – a single physical location where business is conducted or where services or industrial operations are performed; (ii) **firm** – a firm is a business organization consisting of one or more domestic establishments in the same state and industry that were specified under common ownership or control. The firm and the establishment are the same for single-establishment firms. For each multi-establishment firm, establishments in the same industry within a state will be counted as one firm; and (iii) **enterprise** -- an enterprise is a business organization consisting of one or more domestic establishments that were specified under common ownership or control. The enterprise and the establishment are the same for single-establishment firms. Each multi-establishment company forms one enterprise.

Based on data collected through the March 2011 ICR, EPA performed the sales test analysis for impacts on affected small refineries. Four of the 36 small refiners were removed from the analysis because we determined they were not major sources and would not be subject to the rules, and one of the 36 small refiners (Gulf Atlantic Operations) was not analyzed because we had no ICR and/or other publically available employment and sales data.

While we estimated the natural gas recovery offsets or credit at a national level and believe that larger firms are more likely to offset natural gas purchases, the revenues from natural gas recovery offsets might mask disproportionate impacts on small refiners. At present to better identify disproportionate impacts, we examined the potential impacts on refiners based on a scenario where no firms adopt flare gas recovery systems and comply with the NSPS through flare monitoring and flare management and root cause analysis actions. Refer to Tables 3-1 and 3-2 in the prior Section for details on the costs and emissions reductions associated with each of the potential compliance actions. Table 4-2 presents the distribution of estimated cost-to-sales ratios for the small firms in our analysis. The incremental compliance costs imposed on small refineries are not estimated to create significant impacts on a cost-to-sales ratio basis at the firm level.

Table 4-2 Impact Levels of Proposed NSPS Amendments on Small Firms

Impact Level	Number of Small Firms in Sample Estimated to be Affected	% of Small Firms in Sample Estimated to be Affected
Cost-to-Sales Ratio less than 1%	31	100%
Cost-to-Sales Ratio 1-3%	0	--
Cost-to-Sales Ratio greater than 3%	0	--

For comparison, we calculated the cost-to-sales ratios for all of the affected refineries to determine whether potential costs would have a more significant impact on small refineries. As presented in Table 4-3, for all large firms, the average cost-to-sales ratio is less than 0.01 percent; the median cost-to-sales ratio is less than 0.01 percent; and the maximum cost-to-sales ratio is 0.02 percent. For small firms, the average cost-to-sales ratio is about 0.06 percent, the median cost-to-sales ratio is 0.02 percent, and the maximum cost-to-sales ratio is 0.63 percent. While the potential costs show a somewhat larger impact on small refiners, the impacts on small refiners are not significant. Because no small firms are expected to have cost-to-sales ratios greater than one percent, we determined that the cost impacts for Subpart Ja New Source Performance Standards amendments will not have a significant economic impact on a substantial number of small entities (SISNOSE).

Table 4-3 Summary of Sales Test Ratios for Firms Affected by Proposed NSPS Amendments

Firm Size	No. of Known Affected Firms	% of Total Known Affected Firms	Mean Cost-to-Sales Ratio	Median Cost-to-Sales Ratio	Min. Cost-to-Sales Ratio	Max. Cost-to-Sales Ratio
Small	31	55%	0.06%	0.02%	<0.01%	0.63%
Large	25	45%	<0.01%	<0.01%	<0.01%	0.02%
All	56	100%	0.02%	<0.01%	<0.01%	0.63%

4.4 References

U.S. Department of Energy, 2009 Energy Information Administration (EIA). "Performance Profiles of Major Energy Producers 2009." (Data accessed on March 5, 2012.) <http://www.eia.gov/cfapps/frs/frstables.cfm?tableNumber=9>

U.S. Environmental Protection Agency, 2010. Guidelines for Preparing Economic Analyses, EPA 240-R-10-001. <http://yosemite.epa.gov/ee/epa/eed.nsf/pages/Guidelines.html> Accessed on: 11/14/11.

EXHIBIT 25

Economic Impact Analysis

Petroleum Refineries
Proposed Amendments to the National Emissions Standards for Hazardous Air Pollutants and New Source Performance Standards

U.S. Environmental Protection Agency
Office of Air and Radiation
Office of Air Quality Planning and Standards
Research Triangle Park, NC 27711

February 2014

1 EXECUTIVE SUMMARY

1.1 Background

As part of the regulatory process, EPA is required to perform economic analysis. EPA estimates the proposed NESHAP and NSPS amendments will have annualized cost of impacts of less than $100 million, so the Agency has prepared an Economic Impact Analysis (EIA). This EIA includes an analysis of economic impact analysis anticipated from the proposed NESHAP and NSPS amendments. We also provide a small business impacts analysis within this EIA. We assume an analysis year of 2016.

1.2 Results

For the proposed rule, the key results of the EIA follow:

- **Engineering Cost Analysis:** Total annualized engineering costs measure the costs incurred by affected industries annually. The annualized engineering costs for the proposed regulatory alternative are estimated to be $42.4 million.[1] As discussed in Section 3, the annualized engineering costs include $4.5 million associated with proposed requirements for storage vessels, delayed coking units, and fugitive emissions monitoring. The proposed requirements would also result in $36.3 million in annual costs for flare monitoring, $1.4 million in annual costs to monitor relief device releases, and $213,000 in annual costs to conduct performance tests for the FCCU at existing sources.
- **Market Analysis:** The proposed option is predicted to induce minimal change in the average national price of refined petroleum product. Product prices are predicted to increase less than 0.0001% on average, while production levels decrease less than 0.0001% on average, as a result of the proposed option.
- **Small Entity Analyses:** Based on data collected through the April 2011 ICR, EPA performed a cost-to-sales screening analysis for impacts for 28 affected small refineries. The cost-to-sales ratio was below 1 percent for all affected small firms. As such, we determined that proposed options will not have a significant economic impact on a substantial number of small entities (SISNOSE).
- **Employment Impacts Analysis:** We provide a qualitative framework for considering the potential influence of environmental regulation on employment in the U.S. economy, and we discuss the limited empirical literature available. The discussion focuses on both short- and long-term employment impacts on regulated industries.

[1] Note that this estimate does not reflect any corrective action taken in response to the fenceline monitoring program. Any corrective actions associated with fenceline monitoring will result in additional emissions reductions and additional costs.

1.3 Organization of this Report

The remainder of this report details the methodology and the results of the EIA. Section 2 presents the industry profile of petroleum refining industry. Section 3 describes the emissions and engineering cost analysis. Section 4 presents market, employment impact, and small business impact analyses.

4 ECONOMIC IMPACT ANALYSIS AND DISTRIBUTIONAL ASSESSMENTS

4.1 Introduction

This section includes three sets of analyses:

- Market Analysis
- Employment Impacts
- Small Business Impacts Analysis

4.2 Market Analysis

EPA performed a series of single-market partial equilibrium analyses of national markets for five major petroleum products to provide a partial measure of the economic consequences of the regulatory options. With the basic conceptual model described below, we estimated how the regulatory program affects prices and quantities for motor gasoline, jet fuel, distillate fuel oil, residual fuel oil, and liquefied petroleum gases which, when aggregated, constitute a large proportion of refinery production in the United States. We also conducted an economic welfare analysis that estimates the consumer and producer surplus changes associated with the regulatory program. The welfare analysis identifies how the regulatory costs are distributed across two broad classes of stakeholders, consumers and producers, for the five products under evaluation. Because we do not have data on changes in refinery utilization rates, the market analysis does not address costs associated with loss in producer surplus due to potentially lower utilization rates that may result from the proposed standards.

4.2.1 Market Analysis Methods

The national compliance cost estimates are often used to approximate the welfare impacts of the rule. However, in cases where the engineering costs of compliance are used to estimate welfare impacts, the burden of the regulation is typically measured as falling solely on the affected producers, who experience a profit loss exactly equal to these cost estimates. Thus, the entire loss is a change in producer surplus with no change (by assumption) in consumer surplus, because no changes in price and consumption are estimated. This is typically referred to as a "full-cost absorption" scenario in which all factors of production are assumed to be fixed and firms are unable to adjust their output levels when faced with additional costs. In contrast, EPA's economic analysis builds on the engineering cost analysis and incorporates economic theory related to producer and consumer behavior to estimate changes in market conditions.

The partial equilibrium models use a common analytic expression to analyze supply and demand in a single market (Berck and Hoffmann 2002; Fullerton and Metcalf 2002) and follows EPA guidelines for conducting an EIA (U.S. Environmental Protection Agency 2010). We illustrate our approach for estimating market-level impacts using a simple, single partial equilibrium model. The method involves specifying a set of nonlinear supply and demand relationships for the affected market, simplifying the equations by transforming them into a set of linear equations, and then solving the equilibrium system of equations (see Fullerton and Metcalfe (2002) for an example).

First, we consider the formal definition of the elasticity of supply, q_s, with respect to changes in own price, p, where ε_s represents the market elasticity of supply:

$$\varepsilon_s = \frac{dq_s / q_s}{dp / p} \tag{4.1}$$

Next, we can use "hat" notation to transform Eq. 1 to proportional changes and rearrange terms:

$$\hat{q}_s = \varepsilon_s \hat{p} \tag{4.1a}$$

where $\hat{q}_s$ equals the percentage change in the quantity of market supply, and $\hat{p}$ equals the percentage change in market price. As Fullerton and Metcalfe (2002) note, we have taken the elasticity definition and turned it into a linear behavioral equation for the market we are analyzing.

To introduce the direct impact of the regulatory program, we assume the per-unit cost associated with the regulatory program, c, leads to a proportional shift in the marginal cost of production $\left(\hat{mc}\right)$. The per-unit costs are estimated by dividing the total estimated annualized engineering costs accruing to producers within a given product market by the baseline national production in that market. Under the assumption of perfect competition (e.g., price equaling marginal cost), we can approximate this shift at the initial equilibrium point as follows:

$$\widehat{mc} = \frac{c}{mc_0} = \frac{c}{p_0}. \tag{4.1b}$$

The with-regulation supply equation can now be written as

$$\hat{q}_s = \varepsilon_s(\hat{p} - \widehat{mc}) . \tag{4.1c}$$

Next, we can specify a demand equation as follows:

$$\hat{q}_d = \eta_d \hat{p} \tag{4.2}$$

where

$\hat{q}_d$	=	percentage change in the quantity of market demand,
η_d	=	market elasticity of demand, and
$\hat{p}$	=	percentage change in market price.

Finally, we specify the market equilibrium conditions in the affected market. In response to the exogenous increase in production costs, producer and consumer behaviors are represented in Eq. 4-1a and Eq. 4-2, and the new equilibrium satisfies the condition that the change in supply equals the change in demand:

$$\hat{q}_s = \hat{q}_d . \tag{4.3}$$

We now have three linear equations and three unknowns ($\hat{p}$, $\hat{q}_d$, and $\hat{q}_s$), and we can solve for the proportional price change in terms of the elasticity parameters (ε_s and η_d) and the proportional change in marginal cost:

$$\begin{aligned}
\varepsilon_s(\hat{p} - \widehat{mc}) &= \eta_d \hat{p} \\
\varepsilon_s \hat{p} - \varepsilon_s \widehat{mc} &= \eta_d \hat{p} \\
\varepsilon_s \hat{p} - \eta_d \hat{p} &= \varepsilon_s \widehat{mc} \\
\hat{p}(\varepsilon_s - \eta_d) &= \varepsilon_s \widehat{mc} \\
\hat{p} &= \frac{\varepsilon_s}{\varepsilon_s - \eta_d} \widehat{mc}
\end{aligned} \tag{4.4}$$

Given this solution, we can solve for the proportional change in market quantity using Eq. 4-2.

The change in consumer surplus in the affected market can be estimated using the following linear approximation method:

$$\Delta cs = -(q_1 \times p) + (0.5 \times \Delta q \times \Delta p) \tag{4.5}$$

where q_1 equals with-regulation quantities produced. As shown, higher market prices and reduced consumption lead to welfare losses for consumers.

For affected supply, the change in producer surplus can be estimated with the following equation:

$$\Delta ps = (q_1 \times \Delta p) - (q_1 \times c) - (0.5 \times \Delta q \times (\Delta p - c)). \tag{4.6}$$

Increased regulatory costs and output declines have a negative effect on producer surplus, because the net price change $(\Delta p - c)$ is negative. However, these losses are mitigated, to some degree, as a result of higher market prices.

4.2.2 Model Baseline

Standard EIA practice compares and contrasts the state of a market with and without the regulatory policy. EPA selected 2016 as the baseline year for the analysis and collected petroleum product price and quantity forecast information from the Energy Information Administration's 2012 Reference Case Annual Energy Outlook (U.S. EIA 2011a). Baseline data are reported in Table 4-1. Annual Energy Outlook (AEO) reports the quantity of petroleum products produced in terms of barrels, while the price of petroleum products is reported in terms of dollars per gallon. Therefore, to ensure that common units were being used, the number of barrels produced each year was divided by 42, the number of gallons in a barrel.

Table 4-1 Baseline Petroleum Product Market Data, 2016

	Motor Gasoline	Jet Fuel	Distillate Fuel Oil	Residual Fuel Oil	Liquified Petroleum Gases
Price ($2010/per gallon)[1]	3.17	2.73	3.42	2.25	0.96
Quantity (billion gallons/per year)[2]	130.61	22.69	66.69	7.82	40.93

[1]Source: AEO2012 Reference Case, Petroleum Product Prices (Table 12)
[2]Source: AEO2012 Reference Case, Liquid Fuels Supply and Disposition (Table 11)

4.2.3 Model Parameters

Demand elasticity is calculated as the percentage change in the quantity of a product demanded divided by the percentage change in price. An increase in price causes a decrease in the quantity demanded, hence the negative values seen in Table 4-2, which presents the demand elasticities used in this analysis. Demand is considered elastic if demand elasticity exceeds 1.0 in absolute value (i.e., the percentage change in quantity exceeds the percentage change in price). The quantity demanded, then, is very sensitive to price increases. Demand is considered inelastic if demand elasticity is less than 1.0 in absolute value (i.e., the percentage change in quantity is less than the percentage change in price). Inelastic demand implies that the quantity demanded changes very little in response to price changes. As shown in Table 4-2, we draw demand elasticities from U.S. EPA (1995).

Table 4-2 Estimates of Price Elasticity of Demand and Supply[1]

	Motor Gasoline	Jet Fuel	Distillate Fuel Oil	Residual Fuel Oil	Liquified Petroleum Gases
Demand elasticity	-0.69	-0.15	-0.75	-0.68	-0.80
Supply elasticity	1.24	1.24	1.24	1.24	1.24

[1] The source for these elasticities is U.S. EPA (1995). The literature review performed for this EIA indentified more recent estimates of long-term demand elasticities for motor gasoline, which are lower than the elasticity used in this analysis, but we were unable to identify more recent estimates of the other elasticities.

Supply elasticity is calculated as the percentage change in quantity supplied divided by the percentage change in price. An upward sloping supply curve has a positive elasticity since price and quantity move in the same direction. If the supply curve has elasticity greater than one, then supply is considered elastic, which means a small price increase will lead to a relatively large increase in quantity supplied. A supply curve with elasticity less than one is considered inelastic, which means an increase in price will cause little change in quantity supplied. In the long-run, when producers have sufficient time to completely adjust their production to a change in price, the price elasticity of supply is usually greater than one. As shown in Table 4-2, we draw supply elasticities from U.S. EPA (1995).

4.2.4 Entering Estimated Annualized Engineering Compliance Costs into Economic Model

To collect comprehensive, updated information for the proposed rulemaking, EPA conducted a one-time information collection request (ICR) through a survey, under the authority of CAA section 114, of all potentially affected petroleum refineries. The ICR was comprised of four components, and the information collected through component 1 of the ICR included facility location, products produced, capacity, throughput, process and emissions, and employment and sales receipt data for 2010.[17] The throughput quantities provided were the same as those reported to the U.S. EIA on form EIA-810. The ICR information was used to analyze and calculate compliance costs by refinery for the proposed rulemaking. These annualized engineering compliance costs provided the basis for the environmental cost inputs for the series of partial equilibrium economic models.

The annualized engineering compliance cost inputs are incorporated into the partial equilibrium models on a per barrel refining capacity basis. Several steps were required to convert the annualized engineering compliance cost data, by refinery, into the data format required for the economic analysis. First, for each refinery we allocated the compliance costs across total barrels of refinery production. Because EPA collected production information for thirty-nine (39) different refinery products and the economic models allow for production input data for five product types, we then mapped the ICR product types to the shorter list of products used in the economic model. We assumed a uniform refinery utilization rate of 86.4%, which is the operable utilization rate for U.S. refineries for 2010.[18]

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[17] Detailed information on the ICR can be located at https://refineryicr.rti.org/. OMB approved the ICR on March 28, 2011. The OMB Control Number is 2060-0657, and approval expires March 31, 2014.

[18] Recent and historical refinery utilization rate information can be located at U.S. EIA's website: http://www.eia.gov/dnav/pet/pet_pnp_unc_dcu_nus_a.htm.

Table 4-3 Estimated Annualized Engineering Compliance Costs by Petroleum Product Modeled (2010 dollars)

	Motor Gasoline	Jet Fuel	Distillate Fuel Oil	Residual Fuel Oil	Liquified Petroleum Gases	Other	All Products
Total Annualized Engineering Compliance Costs	$20,136,107	$4,130,446	$12,872,696	$1,893,999	$1,514,516	$15,762,038	$56,309,802
Capacity (millions bbls/year)	2,782.51	611.74	1,536.15	227.53	191.97	2,121.04	7,470.94
Capacity (millions gallons/year)	116,865.42	25,693.01	64,518.41	9,556.20	8,062.72	89,083.84	313,779.60
Compliance Costs Per Gallon Capacity ($2010)	$0.00017	$0.00016	$0.00020	$0.00020	$0.00019	$0.00018	$0.00018

Using this engineering cost information and total national production of petroleum products, we estimated the annualized compliance cost per gallon of product produced. These annualized per gallon engineering compliance costs are presented in Table 4-3. For this analysis, we included engineering compliance costs that do not reflect the product recovery credits. At the national level, the total annualized engineering compliance costs are estimated at less than $0.00018 per gallon, or less than two one-hundredths of a cent per gallon. These per-gallon annualized engineering costs estimates were then entered into the series of partial equilibrium market models to estimate impacts on the respective petroleum product markets.

4.2.5 Model Results

Based on EPA's partial equilibrium analysis, the costs induced by this regulatory program do not have a significant impact on market-level prices or quantities. The results of this analysis are summarized in Table 4-4. As this table shows, prices for each of the five products rise by less than two one-hundredths of a penny per gallon, and the quantity of each petroleum product produced declines slightly. Motor gasoline and liquified petroleum gases face the largest absolute quantity reductions (3.14 million and 3.91 million gallons, respectively, or less than 0.0001 percent in both cases).

Table 4-4 Summary of Petroleum Product Market Impacts

	Motor Gasoline	Jet Fuel	Distillate Fuel Oil	Residual Fuel Oil	Liquified Petroleum Gases
Change in Price (%)	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Change in Price (2010$)	0.0001	0.0001	0.0001	0.0001	0.0001
Change In Quantity (%)	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Change In Quantity (million gallons per year)	-3.14	-0.18	-1.82	-0.30	-3.91
			Welfare Impacts		
Change in consumer surplus ($ millions)	-14.46	-3.25	-8.29	-1.00	-4.67
Change in producer surplus ($ millions)	-7.87	-0.23	-4.81	-0.35	-2.83
Change in total surplus ($ millions)	-22.33	-3.48	-13.10	-1.35	-7.50

As a result of higher prices, consumers of petroleum products see a decline in surplus, as shown in Table 4-4. For example, consumers of motor gasoline are estimated to lose $14.46 million of surplus. In addition, producers also receive a smaller surplus as a result of higher production costs. In the case of motor gasoline, producers lose $7.87 million. Total surplus losses for consumers and producers of motor gasoline are estimated to be $22.33 million. The total annualized loss in surplus for the five markets analyzed is $47.77 million. In addition to the loss in surplus for consumers and producers of these five major petroleum products, an additional $15.7 million in costs will affect markets for petroleum products that were not explicitly modeled in this analysis. These include markets for asphalt, lubricants, road oil, petroleum coke and others.

As a sensitivity analysis, we used a more recently estimated, long-run elasticity of demand for motor gasoline from Small and Van Dender (2007), which is based on cross-sectional, time-series data from the U.S. for the period of 1966-2001. If we use this elasticity (-0.38), consumers of motor gasoline could lose $17.23 million of surplus, or an additional $2.77 million loss in surplus compared to the estimate above (Small and Van Dender 2007). In addition, producers of motor gasoline could lose $5.1 million of surplus, or reduce their surplus loss by $2.77 million.

4.2.6 Limitations

Ultimately, the regulatory program may cause negligible increases in the costs of supplying petroleum products to consumers. The partial equilibrium model used in this EIA is designed to evaluate behavioral responses to this change in costs within an equilibrium setting within nationally competitive markets. The national competitive market assumption is clearly strong because the markets in petroleum products may be regional for some products, as well as some product markets within the refining industry may be interdependent. Regional price and quantity impacts could be different from the average impacts reported if local market structures, production costs, or demand conditions are substantially different from those used in this analysis.

4.3 Discussion of Employment Impacts

Executive Order 13563 directs federal agencies to consider the effect of regulations on job creation and employment. According to the Executive Order, "our regulatory system must protect public health, welfare, safety, and our environment while promoting economic growth, innovation, competitiveness, and job creation. It must be based on the best available science" (Executive Order 13563, 2011). Although standard benefit-cost analyses have not typically included a separate analysis of regulation-induced employment impacts,[19] during periods of sustained high unemployment, employment impacts are of particular concern and questions may arise about their existence and magnitude. This section provides a conceptual framework for considering the potential influence of environmental regulation on employment in the U.S. economy and discusses the limited empirical literature that is available. The section then discusses the potential employment impacts in the environmental protection sector, e.g. for construction, manufacture, installation, and operation of needed pollution control equipment. Section 4.3.1 describes the economic theory used for analyzing regulation-induced employment impacts, discussing how standard neoclassical theory alone does not point to a definitive net effect of regulation on labor demand for regulated firms. Section 4.3.2 presents an overview of the peer-reviewed literature relevant to evaluating the effect of environmental regulation on employment. Section 4.3.3 discusses macroeconomic net employment effects. The EPA is

[19] Labor expenses do, however, contribute toward total costs in the EPA's standard benefit-cost analyses.

currently in the process of seeking input from an independent expert panel on economy-wide impacts, including employment effects. Finally, Section 4.3.4 offers several conclusions.

4.3.1 Theory

The effects of environmental regulation on employment are difficult to disentangle from other economic changes and business decisions that affect employment, over time and across regions and industries. Labor markets respond to regulation in complex ways. That response depends on the elasticities of demand and supply for labor and the degree of labor market imperfections (e.g., wage stickiness, long-term unemployment, etc). The unit of measurement (e.g., number of jobs, types of jobs hours worked, or earnings) may affect observability of that response. Net employment impacts are composed of a mix of potential declines and gains in different areas of the economy (i.e., the directly regulated sector, upstream and downstream sectors, and the pollution abatement sector) and over time. In light of these difficulties, economic theory provides a constructive framework for approaching these assessments and for better understanding the inherent complexities in such assessments. In this section, we briefly describe theory relevant to the impact of regulation on labor demand at the regulated firm, in the regulated industry, and in the environmental protection sector; and highlight the importance of considering potential effects of regulation on labor supply, a topic addressed further in a subsequent section.

Neoclassical microeconomic theory describes how profit-maximizing firms adjust their use of productive inputs in response to changes in their economic conditions.[20] In this framework, labor is one of many inputs to production, along with capital, energy, and materials. In competitive output markets, profit maximizing firms take prices as given, and choose quantities of inputs and outputs to maximize profit. Factor demand at the firm, then, is determined by input and output prices.[21,22]

Berman and Bui (2001) and Morgenstern, Pizer, and Shih (2002) have specifically tailored one version of the standard neoclassical model to analyze how environmental regulations affect labor demand decisions.[23] Environmental regulation is modeled as effectively requiring

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[20] See Layard and Walters (1978), a standard microeconomic theory textbook, for a discussion.
[21] See Hamermesh (1993), Chapter 2, for a derivation of the firm's labor demand function from cost-minimization.
[22] In this framework, labor demand is a function of quantity of output and prices (of both outputs and inputs).
[23] Berman and Bui (2001) and Morgenstern, Pizer, and Shih (2002) use a cost-minimization framework, which is a special case of profit-maximization with fixed output quantities.

certain factors of production, such as pollution abatement capital investment, that would not be freely chosen by profit maximizing/cost-minimizing firms.

In Berman and Bui's (2001, p. 274-75) theoretical model, the change in a firm's labor demand arising from a change in regulation is decomposed into two main components: output and substitution effects.[24] For the output effect, by affecting the marginal cost of production, regulation affects the profit-maximizing quantity of output. The output effect describes how, if labor-intensity of production is held constant, a decrease in output generally leads to a decrease in labor demand. However, as noted by Berman and Bui, although it is often assumed that regulation increases marginal cost, and thereby reduces output, it need not be the case. A regulation could induce a firm to upgrade to less polluting, and more efficient equipment that lowers marginal production costs, for example. In such a case, output could theoretically increase. For example, in the proposed refinery amendments, the fitting controls and monitoring equipment for storage vessels were identified as developments in practices, processes and control technologies for storage vessels. The proposed requirement could result in fewer VOC emissions and more product remaining in the storage vessel, potentially increasing output.

The substitution effect describes how, holding output constant, regulation affects the labor-intensity of production. Although increased environmental regulation generally results in higher utilization of production factors such as pollution control equipment and energy to operate that equipment, the resulting impact on labor demand is ambiguous. For example, equipment inspection requirements, specialized waste handling, or pollution technologies that alter the production process may affect the number of workers necessary to produce a unit of output. Berman and Bui (2001) model the substitution effect as the effect of regulation on "quasi-fixed'' pollution control equipment and expenditures that are required by the regulation and the corresponding change in labor-intensity of production. Within the production theory framework, when levels of a given set of inputs are fixed by external constraints such as regulatory requirements, rather than allowing the firm to freely choose all inputs under cost-minimization alone, these inputs are described as "quasi-fixed". For example, materials would be a "quasi-

[24] The authors also discuss a third component, the impact of regulation on factor prices, but conclude that this effect is unlikely to be important for large competitive factor markets, such as labor and capital. Morgenstern, Pizer and Shih (2002) use a very similar model, but they break the employment effect into three parts: 1) the demand effect; 2) the cost effect; and 3) the factor-shift effect.

fixed" factor if there were specific requirements for landfill liner construction, but the footprint of the landfill was flexible. Brown and Christensen (1981) develop a partial static equilibrium model of production with quasi-fixed factors, which Berman and Bui (2001) extend to analyze environmental regulations with technology-based standards.

In summary, as the output and substitution effects may be both positive, both negative or some combination, standard neoclassical theory alone does not point to a definitive net effect of regulation on labor demand at regulated firms. Operating within the bounds of standard neoclassical theory, however, rough estimation of net employment effects is possible with empirical study, specific to the regulated firms, when data and methods of sufficient detail and quality are available. The available literature illustrates some of the difficulties for empirical estimation: studies sometimes rely on confidential plant-level employment data from the U.S. Census Bureau, possibly combined with pollution abatement expenditure data that are too dated to be reliably informative. In addition, the most commonly used empirical methods in the literature do not permit the estimation of net effects. These studies will be discussed at greater length later in this chapter.

The above describes a conceptual framework for analyzing potential employment effects at a particular firm, within a regulated industry. It is important to emphasize that employment impacts at a particular firm will not necessarily represent impacts for the overall industry, therefore the theoretic approach requires some adjustment when applied at the industry level.

As stated, the responsiveness of industry labor demand depends on how the output and substitution effects interact. [25] At the industry-level, labor demand will be more responsive when: (1) the price elasticity of demand for the product is high, (2) other factors of production can be easily substituted for labor, (3) the supply of other factors is highly elastic, or (4) labor costs are a large share of the total costs of production.[26] So, for example, if all firms in the industry are faced with the same compliance costs of regulation and product demand is inelastic, then industry output may not change much at all, and output of individual firms may only be slightly changed.[27] In this case the output effect may be small, while the substitution effect will still depend on the degree of substitutability or complementarity between factors of production.

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[25] Marshall's laws of derived demand – see Ehrenberg & Smith, Chapter 4.
[26] See Ehrenberg & Smith, p. 108.
[27] This discussion draws from Berman and Bui (2001), p. 293.

Continuing the example, if new pollution control equipment requires labor to install and operate, labor is more of a complement than a substitute. In this case the substitution effect may be positive, and if the output effect is small or zero, the total effect may then be positive. As with the potential effects for an individual firm, theory alone is unable to determine the sign or magnitude of industry-level regulatory effects on labor. Determining these signs and magnitudes requires additional sector-specific empirical study. To conduct such targeted research would require estimates of product demand elasticity; production factor substitutability; supply elasticity of production factors; and the share of total costs contributed by wages, by industry, and perhaps even by facility. For environmental rules, many of these data items are not publicly available, would require significant time and resources in order to access confidential U.S. Census data for research, and also would not be necessary for other components of a typical EIA or RIA.

In addition to changes to labor demand in the regulated industry, net employment impacts encompass changes within the environmental protection sector, and, potentially in other related sectors, as well. Environmental regulations often create increased demand for pollution control equipment and services needed for compliance. This increased demand may increase revenue and employment in the environmental protection industry. At the same time, the regulated industry is purchasing the equipment and these costs may impact labor demand at regulated firms. Therefore, it is important to consider the net effect of compliance actions on employment across multiple sectors or industries.

If the U.S. economy is at full employment, even a large-scale environmental regulation is unlikely to have a noticeable impact on aggregate net employment.[28] Instead, labor would primarily be reallocated from one productive use to another (e.g., from producing electricity or steel to producing pollution abatement equipment). Theory supports the argument that, in the case of full employment, the net national employment effects from environmental regulation are likely to be small and transitory (e.g., as workers move from one job to another).[29] On the other hand, if the economy is operating at less than full employment, economic theory does not clearly indicate the direction or magnitude of the net impact of environmental regulation on

[28] Full employment is a conceptual target for the economy where everyone who wants to work and is available to do so at prevailing wages is actively employed.

[29] Arrow et. al. 1996; see discussion on bottom of p. 8. In practice, distributional impacts on individual workers can be important, as discussed in later paragraphs of this section.

employment; it could cause either a short-run net increase or short-run net decrease (Schmalansee and Stavins, 2011). An important fundamental research question is how to accommodate unemployment as a structural feature in economic models. This feature may be important in evaluating the impact of large-scale regulation on employment (Smith 2012).

Affected sectors may experience transitory effects as workers change jobs. Some workers may need to retrain or relocate in anticipation of the new requirements or require time to search for new jobs, while shortages in some sectors or regions could bid up wages to attract workers. It is important to recognize that these adjustment costs can entail local labor disruptions, and although the net change in the national workforce is expected to be small, localized reductions in employment can still have negative impacts on individuals and communities just as localized increases can have positive impacts.

While the current discussion focuses on labor demand effects, environmental regulation may also affect labor supply. In particular, pollution and other environmental risks may impact labor productivity[30] or employees' ability to work. While there is an accompanying, and parallel, theoretical approach to examining impacts on labor supply, similar to labor demand, it is even more difficult and complex to study labor supply empirically. There is a small, nascent empirical literature using more detailed labor and environmental data, and quasi-experimental techniques that is starting to find traction on this question. These will be described in Section 4.3.2.3.

To summarize the discussion in this section, economic theory provides a framework for analyzing the impacts of environmental regulation on employment. The net employment effect incorporates expected employment changes (both positive and negative) in the regulated sector, the environmental protection sector, and other relevant sectors. Using economic theory, labor demand impacts for regulated firms, and also for the regulated industry, can be decomposed into output and substitution effects. With these potentially competing forces, under standard neoclassical theory estimation of net employment effects is possible with empirical study specific to the regulated firms and firms in the environmental protection sector and other relevant sectors when data and methods of sufficient detail and quality are available. Finally, economic theory suggests that labor supply effects are also possible. In the next section, we discuss the available empirical literature.

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[30] e.g., Graff Zivin and Neidell (2012).

4.3.2 Current State of Knowledge Based on the Peer-Reviewed Literature

In the labor economics literature there is an extensive body of peer-reviewed empirical work analyzing various aspects of labor demand, relying on the above theoretical framework.[31] This work focuses primarily on the effects of employment policies, e.g. labor taxes, minimum wage, etc.[32] In contrast, the peer-reviewed empirical literature specifically estimating employment effects of environmental regulations is very limited. In this section, we present an overview of the latter. As discussed in the preceding section on theory, determining the direction of employment effects in regulated industries is challenging because of the complexity of the output and substitution effects. Complying with a new or more stringent regulation may require additional inputs, including labor, and may alter the relative proportions of labor and capital used by regulated firms (and firms in other relevant industries) in their production processes.

Several empirical studies, including Berman and Bui (2001) and Morgenstern et al (2002), suggest that net employment impacts may be zero or slightly positive but small even in the regulated sector. Other research suggests that more highly regulated counties may generate fewer jobs than less regulated ones (Greenstone 2002, Walker 2011). However since these latter studies compare more regulated to less regulated counties they overstate the net national impact of regulation to the extent that regulation causes plants to locate in one area of the country rather than another. List et al. (2003) find some evidence that this type of geographic relocation may be occurring. Overall, the peer-reviewed literature does not contain evidence that environmental regulation has a large impact on net employment (either negative or positive) in the long run across the whole economy.

Environmental regulations seem likely to affect the environmental protection sector earlier than the regulated industry. Rules are usually announced well in advance of their effective dates and then typically provide a period of time for firms to invest in technologies and process changes to meet the new requirements. When a regulation is promulgated, the initial response of firms is often to order pollution control equipment and services to enable compliance when the regulation becomes effective. This can produce a short-term increase in labor demand for

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[31] Again, see Hamermesh (1993) for a detailed treatment.
[32] See Ehrenberg & Smith (2000), Chapter 4: "Employment Effects: Empirical Estimates" for a concise overview.

specialized workers within the environmental protection sector, particularly workers involved in the design, construction, testing, installation, and operation of the new pollution control equipment required by the regulation (see Schmalansee and Stavins, 2011; Bezdek, Wendling, and Diperna, 2008). Estimates of short-term increases in demand for specialized labor within the environmental protection sector have been prepared for several EPA regulations in the past, including the Mercury and Air Toxics Standards (MATS).[33]

4.3.2.1 Regulated Sector

Determining the direction of net employment effects of regulation on industry is challenging. Two papers that present a formal theoretic model of the underlying profit-maximizing/cost-minimizing problem of the firm are Berman and Bui (2001) and Morgenstern, Pizer, and Shih (2002) mentioned above.

Berman and Bui (2001) developed an innovative approach to estimate the effect on employment of environmental regulations in California. Their model empirically examines how an increase in local air quality regulation affects manufacturing employment in the South Coast Air Quality Management District (SCAQMD), which incorporates Los Angeles and its suburbs. During the time frame of their study, 1979 to 1992, the SCAQMD enacted some of the country's most stringent air quality regulations. Using SCAQMD's local air quality regulations, Berman and Bui identify the effect of environmental regulations on net employment in the regulated industries.[34] In particular, they compare changes in employment in affected plants to those in other plants in the same 4-digit SIC industries but in regions not subject to the local regulations.[35] The authors find that "while regulations do impose large costs, they have a limited effect on employment" (Berman and Bui, 2001, p. 269). Their conclusion is that local air quality regulation "probably increased labor demand slightly" but that "the employment effects of both compliance and increased stringency are fairly precisely estimated zeros, even when exit and dissuaded entry effects are included" (Berman and Bui, 2001, p. 269).[36] In their view, the limited effects likely arose because 1) the regulations applied disproportionately to capital-intensive

[33] U.S. EPA (2011b)
[34] Note, like Morgenstern, Pizer, and Shih (2002), this study does not estimate the number of jobs created in the environmental protection sector.
[35] Berman and Bui include over 40 4-digit SIC industries in their sample.
[36] Including the employment effect of exiting plants and plants dissuaded from opening will increase the estimated impact of regulation on employment. This employment effect is not included in Morgenstern et. al. (2002)

plants with relatively little employment, 2) the plants sold to local markets where competitors were subject to the same regulations (so that sales were relatively unaffected), and 3) abatement inputs served as complements to employment.

Morgenstern, Pizer, and Shih (2002) developed a similar structural approach to Berman and Bui's, but their empirical application uses pollution abatement expenditures from 1979 to 1991 at the plant-level, including air, water, and solid waste, to estimate net employment effects in four highly regulated sectors (pulp and paper, plastics, steel, and petroleum refining). Thus, in contrast to Berman and Bui (2001), this study identifies employment effects by examining differences in abatement expenditures rather than geographical differences in stringency. They conclude that increased abatement expenditures generally have *not* caused a significant change in net employment in those sectors.

4.3.2.2 Environmental Protection Sector

The long-term effects of a regulation on the environmental protection sector, which provides goods and services that help protect the environment to the regulated sector, are difficult to assess. Employment in the industry supplying pollution control equipment or services is likely to increase with the increased demand from the regulated industry for increased pollution control.[37]

A report by the U.S. International Trade Commission (2013) shows that domestic environmental services revenues have grown by 41 percent between 2000 and 2010. According to U.S. Department of Commerce (2010) data, by 2008, there were 119,000 environmental technology (ET) firms generating approximately $300 billion in revenues domestically, producing $43.8 billion in exports, and supporting nearly 1.7 million jobs in the United States. Air pollution control accounted for 18% of the domestic ET market and 16% of exports. Small and medium-size companies represent 99% of private ET firms, producing 20% of total revenue (OEEI, 2010).

4.3.2.3 Labor Supply Impacts

As described above, the small empirical literature on employment effects of environmental regulations focuses primarily on labor demand impacts. However, there is a

[37] See Bezdek, Wendling, and Diperna (2008), for example, and U.S. Department of Commerce (2010).

nascent literature focusing on regulation-induced effects on labor supply, though this literature remains very limited due to empirical challenges. This new research uses innovative methods and new data, and indicates that there may be observable impacts of environmental regulation on labor supply, even at pollution levels below mandated regulatory thresholds. Many researchers have found that work loss days and sick days as well as mortality are reduced when air pollution is reduced.[38] EPA's study of the benefits and costs of implementing clean air regulations used these studies to predict how increased labor availability would increase the labor supply and improve productivity and the economy. [39] Another literature estimates how worker productivity improves at the work site when pollution is reduced. Graff Zivin and Neidell (2013) review the work in this literature, focusing on how health and human capital may be affected by environmental quality, particularly air pollution. In previous research, Graff Zivin and Neidell (2012) use detailed worker-level productivity data from 2009 and 2010, paired with local ozone air quality monitoring data for one large California farm growing multiple crops, with a piece-rate payment structure. Their quasi-experimental structure identifies an effect of daily variation in monitored ozone levels on productivity. They find "that ozone levels well below federal air quality standards have a significant impact on productivity: a 10 parts per billion (ppb) decrease in ozone concentrations increases worker productivity by 5.5 percent." (Graff Zivin and Neidell, 2012, p. 3654). Such studies are a compelling start to exploring this new area of research, considering the benefits of improved air quality on productivity, alongside the existing literature exploring the labor demand effects of environmental regulations.

4.3.3 Macroeconomic Net Employment Effects

The preceding sections have outlined the challenges associated with estimating net employment effects within the regulated sector, in the environmental protection sector, and labor supply impacts. These challenges make it very difficult to accurately produce net employment estimates for the whole economy that would appropriately capture the way in which costs, compliance spending, and environmental benefits propagate through the macro-economy.

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[38] The Benefits and Costs of the Clean Air Act from 1990 to 2020 Final Report – Rev. A , U.S. Environmental Protection Agency, Office of Air and Radiation, April 2011a. http://www.epa.gov/air/sect812/feb11/fullreport_rev_a.pdf

[39] The Benefits and Costs of the Clean Air Act from 1990 to 2020 Final Report – Rev. A , U.S. Environmental Protection Agency, Office of Air and Radiation, April 2011a. http://www.epa.gov/air/sect812/feb11/fullreport_rev_a.pdf

Quantitative estimates are further complicated by the fact that macroeconomic models often have very little sectoral detail and usually assume that the economy is at full employment. The EPA is currently in the process of seeking input from an independent expert panel on modeling economy-wide impacts, including employment effects.

4.3.4 Conclusions

In conclusion, deriving estimates of how environmental regulations will impact net employment is a difficult task, requiring consideration of labor demand in both the regulated and environmental protection sectors. Economic theory predicts that the total effect of an environmental regulation on labor demand in regulated sectors is not necessarily positive or negative. Peer-reviewed econometric studies that use a structural approach, applicable to overall net effects in the regulated sectors, converge on the finding that such effects, whether positive or negative, have been small and have not affected employment in the national economy in a significant way. Effects on labor demand in the environmental protection sector seem likely to be positive. Finally, new evidence suggests that environmental regulation may improve labor supply and productivity.

4.4 Small Business Impacts Analysis

The Regulatory Flexibility Act (RFA) as amended by the Small Business Regulatory Enforcement Fairness Act (SBREFA) generally requires an agency to prepare a regulatory flexibility analysis of any rule subject to notice and comment rulemaking requirements under the Administrative Procedure Act or any other statute, unless the agency certifies that the rule will not have a significant economic impact on a substantial number of small entities. Small entities include small businesses, small governmental jurisdictions, and small not-for-profit enterprises. The petroleum refining industry (NAICS code 324110) does not include small governmental jurisdictions or small not-for-profit enterprises. Under Small Business Administration (SBA) regulations, a small refiner is defined as a refinery with no more than 1,500 employees.[40] For this analysis we applied the small refiner definition of a refinery with no more than 1,500 employees. For additional information on the Agency's application of the definition for small

[40] See Table in 13 CFR 121.201, NAICS code 324110.

refiner, see the June 24, 2008 Federal Register Notice for 40 CFR Part 60, Standards of Performance for Petroleum Refineries (Volume 73, Number 122, page 35858).[41]

4.4.1 Small Entity Economic Impact Measures

The analysis provides EPA with an estimate of the magnitude of impacts that the proposed standards may have on the ultimate domestic parent companies that own the small refineries. This section references the data sources used in the screening analysis and presents the methodology we applied to develop estimates of impacts, the results of the analysis, and conclusions drawn from the results.

The small business impacts analysis for the risk and technology reviews for existing MACT 1 and MACT 2 standards and for Subpart Ja New Source Performance Standards amendments relies upon data collected through the April 2011 Information Collection Request (ICR -- OMB Control No. 2060-0657). Information collected through component 1 of the ICR includes facility location, products produced, capacity, throughput, process and emissions, and employment and sales receipt data. EPA performed a screening analysis for impacts on all affected small refineries by comparing compliance costs to revenues at the parent company level. This is known as the cost-to-revenue or cost-to-sales ratio, or the “sales test.” The “sales test” is the impact methodology EPA employs in analyzing small entity impacts as opposed to a “profits test,” in which annualized compliance costs are calculated as a share of profits. The sales test is frequently used because revenues or sales data are commonly available for entities impacted by EPA regulations, and profits data normally made available are often not the true profit earned by firms because of accounting and tax considerations. The use of a “sales test” for estimating small business impacts for a rulemaking is consistent with guidance offered by EPA on compliance with the RFA[42] and is consistent with guidance published by the U.S. SBA’s Office

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[41] Refer to http://www.sba.gov/sites/default/files/Size_Standards_Table.pdf for more information on SBA small business size standards.

[42] The RFA compliance guidance to EPA rulewriters regarding the types of small business analysis that should be considered can be found at <http://www.epa.gov/sbrefa/documents/rfaguidance11-00-06.pdf>

of Advocacy that suggests that cost as a percentage of total revenues is a metric for evaluating cost increases on small entities in relation to increases on large entities (U.S. SBA, 2010).[43]

4.4.2 Small Entity Economic Impact Analysis

As discussed in Section 2 of this EIA, as of January 2011 there were 148 petroleum refineries operating in the continental United States and US territories with a cumulative capacity of processing over 17 million barrels of crude per calendar day (EIA, 2011b). Sixty-four (64) parent companies own these refineries, and we have employment and sales data for 62 (96%) of them. Thirty-five (35) companies (56% of the 62 firm total) employ fewer than 1,500 workers and are considered small businesses. These firms earned an average of $1.36 billion of revenue per year, while firms employing more than 1,500 employees earned an average of $82.5 billion of revenue per year.[44]

Based on data collected through the April 2011 ICR, EPA performed the sales test analysis for impacts on affected small refineries. Five (5) of the 35 small refiners were removed from the analysis because we determined they were not major sources and would not be subject to the rules, and two (2) of the 35 small refiners were not analyzed because we had no ICR and/or other publically available employment and sales data. The 5 small refiners removed from the analysis had parent company revenues ranging from $5 million to $225 million, with average revenues of $64 million. Two of these small refiners had revenues of less than $10 million, and another small refiner had revenues just over $10 million. Of the 2 small refiners that were not analyzed because of missing data, one (1) small refiner shut down in 2007 and the other provided information that they were a specialty chemical company and not a refinery. These seven small refiners will not be subject to the rule.

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[43]U.S. SBA, Office of Advocacy. A Guide for Government Agencies, How to Comply with the Regulatory Flexibility Act, Implementing the President's Small Business Agenda and Executive Order 13272, June 2010.

[44] The U.S. Census Bureau's Statistics of U.S. Businesses include the following relevant definitions: (i) **establishment** – a single physical location where business is conducted or where services or industrial operations are performed; (ii) **firm** – a firm is a business organization consisting of one or more domestic establishments in the same state and industry that were specified under common ownership or control. The firm and the establishment are the same for single-establishment firms. For each multi-establishment firm, establishments in the same industry within a state will be counted as one firm; and (iii) **enterprise** -- an enterprise is a business organization consisting of one or more domestic establishments that were specified under common ownership or control. The enterprise and the establishment are the same for single-establishment firms. Each multi-establishment company forms one enterprise.

Table 4-5 presents the distribution of estimated cost-to-sales ratios for the small firms in our analysis. We analyzed the estimated cost-to-sales with and without the recovery credit, and in both cases the incremental compliance costs imposed on small refineries are not estimated to create significant impacts on a cost-to-sales ratio basis at the firm level.

Table 4-5 Impact Levels of Proposed NESHAP Amendments on Small Firms

Impact Level	Number of Small Firms in Sample Estimated to be Affected	% of Small Firms in Sample Estimated to be Affected
Cost-to-Sales Ratio less than 1%	28	100%
Cost-to-Sales Ratio 1-3%	0	--
Cost-to-Sales Ratio greater than 3%	0	--

For comparison, we calculated the cost-to-sales ratios for all of the affected refineries to determine whether potential costs would have a more significant impact on small refineries. As presented in Table 4-6, for large firms, without recovery credits the average cost-to-sales ratio is approximately 0.02 percent; the median cost-to-sales ratio is less than 0.01 percent; and the maximum cost-to-sales ratio is approximately 0.89 percent; with recovery credits these impacts do not substantially change, except the maximum cost-to-sales ratio decreases to approximately 0.44 percent. For small firms, without recovery credits the average cost-to-sales ratio is about 0.07 percent, the median cost-to-sales ratio is 0.03 percent, and the maximum cost-to-sales ratio is 0.62 percent; with recovery credits these impacts do not substantially change, except the maximum cost-to-sales ratio decreases slightly to approximately 0.60 percent. The potential costs do not have a more significant impact on small refiners and because no small firms are expected to have cost-to-sales ratios greater than one percent, we determined that the cost impacts for the risk and technology reviews for existing MACT 1 and MACT 2 standards will not have a significant economic impact on a substantial number of small entities (SISNOSE).

Table 4-6 Summary of Sales Test Ratios for Firms Affected by Proposed NESHAP Amendments

Firm Size	No. of Known Affected Firms	% of Total Known Affected Firms	Mean Cost-to-Sales Ratio	Median Cost-to-Sales Ratio	Min. Cost-to-Sales Ratio	Max. Cost-to-Sales Ratio
Small	28	51%	0.07%	0.03%	<0.01%	0.62%
Large	27	49%	0.02%	<0.01%	<0.01%	0.89%
All	55	100%	0.03%	<0.01%	<0.01%	0.89%

4.5 References

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