# Regulatory Impact Analysis (RIA) for Existing Stationary Compression Ignition Engines NESHAP

Final Draft

*This page is intentionally blank.*

EPA 452/R-10-002
February 2010

# Regulatory Impact Analysis (RIA) for Existing Stationary Compression Ignition Engines NESHAP

By:
Paramita Sinha, Brooks Depro, and Fern Braun
RTI International
Research Triangle Park, North Carolina

Prepared for:
Larry Sorrels

Contract No. EP-D-06-003

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

RTI Project Number
0209897.003.061

# Regulatory Impact Analysis (RIA) for Existing Stationary Compression Ignition Engines NESHAP

## Final Report

**February 2010**

Prepared for

Larry Sorrels
U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards (OAQPS)
Air Benefit and Cost Group (ABCG)
(MD-C439-02)
Research Triangle Park, NC 27711

Prepared by

Paramita Sinha
Brooks Depro
Fern Braun
RTI International
3040 Cornwallis Road
Research Triangle Park, NC 27709

# CONTENTS

## LIST OF FIGURES

**Number** **Page**

**LIST OF TABLES**

# SECTION 1
# EXECUTIVE SUMMARY

EPA estimates that complying with the final RICE rule will have an annualized cost of approximately $373 million per year (2008 dollars) in the year of full implementation of the rule (2013). Using these costs, EPA estimates in its economic impact analysis that the NESHAP will have limited impacts on the industries affected and their consumers. Using sales data obtained for affected small entities in an analysis of the impacts of this proposal on small entities, EPA expects that the NESHAP will not result in a SISNOSE (significant economic impacts for a substantial number of small entities). EPA also does not expect significant adverse energy impacts based on Executive Order 13211, an Executive Order that requires analysis of energy impacts for rules such as this one that are economically significant under Executive Order 12866.

The RICE rule is also considered subject to the requirements of the Office of Management and Budget's (OMB's) Circular A-4 because EPA expects that either the benefits or the costs are potentially $1 billion or higher. EPA, estimates the total monetized co-benefits of the NESHAP to be $940 million to $2.3 billion (2008$) at a 3% discount rate and $850 million to $2.1 billion at a 7% discount rate in the year of full implementation of the rule (2013). EPA believes that the benefits are likely to exceed the annualized costs of $373 million by a substantial margin under this rulemaking even when taking into account uncertainties in the cost and benefit estimates. These estimates are "snapshots" of benefits and costs at year 2013.

# SECTION 2
# INTRODUCTION

EPA is promulgating national emission standards for hazardous air pollutants for existing stationary compression ignition reciprocating internal combustion engines that either are located at area sources of hazardous air pollutant emissions or that have a site rating of less than or equal to 500 brake horsepower and are located at major sources of hazardous air pollutant emissions. In addition, EPA is promulgating national emission standards for hazardous air pollutants for existing nonemergency stationary compression ignition engines greater than 500 brake horsepower that are located at major sources of hazardous air pollutant emissions.

The rule is economically significant according to Executive Order 12866. As part of the regulatory process of preparing these standards, EPA has prepared a regulatory impact analysis (RIA). This analysis includes an analysis of impacts to small entities as part of compliance with the Small Business Regulatory Enforcement Fairness Act (SBREFA) and an analysis of impacts on energy consumption and production to comply with Executive Order 13211 (Statement of Energy Effects).

## 2.1 Organization of this Report

The remainder of this report supports and details the methodology and the results of the EIA:

- Section 3 presents a profile of the affected industries.
- Section 4 presents a summary of regulatory alternatives considered in the proposed rule, and provides the compliance costs of the rule.
- Section 5 describes the estimated costs of the regulation and describes the EIA methodology and reports market, welfare, and energy impacts.
- Section 6 presents estimated impacts on small entities.
- Section 7 presents the benefits estimates.

# SECTION 3
# INDUSTRY PROFILE

Compression-ignition (CI) engines CI units almost always operate as lean burn engines. They can be configured as either two-stroke lean burn (2SLB) or 4-stroke lean burn (4SLB); the distinction is that CI engines are fueled by distillate fuel oil (diesel oil), not by natural gas. Industries in which CI engines are found are:

- electric power generation, transmission, and distribution (NAICS 2211)
- oil and gas extraction (including marginal wells) (NAICS 211111)
- pipeline transportation of natural gas (NAICS 211112),
- general medical and surgical hospitals (NAICS 622110)
- irrigation sets and welding equipment (NAICS 335312 and 333992).

This section provides an introduction to the industries affected by the rule. The purpose is to give the reader a general understanding of the economic aspects of the industry; their relative size, relationships with other sectors in the economy, trends for the industries, and financial statistics. The sectors discussed are

## 3.1 Electric Power Generation, Transmission, and Distribution

### *3.1.1 Overview*

Electric power generation, transmission, and distribution (NAICS 2211) is an industry group within the utilities sector (NAICS 22). It includes establishments that produce electrical energy or facilitate its transmission to the final consumer.

From 1997 to 2002, revenues from electric power grew about 10% to over $373 billion ($2007) (Table 3-1). At the same time, payroll rose about 6.5% and the number of employees decreased by over 5%. The number of establishments rose by over 15%, resulting in a decrease in average establishment revenue of almost 7%. Industrial production within NAICS 2211 has increased 25% since 1997 (Figure 3-1).

Electric utility companies have traditionally been tightly regulated monopolies. Since 1978, several laws and orders have been passed to encourage competition within the electricity market. In the late 1990s, many states began the process of restructuring their utility regulatory framework to support a competitive market. Following market manipulation in the early 2000s, however, several states have suspended their restructuring efforts. The majority (58%) of diesel power generators controlled by combined heat and power (CHP) or independent power producers are located in states undergoing active restructuring (Figure 3-2).

**Table 3-1. Key Statistics: Electric Power Generation, Transmission, and Distribution (NAICS 2211) ($2007)**

| | 1997 | 2002 |
|---|---|---|
| Revenue ($$10^6$) | 337,490 | 373,309 |
| Payroll ($$10^6$) | 38,176 | 40,842 |
| Employees | 564,525 | 535,675 |
| Establishments | 7,935 | 9,394 |

Source: U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 22: Utilities: Geographic Area Series: Summary Statistics: 2002 and 1997." <http://factfinder.census.gov>; (November 26, 2008).

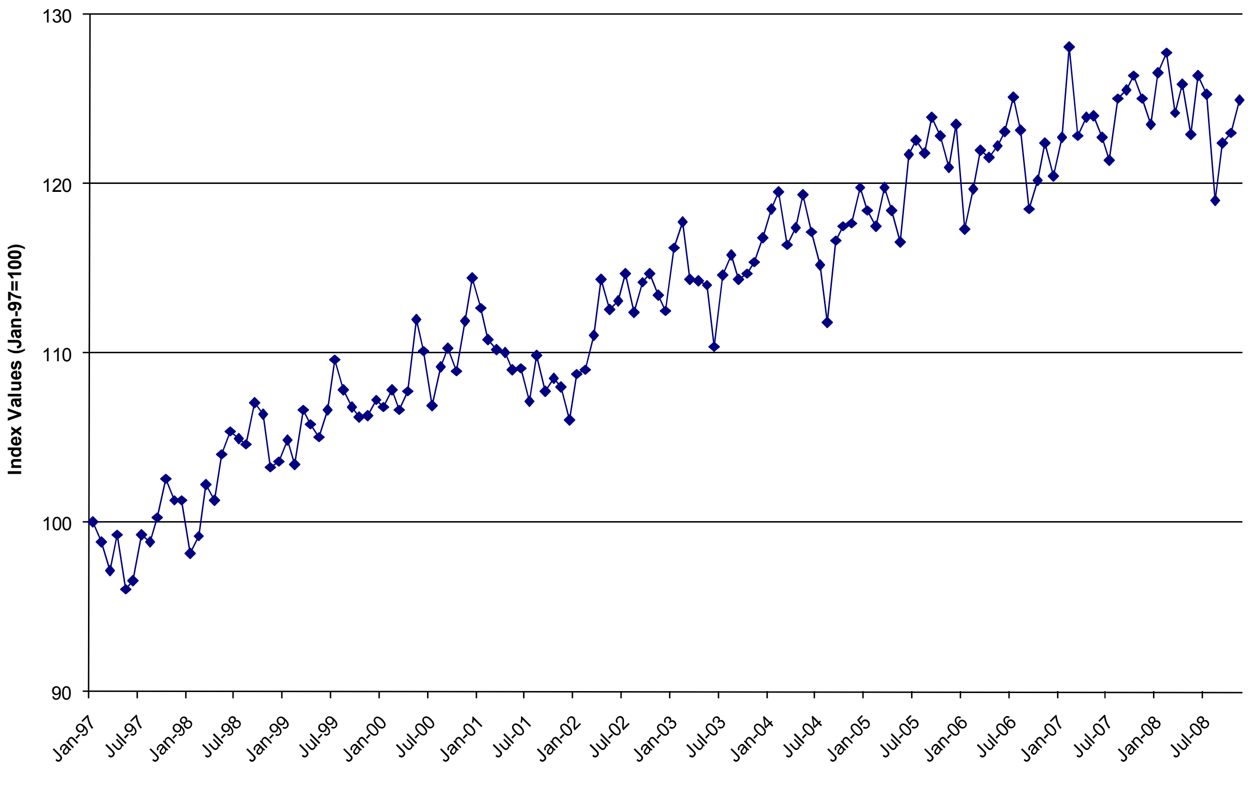



**Figure 3-1. Industrial Production Index (NAICS 2211)**

Source: The Federal Reserve Board. "Industrial Production and Capacity Utilization: Industrial Production" Series ID: G17/IP_MINING_AND_UTILITY_DETAIL/IP.G2211.S <http://www.federalreserve.gov/datadownload/>. (15 December, 2008)

### *3.1.2 Goods and Services Used*

In Table 3-2, we use the latest detailed benchmark input-output data report by the Bureau of Economic Analysis (BEA) (2002) to identify the goods and services used in electric power generation. As shown, labor and tax requirements represent a significant share of the value of

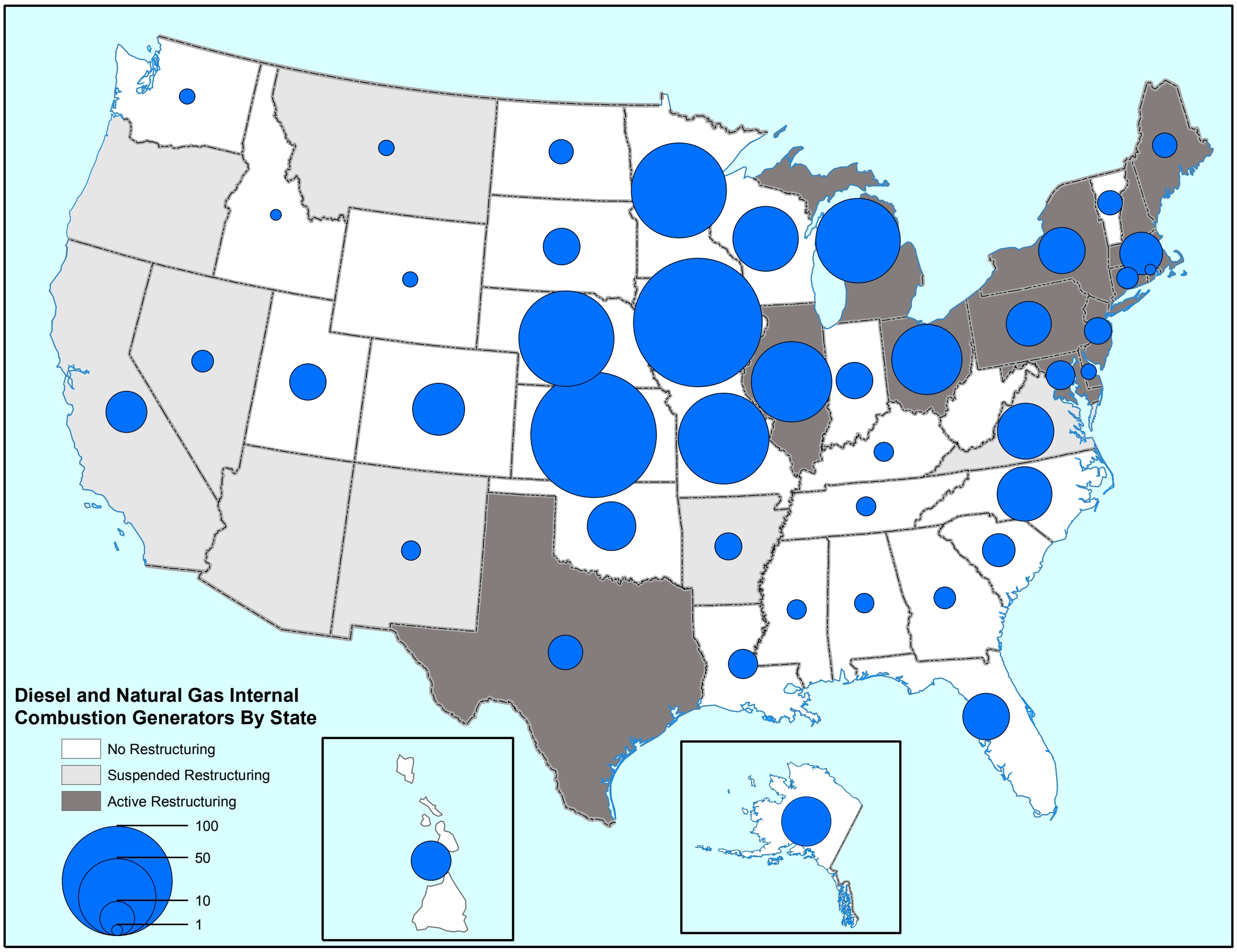



**Figure 3-2. Internal Combustion Generators by State: 2006**

Source: U.S. Department of Energy, Energy Information Administration. 2007. “2006 EIA-906/920 Monthly Time Series.”

power generation. Extraction, transportation, refining, and equipment requirements potentially associated with reciprocating internal combustion engines (oil and gas extraction, pipeline transportation, petroleum refineries, and turbine manufacturing) represent around 10% of the value of services.

### *3.1.3 Business Statistics*

The U.S. Economic Census and Statistics of U.S. Businesses (SUSB) programs provide national information on the distribution of economic variables by industry, location, and size of business. Throughout this section and report, we use the following definitions:

- *Establishmen*t: An establishment is a single physical location where business is conducted or where services or industrial operations are performed.

**Table 3-2. Direct Requirements for Electric Power Generation, Transmission, and Distribution (NAICS 2211): 2002**

| Commodity | Commodity Description | Direct Requirements Coefficients[a] |
|---|---|---|
| V00100 | Compensation of employees | 20.52% |
| V00200 | Taxes on production and imports, less subsidies | 13.71% |
| 211000 | Oil and gas extraction | 6.16% |
| 212100 | Coal mining | 5.86% |
| 482000 | Rail transportation | 3.01% |
| 230301 | Nonresidential maintenance and repair | 2.83% |
| 486000 | Pipeline transportation | 1.70% |
| 722000 | Food services and drinking places | 1.40% |
| 52A000 | Monetary authorities and depository credit intermediation | 1.39% |
| 541100 | Legal services | 1.13% |

[a] These values show the amount of the commodity required to produce $1.00 of the industry's output. The values are expressed in percentage terms (coefficient ×100).

Source: U.S. Bureau of Economic Analysis. 2002. 2002 Benchmark Input-Output Accounts: Detailed Make Table, Use Table and Direct Requirements Table. Tables 4 and 5.

- *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.

- *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 multiestablishment firm, establishments *in the same industry within a state* are counted as one firm; the firm employment and annual payroll are summed from the associated establishments.

- *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 multiestablishment company forms one enterprise; the enterprise employment and annual payroll are summed from the associated establishments. Enterprise size designations are determined by the summed employment of all associated establishments.

In 2002, Texas had almost 1,000 power establishments, while California, Georgia, and Ohio all had between 400 and 500 (Figure 3-3). Hawaii, Nebraska, and Rhode Island all had fewer than 20 establishments in their states.

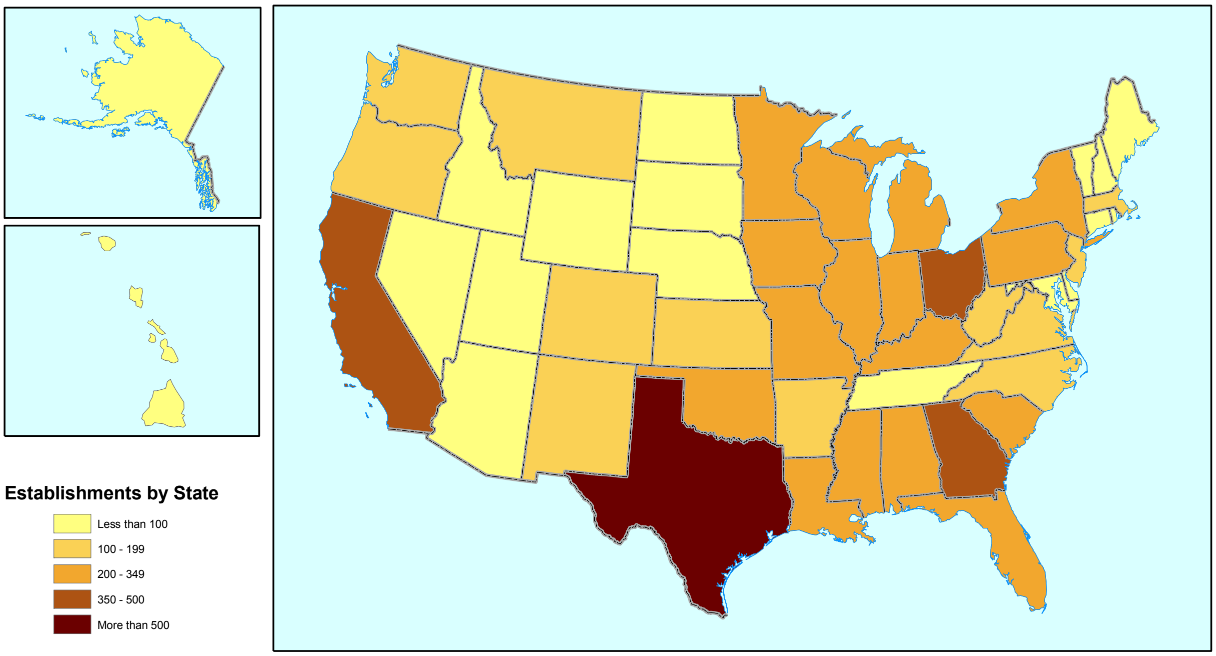



**Figure 3-3. 2002 Regional Distribution of Establishments: Electric Power Generation, Transmission, and Distribution Industry (NAICS 2211)**

Source: U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 22: Utilities: Geographic Area Series: Summary Statistics: 2002." <http://factfinder.census.gov>; (November 10, 2008).

As shown in Table 3-3, the four largest firms owned over 1,200 establishments and accounted for about 16% of total industry receipts/revenue. The 50 largest firms accounted for almost 6,000 establishments and about 78% of total receipts/revenue.

Investor-owned energy providers accounted for 67.5% of retail electricity sold in the United States in 2006 (Table 3-4). In 2007, less regulated investor-owned electric utility companies were on average more profitable than companies with greater regulation (Table 3-5). In 2006, enterprises within NAICS 2211 had a pre-tax profit margin of only 0.9% (Table 3-6).

In 2002, about 82% of firms generating, transmitting, or distributing electric power had receipts of under $50 million (Table 3-7). However, these firms accounted for only 11% of employment, with 89% of employees working for firms with revenues in excess of $100 million.

## 3.2 Oil and Gas Extraction

### *3.2.1 Overview*

Oil and gas extraction (NAICS 211) is an industry group within the mining sector (NAICS 21). It includes establishments that operate or develop oil and gas field properties

**Table 3-3. Firm Concentration for Electric Power Generation, Transmission, and Distribution (NAICS 2211): 2002**

| | | Receipts/Revenue | | | |
|---|---|---|---|---|---|
| **Commodity** | **Establishments** | **Amount ($10^6^)** | **Percentage of Total** | **Number of Employees** | **Employees per Establishment** |
| All firms | 9,394 | $325,028 | 100.0% | 535,675 | 57 |
| 4 largest firms | 1,260 | $52,349 | 16.1% | 68,432 | 54 |
| 8 largest firms | 2,566 | $95,223 | 29.3% | 151,575 | 59 |
| 20 largest firms | 3,942 | $173,207 | 53.3% | 271,393 | 69 |
| 50 largest firms | 5,887 | $253,015 | 77.8% | 408,021 | 69 |

Source: U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 22: Utilities: Subject Series—Estab & Firm Size: Concentration by Largest Firms for the United States: 2002." <http://factfinder.census.gov>; (November 21, 2008).

through such activities as exploring for oil and gas, drilling and equipping wells, operating on-site equipment, and conducting other activities up to the point of shipment from the property.

Oil and gas extraction consists of two industries: crude petroleum and natural gas extraction (NAICS 211111) and natural gas liquid extraction (NAICS 211112). Crude petroleum and natural gas extraction is the larger industry; in 2002, it accounted for 93% of establishments and 75% of oil and gas extraction revenues.

Industrial production in this industry is particularly sensitive to hurricanes in the Gulf Coast. In September of both 2005 and 2008, production dropped 14% from the previous month. Production is currently 6% lower than it was in 1997 (Figure 3-4).

From 1997 to 2002, revenues from crude petroleum and natural gas extraction (NAICS 211111) grew less than 1% to almost $100 billion ($2007) (Table 3-8). At the same time, payroll dropped almost 8% and the number of employees dropped by almost 6%. The number of establishments dropped by over 8%; as a result, the average establishment revenue increased by 2.5%. Materials costs were approximately 25% of revenue over the period.

From 1997 to 2002, revenue from natural gas liquid extraction (NAICS 211112) grew over 7% to about $34 billion (Table 3-9). At the same time, payroll dropped 12% and the number of employees dropped by almost 9%. The number of establishments dropped by over 3%, resulting in an increase of revenue per establishment of about 10%.

## Table 3-4. United States Retail Electricity Sales Statistics: 2006

| | Full-Service Providers | | | | | Other Providers | | |
|---|---|---|---|---|---|---|---|---|
| **Item** | **Investor-Owned** | **Public** | **Federal** | **Cooperative** | **Facility** | **Energy** | **Delivery** | **Total** |
| Number of entities | 215 | 2,010 | 9 | 882 | 49 | 150 | 64 | 3,379 |
| Number of retail customers | 100,245,547 | 20,345,236 | 39,430 | 17,465,423 | 2,166 | 2,306,163 | NA | 140,403,965 |
| Retail Sales ($10^3$ megawatthours) | 2,476,445 | 549,124 | 42,359 | 370,410 | 12,397 | 219,185 | NA | 3,669,919 |
| Percentage of retail sales | 67.48 | 14.96 | 1.15 | 10.09 | 0.34 | 5.97 | NA | 100 |
| Revenue from retail sales ($\$10^6$) | 224,637 | 44,271 | 1,494 | 31,411 | 868 | 16,784 | 7,040 | 326,506 |
| Percentage of revenue | 68.8 | 13.56 | 0.46 | 9.62 | 0.27 | 5.14 | 2.16 | 100 |
| Average retail price (cents/kWh) | 9.06 | 8.06 | 3.53 | 8.48 | 7 | 7.66 | 3.21 | 8.9 |

**Table 3-5. FY 2007 Financial Data for 70 U.S. Shareholder-Owned Electric Utilities**

| | Profit Margin | Net Income | Operating Revenues |
|---|---|---|---|
| Investor-Owned Utilities | 8.36% | $33,933 | $405,938 |
| Regulated[a] | 7.12% | $12,078 | $169,699 |
| Mostly regulated[b] | 8.89% | $13,776 | $154,916 |
| Diversified[c] | 9.93% | $8,078 | $81,323 |

[a] 80%+ of total assets are regulated.

[b] 50% to 80% of total assets are regulated.

[c] Less than 50% of total assets are regulated.

Source: Edison Electric Institute. "Income Statement: Q4 2007 Financial Update. Quarterly Report of the U.S. Shareholder-Owned Electric Utility Industry." <http://www.eei.org>.

**Table 3-6. Aggregate Tax Data for Accounting Period 7/05–6/06: NAICS 2211**

| | |
|---|---|
| Number of enterprises[a] | 836 |
| Total receipts ($10^3$) | $308,702,953 |
| Net sales($10^3$) | $289,887,930 |
| Profit margin before tax | 0.9% |
| Profit margin after tax | — |

[a] Includes corporations with and without net income.

Source: Troy, Leo. 2008. "Almanac of Business and Industrial Financial Ratios: 2009 Edition." CCH.

### *3.2.2 Goods and Services Used*

The oil and gas extraction industry has similar labor and tax requirements as the electric power generation sector. Extraction, support, power, and equipment requirements potentially associated with reciprocating internal combustion engines (oil and gas extraction, support activities, electric power generation, machinery and equipment rental and leasing, and pipeline transportation) represent around 8% of the value of services (Table 3-10).

### *3.2.3 Business Statistics*

The U.S. Economic Census and SUSB programs provide national information on the distribution of economic variables by industry, location, and size of business. Throughout this section and report, we use the following definitions:

- *Establishment*: An establishment is a single physical location where business is conducted or where services or industrial operations are performed.

**Table 3-7. Key Enterprise Statistics by Receipt Size for Electric Power Generation, Transmission, and Distribution (NAICS 2211): 2002**

| Variable | All Enterprises | Owned by Enterprises with 0–99K Receipts | 100–499.9K Receipts | 500–999.9K Receipts | 1,000–4,999.9K Receipts | 5,000,000–9,999,999K Receipts | <10,000K Receipts | 10,000–49,999K Receipts | 50,000–99,999K Receipts | 100,000K+ Receipts |
|---|---|---|---|---|---|---|---|---|---|---|
| Firms | 1,756 | 129 | 250 | 80 | 232 | 205 | 896 | 538 | 112 | 210 |
| Establishments | 9,493 | 129 | 250 | 85 | 245 | 262 | 971 | 978 | 403 | 7,141 |
| Employment | 515,769 | 429 | 834 | 3,139 | 2,712 | 5,620 | 12,734 | 31,573 | 14,858 | 456,604 |
| Receipts ($\$10^3$) | \$320,502,670 | \$5,596 | \$63,339 | \$57,363 | \$627,414 | \$1,472,405 | \$2,226,117 | \$12,171,098 | \$7,607,166 | \$298,498,289 |
| Receipts/firm ($\$10^3$) | \$182,519 | \$43 | \$253 | \$717 | \$2,704 | \$7,182 | \$2,485 | \$22,623 | \$67,921 | \$1,421,420 |
| Receipts/establishment ($\$10^3$) | \$33,762 | \$43 | \$253 | \$675 | \$2,561 | \$5,620 | \$2,293 | \$12,445 | \$18,876 | \$41,801 |
| Receipts/employment (\$) | \$621,407 | \$13,044 | \$75,946 | \$18,274 | \$231,347 | \$261,994 | \$174,817 | \$385,491 | \$511,991 | \$653,736 |

Source: U.S. Small Business Administration (SBA). 2008. "Firm Size Data from the Statistics of U.S. Businesses: U.S. All Industries Tabulated by Receipt Size: 2002." <http://www.census.gov/csd/susb/susb02.htm>.

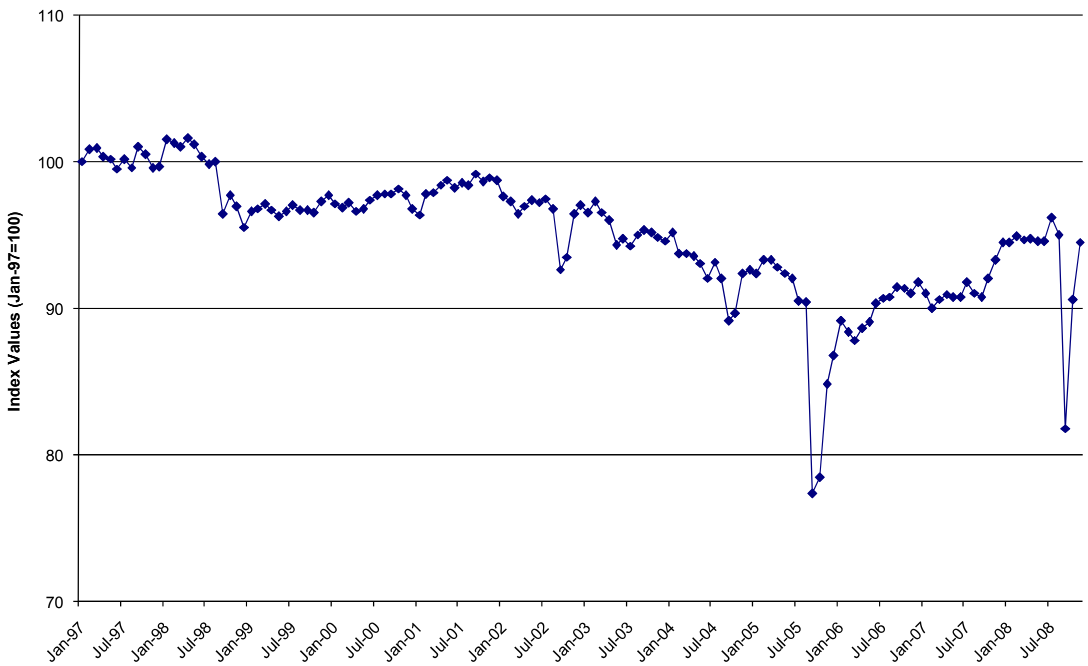



**Figure 3-4. Industrial Production Index (NAICS 211)**

Source: The Federal Reserve Board. "Industrial Production and Capacity Utilization: Industrial Production" Series ID: G17/IP_MINING_AND_UTILITY_DETAIL/IP.G211.S <http://www.federalreserve.gov/datadownload/>. (December 15, 2008).

**Table 3-8. Key Statistics: Crude Petroleum and Natural Gas Extraction (NAICS 211111): ($2007)**

| | 1997 | 2002 |
|---|---|---|
| Revenue ($$10^6$) | 97,832 | 98,667 |
| Payroll ($$10^6$) | 6,232 | 5,785 |
| Employees | 100,333 | 94,886 |
| Establishments | 7,784 | 7,178 |

Source: U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 21: Mining: Industry Series: Historical Statistics for the Industry: 2002 and 1997." <http://factfinder.census.gov>; (November 26, 2008).

- *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.

- *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-

**Table 3-9. Key Statistics: Natural Gas Liquid Extraction (NAICS 211112) ($2007)**

| | 1997 | 2002 |
|---|---|---|
| Revenue ($$10^6$) | 31,139 | 33,579 |
| Payroll ($$10^6$) | 679 | 607 |
| Employees | 10,548 | 9,693 |
| Establishments | 528 | 511 |

Source: U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 21: Mining: Industry Series: Historical Statistics for the Industry: 2002 and 1997." <http://factfinder.census.gov>; (November 26, 2008).

**Table 3-10. Direct Requirements for Oil and Gas Extraction (NAICS 211): 2002**

| Commodity | Commodity Description | Direct Requirements Coefficients[a] |
|---|---|---|
| V00200 | Taxes on production and imports, less subsidies | 8.93% |
| V00100 | Compensation of employees | 6.67% |
| 230301 | Nonresidential maintenance and repair | 6.36% |
| 211000 | Oil and gas extraction | 1.91% |
| 213112 | Support activities for oil and gas operations | 1.51% |
| 221100 | Electric power generation, transmission, and distribution | 1.47% |
| 541300 | Architectural, engineering, and related services | 1.24% |
| 532400 | Commercial and industrial machinery and equipment rental and leasing | 1.20% |
| 33291A | Valve and fittings other than plumbing | 1.10% |
| 541511 | Custom computer programming services | 0.99% |

[a] These values show the amount of the commodity required to produce $1.00 of the industry's output. The values are expressed in percentage terms (coefficient ×100).

Source: U.S. Bureau of Economic Analysis. 2002. 2002 Benchmark Input-Output Accounts: Detailed Make Table, Use Table and Direct Requirements Table. Tables 4 and 5.

establishment firms. For each multiestablishment firm, establishments *in the same industry within a state* are counted as one firm; the firm employment and annual payroll are summed from the associated establishments.

- *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 multiestablishment company forms one enterprise; the enterprise employment and annual payroll are summed from the associated establishments. Enterprise size designations are determined by the summed employment of all associated establishments.

In 2002, Texas had almost 3,000 crude petroleum and natural gas extraction establishments, Oklahoma had about 1,000, and every other state had under 450 (Figure 3-5). Twenty states had fewer than 10 establishments. Similarly, Texas had 180 natural gas liquid extraction establishments, Louisiana had 76, and every other state had under 40 (Figure 3-6). Only nine states had 10 or more establishments, and 17 had no establishments.

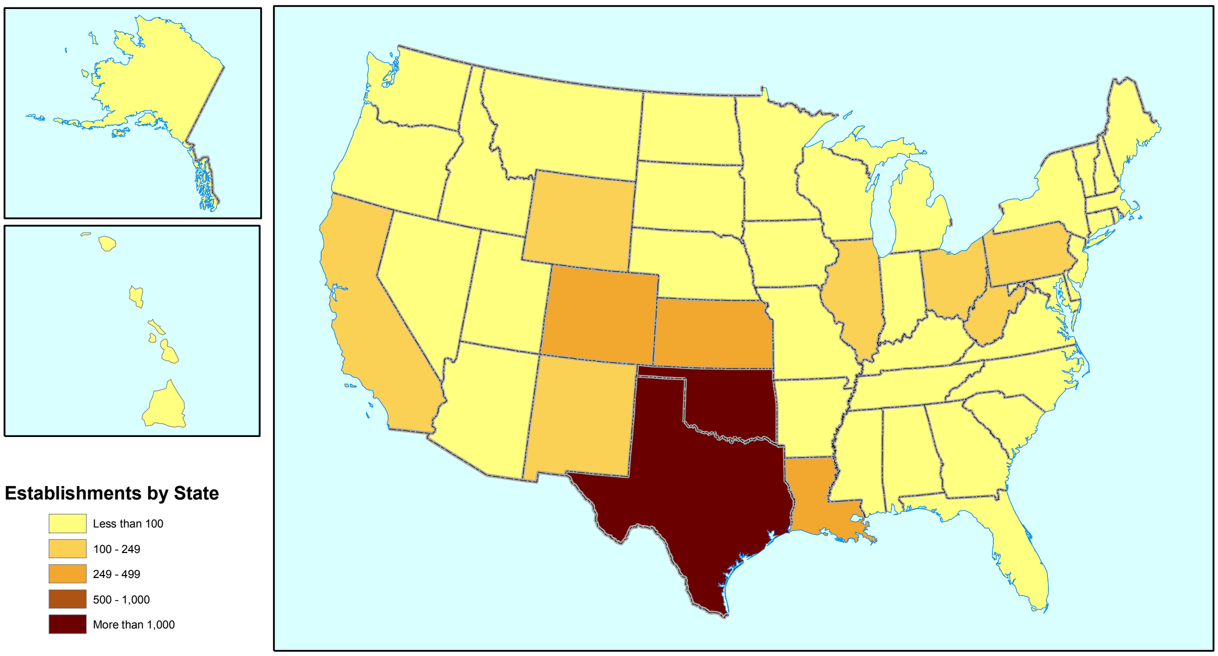



**Figure 3-5. 2002 Regional Distribution of Establishments: Crude Petroleum and Natural Gas Extraction Industry (NAICS 211111)**

Source: U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 21: Mining: Geographic Area Series: Industry Statistics for the State or Offshore Areas: 2002." <http://factfinder.census.gov>; (November 10, 2008).

According to the SUSB, 89% of crude petroleum and natural gas extraction firms had fewer than 500 employees in 2002 (Table 3-11). Sixty-three percent of natural gas liquid extraction firms had fewer than 500 employees in 2002 (Table 3-12).

Enterprises within this industry generated $165 billion in total receipts in 2006. Including those enterprises without net income, the industry averaged an after-tax profit margin of 18.3% (Table 3-13).

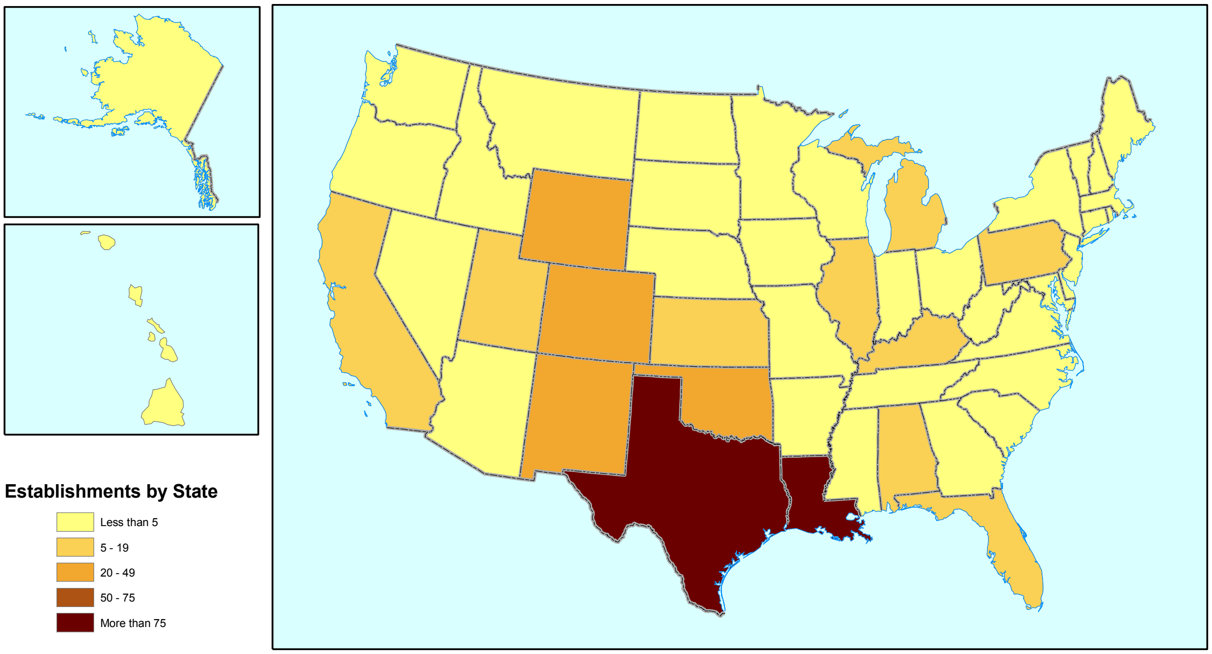



**Figure 3-6. 2002 Regional Distribution of Establishments: Natural Gas Liquid Extraction Industry (NAICS 211112)**

Source: U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 21: Mining: Geographic Area Series: Industry Statistics for the State or Offshore Areas: 2002." <http://factfinder.census.gov>; (November 10, 2008).

**Table 3-11. Key Enterprise Statistics by Employment Size for Crude Petroleum and Natural Gas Extraction (NAICS 211111): 2002**

| Variable | All Enterprises | Owned by Enterprises with 1–20 Employees | 20–99 Employees | 100–499 Employees | 500–749 Employees | 750–999 Employees | 1,000–1,499 Employees |
|---|---|---|---|---|---|---|---|
| Firms | 6,238 | 5,130 | 348 | 85 | 11 | 11 | 5 |
| Establishments | 7,135 | 5,185 | 449 | 254 | 37 | 63 | 25 |
| Employment | 76,794 | 5,825 | 5,171 | 2,757 | Not disclosed | Not disclosed | Not disclosed |
| Receipts ($\$10^3$) | $88,388,300 | $2,353,181 | $2,559,239 | $2,051,860 | Not disclosed | Not disclosed | Not disclosed |
| Receipts/firm ($\$10^3$) | $14,169 | $459 | $7,354 | $24,140 | Not disclosed | Not disclosed | Not disclosed |
| Receipts/establishment ($\$10^3$) | $12,388 | $454 | $5,700 | $8,078 | Not disclosed | Not disclosed | Not disclosed |
| Receipts/employment ($) | $1,150,979 | $403,980 | $494,921 | $744,236 | Not disclosed | Not disclosed | Not disclosed |

Source: U.S. Census Bureau. 2008a. Firm Size Data from the Statistics of U.S. Businesses: U.S. Detail Employment Sizes: 2002. <http://www2.census.gov/csd/susb/2002/02us_detailed%20sizes_6digitnaics.txt>.

### *3.2.4 Case Study: Marginal Wells*

To provide additional context for understanding energy sectors that use reciprocating internal combustion engines, we examine one segment of the oil and gas sector: marginal wells.

### Table 3-12. Key Enterprise Statistics by Employment Size for Crude Natural Gas Liquid Extraction (NAICS 211112): 2002

| Variable | All Enterprises | Owned by Enterprises with 1–20 Employees | 20–99 Employees | 100–499 Employees | 500–749 Employees | 750–999 Employees | 1,000–1,499 Employees |
|---|---|---|---|---|---|---|---|
| Firms | 113 | 54 | 7 | 10 | 2 | 1 | 2 |
| Establishments | 494 | 54 | 7 | 38 | 23 | 1 | 6 |
| Employment | 11,486 | 65 | Not disclosed | 241 | Not disclosed | Not disclosed | Not disclosed |
| Receipts ($$10^3$) | $72,490,930 | $13,862 | Not disclosed | $383,496 | Not disclosed | Not disclosed | Not disclosed |
| Receipts/firm ($$10^3$) | $641,513 | $257 | Not disclosed | $38,350 | Not disclosed | Not disclosed | Not disclosed |
| Receipts/establishment ($$10^3$) | $146,743 | $257 | Not disclosed | $10,092 | Not disclosed | Not disclosed | Not disclosed |
| Receipts/employment ($) | $6,311,242 | $213,262 | Not disclosed | $1,591,270 | Not disclosed | Not disclosed | Not disclosed |

Source: U.S. Census Bureau. 2008a. Firm Size Data from the Statistics of U.S. Businesses: U.S. Detail Employment Sizes: 2002. <http://www2.census.gov/csd/susb/2002/02us_detailed%20sizes_6digitnaics.txt>.

### Table 3-13. Aggregate Tax Data for Accounting Period 7/05–6/06: NAICS 211

| | |
|---|---|
| Number of enterprises[a] | 17,097 |
| Total receipts ($10^3$) | $164,841,432 |
| Net sales($10^3$) | $142,424,188 |
| Profit margin before tax | 24.6% |
| Profit margin after tax | 18.3% |

[a] Includes corporations with and without net income.

Source: Troy, Leo. 2008. “Almanac of Business and Industrial Financial Ratios: 2009 Edition.” CCH.

This industry includes small-volume wells that are mature in age, are more difficult to extract oil or natural gas from than other types of wells, and generally operate at very low levels of profitability. As a result, well operations can be quite responsive to small changes in the benefits and costs of their operation.

In 2006, there were approximately 420,000 marginal oil wells and 300,000 marginal gas wells (Interstate Oil and Gas Compact Commission [IOGCC], 2007). These wells provide the United States with 18% of oil and 9% of natural gas production (IOGCC, 2007). Data for 2006 show that revenue from the over 700,000 wells was approximately $31.3 billion (Table 3-14).

Historical data show marginal oil production fluctuated between 1997 and 2006, reflecting the industry’s sensitivity to changes in economic conditions of fuel markets (see

**Table 3-14. Reported Gross Revenue Estimates from Marginal Wells: 2006**

| Well Type | Number of Wells | Production from Marginal Wells | Estimated Gross Revenue ($$10^9$) |
|---|---|---|---|
| Oil | 422,255 | 335.312467 MMbbls | $20.1 |
| Natural gas | 296,721 | 1708.407584 MCF | $11.1 |
| Total | 718,976 | | $31.3 |

Source: Interstate Oil & Gas Compact Commission. 2007. "Marginal Wells: Fuel for Economic Growth." Table 3.B. Available at <http://iogcc.publishpath.com/Websites/iogcc/pdfs/2007-Marginal-Well-Report.pdf>.

Figure 3-7). In contrast, the number of marginal gas wells has continually increased during the past decade; the IOGCC estimates that daily production levels from these wells reached a 10-year high in 2005. Although we have been unable to find data on what fraction of these marginal wells are operated by small businesses, the IOGCC states that many are run by "mom and pop operators" (IOGCC, 2007).

## 3.3 Pipeline Transportation of Natural Gas

### *3.3.1 Overview*

Pipeline transportation of natural gas (NAICS 48621) is an industry group within the transportation and warehousing sector (NAICS 48-49), but more specifically in the pipeline transportation subsector (486). It includes the transmission of natural gas as well as the distribution of the gas through a local network to participating businesses.

From 1997 to 2002, natural gas transportation revenues fell by 7% to just under $23 billion ($2007) (Table 3-15). At the same time, payroll decreased by 7%, while the number of paid employees decreased by nearly 9%. However, the number of establishments increased by 17% from 1,450 establishments in 1997 to 1,701 in 2002.

### *3.3.2 Goods and Services Used*

The BEA reports pipeline transportation of natural gas only for total pipeline transportation (3-digit NAICS 486). In addition to pipeline transportation of natural gas (NAICS 4862), this industry includes pipeline transportation of crude oil (NAICS 4861) and other pipeline transportation (NAICS 4869). However, the BEA data are likely representative of the affected sector since pipeline transportation of natural gas accounts for 68% of NAICS 486 establishments and 72% of revenues (Figures 3-8 and 3-9).

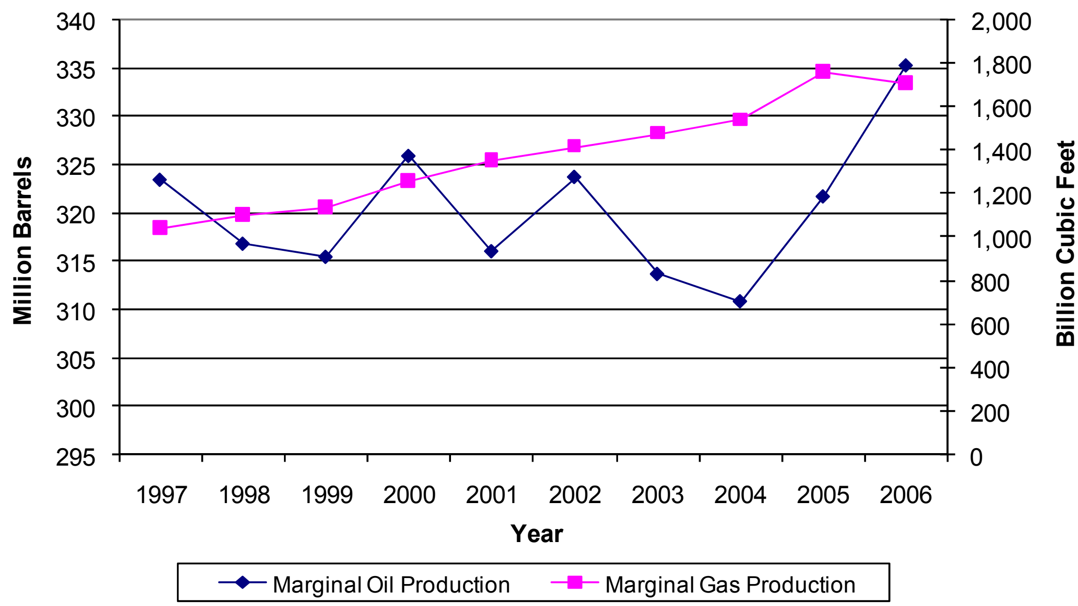



**Figure 3-7. Trends in Marginal Oil and Gas Production: 1997 to 2006**

Source: Interstate Oil & Gas Compact Commission. 2007. "Marginal Wells: Fuel for Economic Growth." Pages 3 and 11. Available at < http://iogcc.myshopify.com/collections/frontpage/products/2007-marginal-well-report-2007.pdf>.

**Table 3-15. Key Statistics: Pipeline Transportation of Natural Gas (NAICS 48621) ($2007)**

| Year | 1997 | 2002 |
|---|---|---|
| Revenue ($$10^6$) | 24,646 | 22,964 |
| Payroll ($$10^6$) | 2,662 | 2,438 |
| Employees | 35,789 | 32,542 |
| Establishments | 1,450 | 1,701 |

Source: U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 48: Transportation and Warehousing: Industry Series: Comparative Statistics for the United States (1997 NAICS Basis): 2002 and 1997" <http://factfinder.census.gov>; (December 12, 2008).

In Table 3-16, we use the latest detailed benchmark input-output data report by the BEA (2002) to identify the goods and services used by pipeline transportation (NAICS 486). As shown, labor, refineries, and maintenance requirements represent significant share of the cost associated with pipeline transportation. Power and equipment requirements potentially associated with reciprocating internal combustion engines (electric power generation and commercial and industrial machinery and equipment repair and maintenance) represent less than 2% of the value of services.

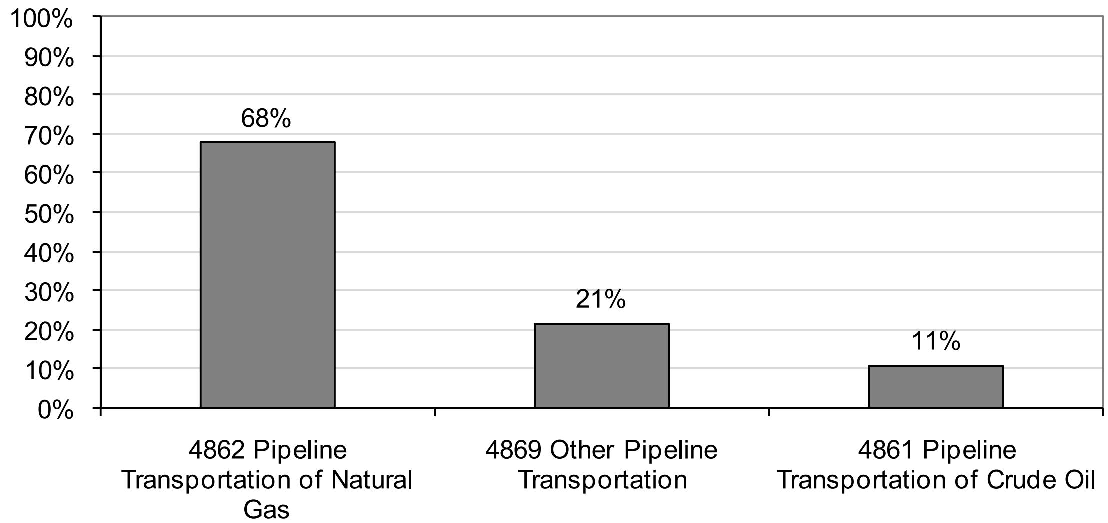



**Figure 3-8. Distribution of Establishments within Pipeline Transportation (NAICS 486)**

Source: U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 48: Transportation and Warehousing: Industry Series: Summary Statistics for the United States: 2002" <http://factfinder.census.gov>; (December 12, 2008).

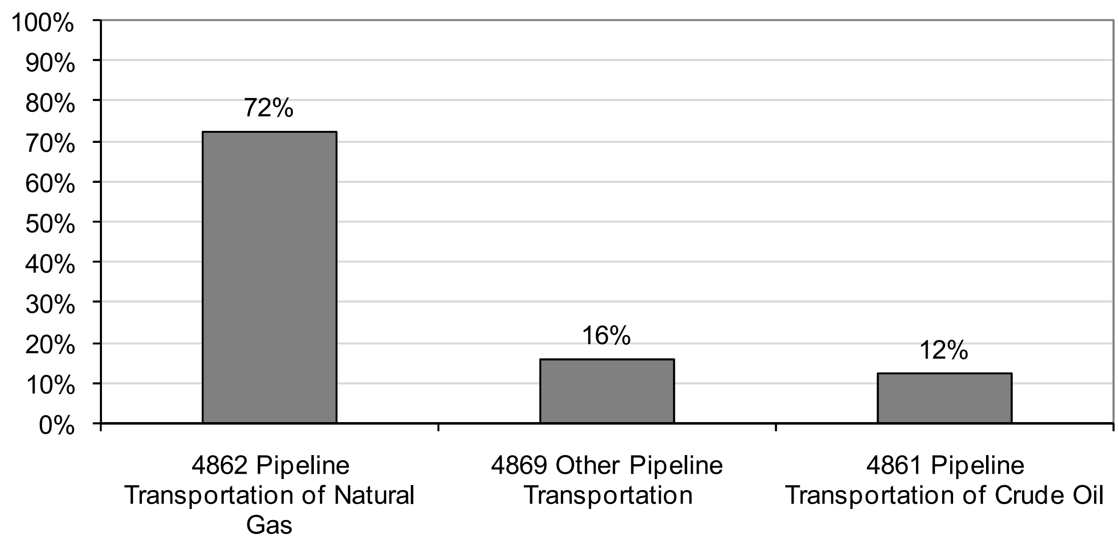



**Figure 3-9. Distribution of Revenue within Pipeline Transportation (NAICS 486)**

Source: U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 48: Transportation and Warehousing: Industry Series: Summary Statistics for the United States: 2002" <http://factfinder.census.gov>; (December 12, 2008).

**Table 3-16. Direct Requirements for Pipeline Transportation (NAICS 486): 2002**

| Commodity | Commodity Description | Direct Requirements Coefficients[a] |
|---|---|---|
| V00100 | Compensation of employees | 14.78% |
| 324110 | Petroleum refineries | 13.55% |
| 230301 | Nonresidential maintenance and repair | 6.07% |
| 211000 | Oil and gas extraction | 4.94% |
| 333415 | Air conditioning, refrigeration, and warm air heating equipment manufacturing | 4.40% |
| 561300 | Employment services | 4.26% |
| 5416A0 | Environmental and other technical consulting services | 3.04% |
| 541300 | Architectural, engineering, and related services | 3.04% |
| 420000 | Wholesale trade | 2.79% |
| 332310 | Plate work and fabricated structural product manufacturing | 2.72% |
| 5419A0 | All other miscellaneous professional, scientific, and technical services | 2.48% |
| 524100 | Insurance carriers | 2.38% |
| 531000 | Real estate | 2.33% |
| 52A000 | Monetary authorities and depository credit intermediation | 1.76% |
| V00200 | Taxes on production and imports, less subsidies | 1.41% |
| 541100 | Legal services | 1.19% |
| 221100 | Electric power generation, transmission, and distribution | 1.13% |

[a] These values show the amount of the commodity required to produce $1.00 of the industry's output. The values are expressed in percentage terms (coefficient ×100).

Source: U.S. Bureau of Economic Analysis. 2002. 2002 Benchmark Input-Output Accounts: Detailed Make Table, Use Table and Direct Requirements Table. Tables 4 and 5.

### *3.3.3 Business Statistics*

The pipeline transportation of natural gas is clearly concentrated in the two states closest to the refineries in the Gulf of Mexico. In 2002, Texas and Louisiana contributed to 31% of all pipeline transportation establishments in the United States (Figure 3-10) and 41% of all U.S. revenues. Other larger contributors with over 50 establishments in their states include Oklahoma, Pennsylvania, Kansas, Mississippi, and West Virginia.

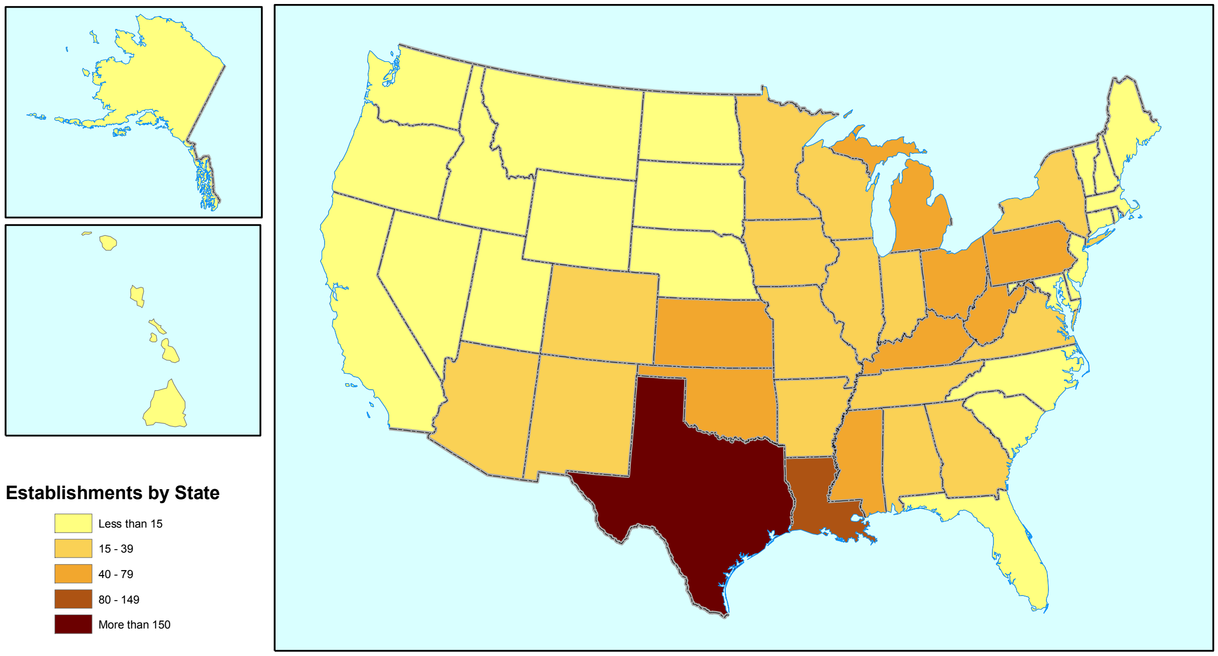



**Figure 3-10. 2002 Regional Distribution of Establishments: Pipeline Transportation (NAICS 486)**

Source: U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 48-49: Geographic Distribution—Pipeline transportation of natural gas: 2002." <http://factfinder.census.gov>; (November 10, 2008).

According to 2002 U.S. Census data, about 86% of transportation of natural gas establishments were owned by corporations and about 8% were owned by individual proprietorships. About 6% were owned by partnerships (Figure 3-11). As shown in Table 3-17, the four largest firms accounted for nearly half of the establishments with 698, and just over half, 51%, of total revenue. The 50 largest firms accounted for over 1,354 establishments and about 99% of total revenue. The average number of employees per establishment was approximately 17 across all groups of firms.

Enterprises within pipeline transportation (NAICS 486) generated $6.6 billion in total receipts in 2006. Including those enterprises without net income, the industry averaged an after-tax profit margin of 7.9% (Table 3-18).

The 2002 SUSB shows that 47% of all firms in this industry made under $5 million in revenue. Enterprises with revenue over $100 million provided an overwhelming share of employment in this industry (98%) (Table 3-19).

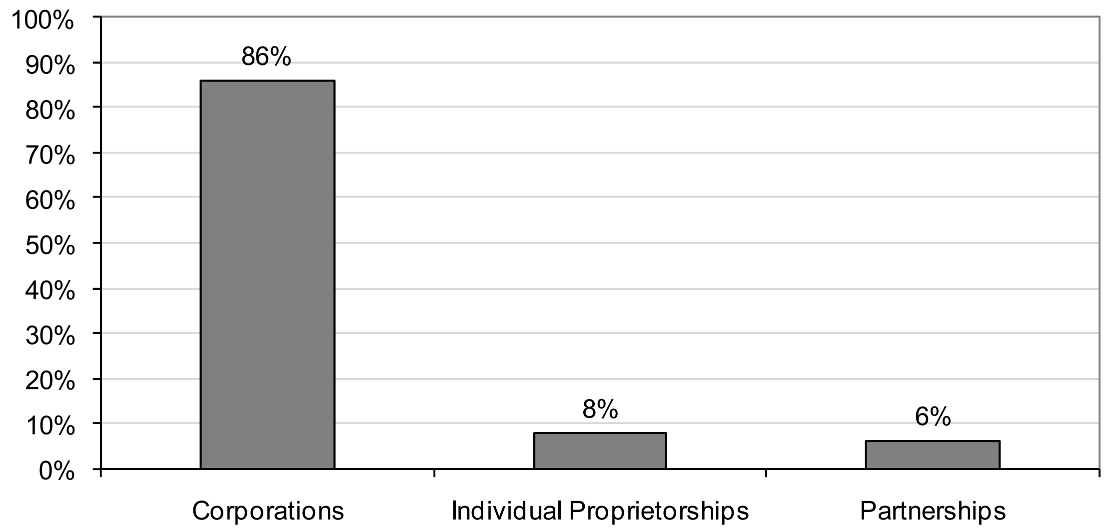



**Figure 3-11. Share of Establishments by Legal Form of Organization in the Pipeline Transportation of Natural Gas Industry (NAICS 48621): 2002**

Source: U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 48-49: Transportation and Warehousing: Subject Series—Estab & Firm Size: Legal Form of Organization for the United States: 2002" <http://factfinder.census.gov>; (December 12, 2008).

**Table 3-17. Firm Concentration for Pipeline Transportation of Natural Gas (NAICS 48621): 2002**

| | | Receipts/Revenue | | | |
|---|---|---|---|---|---|
| **Commodity** | **Establishments** | **Amount ($10^6)** | **Percentage of Total** | **Number of Employees** | **Employees per Establishment** |
| All firms | 1,431 | $14,797 | 100% | 23,677 | 16.5 |
| 4 largest firms | 698 | $7,551 | 51% | 11,814 | 16.9 |
| 8 largest firms | 912 | $10,059 | 68% | 15,296 | 16.8 |
| 20 largest firms | 1,283 | $13,730 | 93% | 21,792 | 17.0 |
| 50 largest firms | 1,354 | $14,718 | 99% | 23,346 | 17.2 |

Source: U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 48: Transportation and Warehousing: Subject Series—Estab & Firm Size: Concentration by Largest Firms for the United States: 2002" <http://factfinder.census.gov>; (December 12, 2008).

**Table 3-18. Aggregate Tax Data for Accounting Period 7/05–6/06: NAICS 486**

| | |
|---|---|
| Number of enterprises[a] | 410 |
| Total receipts ($10^3$) | $6,606,472 |
| Net sales($10^3$) | $6,118,827 |
| Profit margin before tax | 12.9% |
| Profit margin after tax | 7.8% |

[a] Includes corporations with and without net income.

Source: Troy, Leo. 2008. "Almanac of Business and Industrial Financial Ratios: 2009 Edition." CCH.

## 3.4 General Medical and Surgical Hospitals

### *3.4.1 Overview*

General medical and surgical hospitals (NAICS 6221) is an industry group within the health care and social assistance sector (NAICS 62). It includes hospitals engaged in diagnostic and medical treatment (both surgical and nonsurgical) for inpatients with a broad range of medical conditions. They usually provide other services as well, including outpatient care, anatomical pathology, diagnostic X-rays, clinical laboratory work, and pharmacy services.

From 1997 to 2002, hospital revenues grew about 18% to over $500 billion ($2007) (Table 3-20). At the same time, payroll rose about 14%, while the number of employees increased by only 5%. The number of establishments declined during this period by almost 6%, resulting in an increase in revenue per establishment of almost 22%.

### *3.4.2 Goods and Services Used*

The BEA reports hospital expenditures only for hospitals (3-digit NAICS 622). In addition to general hospitals (NAICS 6221), this industry includes psychiatric and substance abuse hospitals (NAICS 6222) and specialty hospitals (NAICS 6223). However, these data should be representative of the affected sector since in 2002, general medical and surgical hospitals accounted for 92% of NAICS 622 establishments and 94% of revenues.

In Table 3-21, we use the latest detailed benchmark input-output data report by the BEA (2002) to identify the goods and services used by hospitals (NAICS 622). As shown, labor and land requirements represent a significant share of the value of hospital services. Power and equipment requirements potentially associated with reciprocating internal combustion engines (electric power generation and commercial and industrial machinery and equipment repair and maintenance) represent less than 2% of the value of services.

## Table 3-19. Key Enterprise Statistics by Receipt Size for Pipeline Transportation of Natural Gas (NAICS 48621): 2002

| | | Owned by Enterprises with | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Variable | All Enterprises | 0–99K Receipts | 100–499.9K Receipts | 500–999.9K Receipts | 1,000–4,999.9K Receipts | 5,000,000–9,999,999K Receipts | <10,000K Receipts | 10,000–49,999K Receipts | 50,000–99,999K Receipts | 100,000K+ Receipts |
| Firms | 154 | 8 | 32 | 10 | 22 | 6 | 78 | 11 | 4 | 61 |
| Establishments | 1,936 | 8 | 32 | 10 | 22 | 7 | 79 | 21 | 4 | 1,832 |
| Employment | 37,450 | 15 | 58 | 69 | 138 | 88 | 368 | 216 | 274 | 36,592 |
| Receipts ($\$10^3$) | $35,896,535 | $524 | $8,681 | $7,451 | $46,429 | $40,967 | $104,052 | $188,424 | $154,384 | $35,449,675 |
| Receipts/firm ($\$10^3$) | $233,094 | $66 | $271 | $745 | $2,110 | $6,828 | $1,334 | $17,129 | $38,596 | $581,142 |
| Receipts/establishment ($\$10^3$) | $18,542 | $66 | $271 | $745 | $2,110 | $5,852 | $1,317 | $8,973 | $38,596 | $19,350 |
| Receipts/employment ($) | $958,519 | $34,933 | $149,672 | $107,986 | $336,442 | $465,534 | $282,750 | $872,333 | $563,445 | $968,782 |

Source: U.S. Census Bureau. 2008b. Firm Size Data from the Statistics of U.S. Businesses, U.S. All Industries Tabulated by Receipt Size: 2002. http://www2.census.gov/csd/susb/2002/usalli_r02.xls.

**Table 3-20. Key Statistics: General Medical and Surgical Hospitals (NAICS 6221) ($2007)**

| | 1997 | 2002 |
|---|---|---|
| Revenue ($$10^6$) | 444,141 | 539,502 |
| Payroll ($$10^6$) | 178,874 | 209,063 |
| Employees | 4,526,591 | 4,772,422 |
| Establishments | 5,487 | 5,193 |

Source: U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 62: Health Care and Social Assistance: Geographic Area Series: 2002 and 1997." <http://factfinder.census.gov>; (November 10, 2008).

**Table 3-21. Direct Requirements for Hospitals (NAICS 622): 2002**

| Commodity | Commodity Description | Direct Requirements Coefficients[a] |
|---|---|---|
| V00100 | Compensation of employees | 51.90% |
| 531000 | Real estate | 10.76% |
| 550000 | Management of companies and enterprises | 4.02% |
| 621B00 | Medical and diagnostic labs and outpatient and other ambulatory care services | 2.22% |
| 561300 | Employment services | 1.90% |
| 325412 | Pharmaceutical preparation manufacturing | 1.86% |
| 325413 | In-vitro diagnostic substance manufacturing | 1.66% |
| 524100 | Insurance carriers | 1.66% |
| 420000 | Wholesale trade | 1.62% |
| 221100 | Electric power generation, transmission, and distribution | 1.14% |

[a] These values show the amount of the commodity required to produce $1.00 of the industry's output. The values are expressed in percentage terms (coefficient ×100).

Source: U.S. Bureau of Economic Analysis. 2002. 2002 Benchmark Input-Output Accounts: Detailed Make Table, Use Table and Direct Requirements Table. Tables 4 and 5.

### *3.4.3 Business Statistics*

In 2002, California and Texas each had around 400 hospitals, and New York, Pennsylvania, Florida, and Illinois all had more than 200 (Figure 3-12). Vermont, Rhode Island, Delaware, and the District of Columbia all had fewer than 20 hospital establishments in their states.

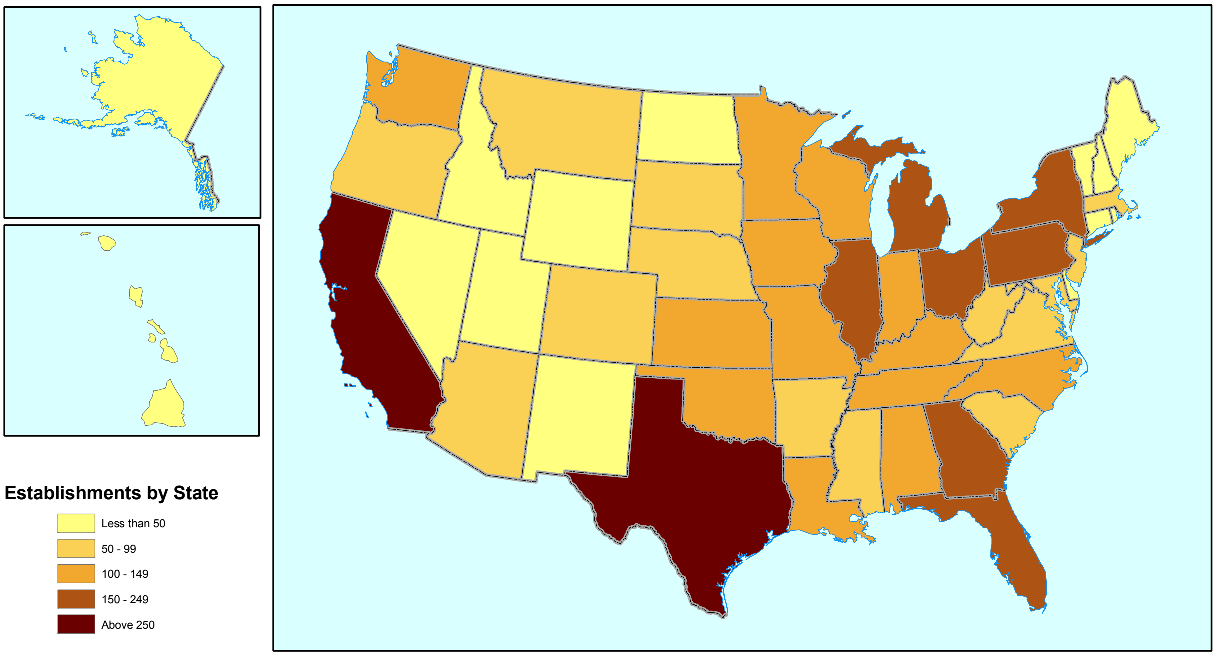



**Figure 3-12. 2002 Regional Distribution of Establishments: General Medical and Surgical Hospital Industry (NAICS 6221)**

Source: U.S. Census Bureau; generated by RTI International; using American FactFinder; “Sector 62: Health Care and Social Assistance: Geographic Area Series: Summary Statistics: 2002.” <http://factfinder.census.gov>; (November 10, 2008).

According to 2002 Census data, 79.6% of general hospitals were owned by corporations, 19.5% were individual proprietorships, and about 0.7% were partnerships (Figure 3-13). As shown in Table 3-22, the four largest firms accounted for almost 400 establishments and about 10% of total revenue. The 50 largest firms accounted for over 1,100 establishments and about 30% of total revenue. In addition, about 27% of all general hospitals are owned or controlled by the government, with most of those at the local level (Table 3-23).

In 2006, the United States had 4,927 community hospitals (Table 3-24); nongovernmental not-for-profit hospitals accounted for 59% of these hospitals, and 75% of the expenses of all community hospitals.

Enterprises including hospitals, nursing and residential care facilities, and social assistance (NAICS 622-4) generated $108 billion in total receipts in 2006. Including those enterprises without net income, the industry averaged an after-tax profit margin of 3.1% (Table 3-25).

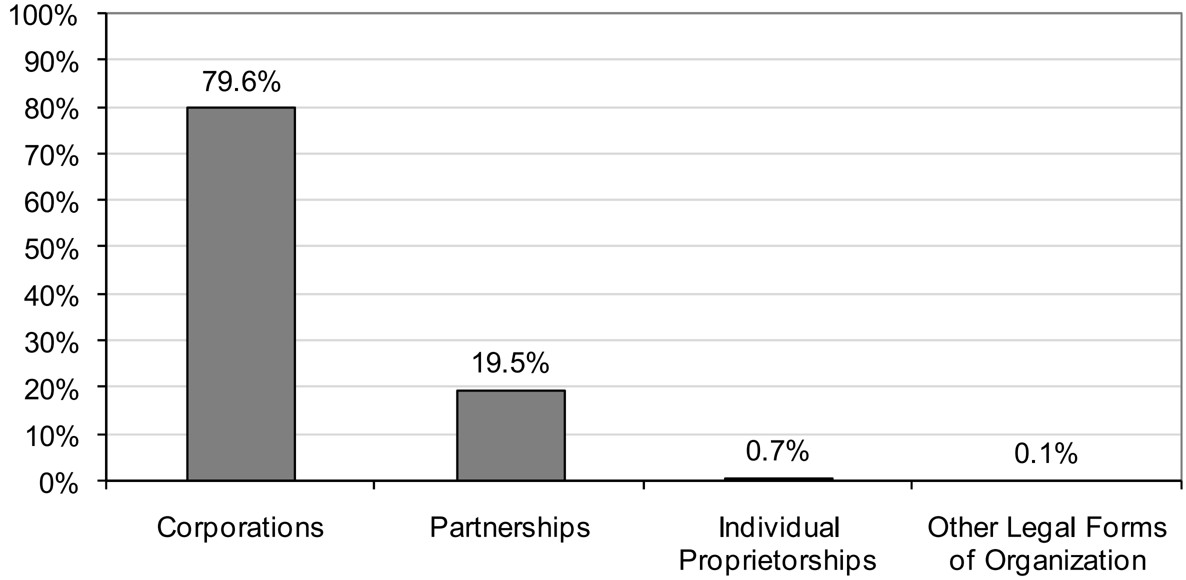



**Figure 3-13. Share of Establishments by Legal Form of Organization in the General Medical and Surgical Hospitals Industry (NAICS 6221): 2002**

Source: U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 62: Health Care and Social Assistance: Subject Series—Estab & Firm Size: Legal Form of Organization for the United States: 2002" <http://factfinder.census.gov>; (November 21, 2008).

**Table 3-22. Firm Concentration for General Medical and Surgical Hospitals (NAICS 6221): 2002**

| | | Receipts/Revenue | | | |
|---|---|---|---|---|---|
| **Commodity** | **Establishments** | **Amount ($$10^6$)** | **Percentage of Total** | **Number of Employees** | **Employees per Establishment** |
| All firms | 5,193 | $469,727 | 100.0% | 4,772,422 | 919 |
| 4 largest firms | 391 | $44,124 | 9.4% | 389,152 | 995 |
| 8 largest firms | 507 | $60,708 | 12.9% | 537,695 | 1,061 |
| 20 largest firms | 777 | $92,466 | 19.7% | 831,988 | 1,071 |
| 50 largest firms | 1,138 | $139,501 | 29.7% | 1,279,444 | 1,124 |

Source: U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 62: Health Care and Social Assistance: Subject Series—Estab & Firm Size: Concentration by Largest Firms for the United States: 2002" <http://factfinder.census.gov>; (November 21, 2008).

**Table 3-23. Government Control and Ownership for General Medical and Surgical Hospitals (NAICS 6221): 2002**

| Commodity | Establishments | Percentage of Total | Receipts/Revenue Amount ($\$10^6$) | Receipts/Revenue Percentage of Total | Number of Employees | Employees per Establishment |
|---|---|---|---|---|---|---|
| All firms | 5,193 | 100.0% | $469,727 | 100.0% | 4,772,422 | 919 |
| All government owned and controlled hospitals | 1,408 | 27.1% | $91,956 | 19.6% | 962,772 | 684 |
| Federal government | 258 | 5.0% | $25,993 | 5.5% | 257,766 | 999 |
| State government | 98 | 1.9% | $19,029 | 4.1% | 176,754 | 1,804 |
| Local government | 1,052 | 20.3% | $46,934 | 10.0% | 528,252 | 502 |

Source: U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 62: Health Care and Social Assistance: Subject Series—Estab & Firm Size: Concentration by Largest Firms for the United States: 2002" <http://factfinder.census.gov>; (November 21, 2008).

**Table 3-24. Hospital Statistics: 2006**

| Community Hospitals | Number | Total Expenses ($10^3$) | Total Net Revenue ($10^3$) |
|---|---|---|---|
| Total | 4,927 | $551,835,328 | $587,050,914 |
| Nongovernment not-for-profit | 2,919 | $412,867,575 | NA |
| Investor-owned | 889 | $54,994,199 | NA |
| State and local government | 1,119 | $83,973,554 | NA |

NA = Not available

Source: American Hospital Association. 2007. "AHA Hospital Statistics: 2008 Edition." Health Forum.

**Table 3-25. Aggregate Tax Data for Accounting Period 7/05–6/06: NAICS 622-4**

| | |
|---|---|
| Number of enterprises[a] | 18,263 |
| Total receipts ($10^3$) | $108,074,793 |
| Net sales($10^3$) | $102,300,229 |
| Profit margin before tax | 4.4% |
| Profit margin after tax | 3.1% |

[a] Includes corporations with and without net income.

Source: Troy, Leo. 2008. "Almanac of Business and Industrial Financial Ratios: 2009 Edition." CCH.

The SUSB reports 27% of general hospitals have receipts of less than $10 million and 41% report receipts above $50 million (Table 3-26). Large hospitals employ a significant share of the people working in this industry.

## 3.5 Irrigation Sets and Welding Equipment

### *3.5.1 Overview*

The U.S. Economic Census classifies irrigation equipment under the farm machinery and equipment manufacturing industry group (NAICS 333111). This U.S. industry comprises establishments primarily engaged in manufacturing agricultural and farm machinery and equipment and other turf and grounds care equipment, including planting, harvesting, and grass-mowing equipment (except lawn and garden type).

From 1997 to 2002, farm machinery and equipment manufacturing revenues fell by $3 billion from $18 billion to $15 billion (Table 3-27). At the same time, payroll decreased by 19% and the number of paid employees decreased by nearly 19%. The number of establishments dropped by 9% from 1,339 establishments in 1997 to 1,214 in 2002. Industrial production in the industry is currently 13% lower than in 1997 (Figure 3-14).

The U.S. Economic Census classifies welding equipment under the welding and soldering equipment manufacturing industry group (NAICS 333992). This U.S. industry comprises establishments primarily engaged in manufacturing welding and soldering equipment and accessories (except transformers), such as welding electrodes, welding wire, and soldering equipment (except handheld).

From 1997 to 2002 welding and soldering equipment manufacturing revenue fell by about 22% to $1 billion (Table 3-28). At the same time, payroll decreased by 21% and the number of paid employees decreased by nearly 28%. The number of establishments dropped by 8% from 250 establishments in 1997 to 231 in 2002.

### *3.5.2 Irrigation and Welding Services*

The demand for equipment is derived from the demand for the services the equipment provides. We describe uses and industrial consumers of this equipment.

#### *3.5.2.1 Irrigation*

Demand for irrigation equipment is driven by farm operation decisions, optimal replacement considerations, and climate and weather conditions. The National Agriculture Statistics Service (NASS) 2003 Farm and Ranch Irrigation Survey (USDA-NASS, 2004) shows

## Table 3-26. Key Enterprise Statistics by Receipt Size for General Medical and Surgical Hospitals (NAICS 6221): 2002 ($2007)

| | | Owned by Enterprises with | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variable** | **All Enterprises** | **0–99K Receipts** | **100–499.9K Receipts** | **500–999.9K Receipts** | **1,000–4,999.9K Receipts** | **5,000,000–9,999,999K Receipts** | **<10,000K Receipts** | **10,000–49,999K Receipts** | **50,000–99,999K Receipts** | **100,000K+ Receipts** |
| Firms | 3,581 | 64 | 77 | 59 | 344 | 437 | 981 | 1,116 | 438 | 1,046 |
| Establishments | 5,971 | 64 | 77 | 59 | 356 | 454 | 1,010 | 1,203 | 519 | 3,239 |
| Employment | 4,713,450 | 2,500–4999 | 250–499 | 730 | 18,675 | 56,296 | 78,980 | 347,613 | 337,885 | 3,948,972 |
| Receipts ($$10^3$) | $468,007,640 | Not disclosed | Not disclosed | $42,017 | $1,084,945 | $3,165,513 | $4,317,321 | $26,036,570 | $29,039,799 | $408,613,950 |
| Receipts/firm ($$10^3$) | $130,692 | Not disclosed | Not disclosed | $712 | $3,154 | $7,244 | $4,401 | $23,330 | $66,301 | $390,644 |
| Receipts/establishment ($$10^3$) | $78,380 | Not disclosed | Not disclosed | $712 | $3,048 | $6,972 | $4,275 | $21,643 | $55,953 | $126,154 |
| Receipts/employment ($) | $99,292 | Not disclosed | Not disclosed | $57,558 | $58,096 | $56,230 | $54,663 | $74,901 | $85,946 | $103,473 |

Source: U.S. Small Business Administration (SBA). 2008. "Firm Size Data from the Statistics of U.S. Businesses: U.S. All Industries Tabulated by Receipt Size: 2002." <http://www.census.gov/csd/susb/susb02.htm>.

**Table 3-27. Key Statistics: Farm Machinery and Equipment Manufacturing (NAICS 333111) ($2007)**

| | 1997 | 2002 |
|---|---|---|
| Revenue ($$10^6$) | $17,838 | $15,006 |
| Payroll ($$10^6$) | $2,644 | $2,132 |
| Employees | 66,370 | 53,817 |
| Establishments | 1,339 | 1,214 |

Source: U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 31: Manufacturing: Industry Series: Historical Statistics for the Industry: 2002 and Earlier Years" <http://factfinder.census.gov>; (November 25, 2008).

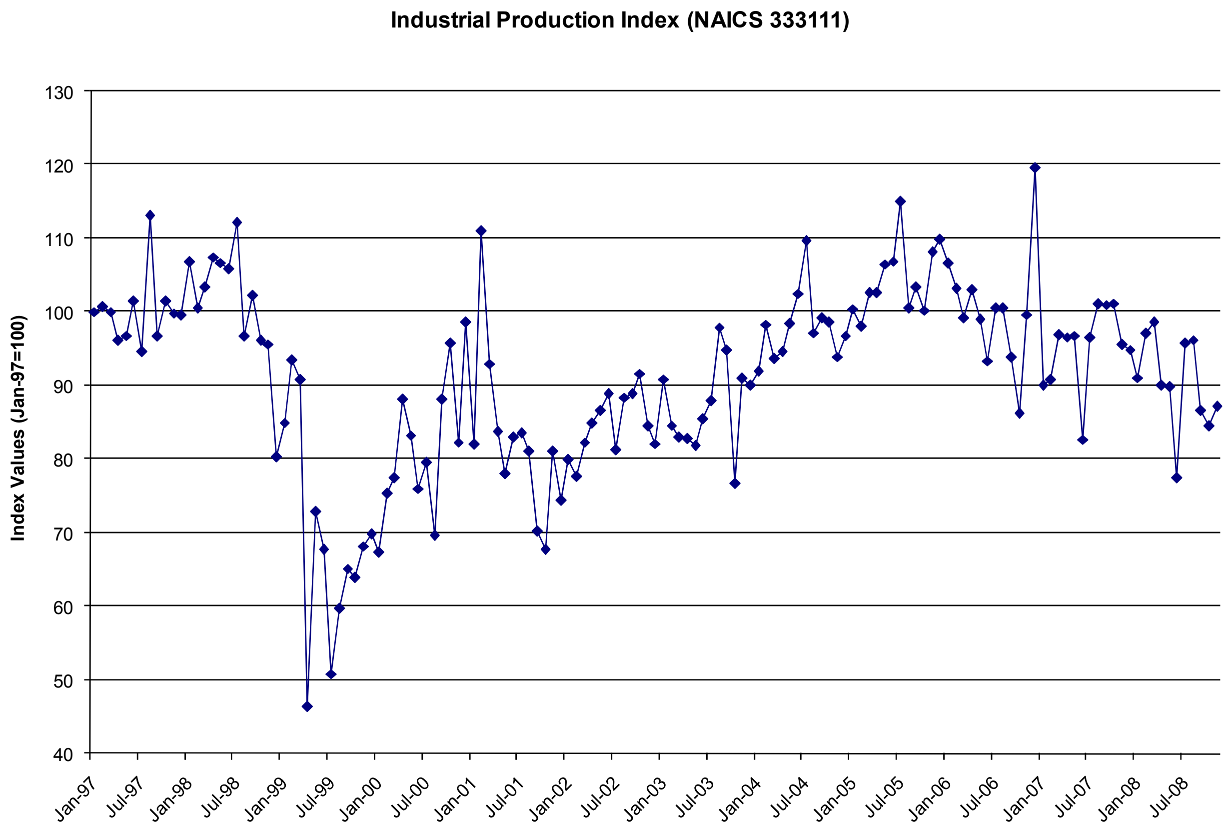



**Figure 3-14. Industrial Production Index (NAICS 333111)**

**Table 3-28. Key Statistics: Welding and Soldering Equipment Manufacturing (NAICS 333992) ($2007)**

| | 1997 | 2002 |
|---|---|---|
| Revenue ($$10^6$) | $4,957 | $3,880 |
| Payroll ($$10^6$) | $1,024 | $811 |
| Employees | 22,505 | 16,128 |
| Establishments | 250 | 231 |

Source: U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 31: Manufacturing: Industry Series: Historical Statistics for the Industry: 2002 and Earlier Years." <http://factfinder.census.gov>; (November 25, 2008).

that the top five states ranked by total acres irrigated are California, Nebraska, Texas, Arkansas, and Idaho. Approximately 32 million of the 53 million, or 68%, of U.S. irrigated acres are used to support oilseed and grain farming and other crop farming (tobacco, cotton, sugar cane, and other). Virtually all of these irrigated areas are west of the Mississippi River.

The survey reported that approximately 500,000 pumps were used on U.S. farms in 2003 with energy expenses totaling $1.6 billion. Electricity is the dominant form of energy expense for irrigation pumps, accounting for 60% of total energy expenses. Diesel fuel is second (18%), followed by natural gas (18%) and other forms of energy such as gasoline (4%).

Per-acre operating costs for these irrigation systems vary by fuel type, and natural gas was the most expensive in 2003 ($57 per acre for well systems and $34 per acre for surface water systems) (Table 3-29). Systems using diesel fuel were operated at approximately half of these per-acre costs ($25 per acre for well systems and $16 per acre for surface water systems). Gasoline- and gasohol-powered systems offered the least expensive operating costs ($12 per acre for well systems and $18 per acre for surface water systems).

As shown in Table 3-30, the number of on-farm pumps fell from 508,727 to 497,443 (2%) between 1998 and 2003. However, the use of electric- and diesel-powered pumps increased during this period (3% and 4%, respectively), while other fuel sources such as gasoline declined significantly. Pumps powered by gasoline and gasohol, for example, declined from 8,965 to 6,178, a 31% change during this period. Pumps powered by natural gas, LP gas, propane, and butane also declined by 26% to 29%. Although 1998 operating cost data are not available, the change in relative costs of operation across fuels between 1998 and 2003 may partly explain

**Table 3-29. Expenses per Acre by Type of Energy: 2003**

| Fuel Type | Irrigated by Water from Wells | Irrigated by Surface Water |
|---|---|---|
| Electricity | $42.64 | $29.84 |
| Natural gas | $57.25 | $33.67 |
| LP gas, propane, butane | $27.21 | $22.68 |
| Diesel fuel | $25.09 | $16.27 |
| Gasoline and gasohol | $11.60 | $18.05 |
| Total | $39.50 | $26.39 |

Source: U.S. Department of Agriculture, National Agricultural Statistics Service. 2004. "2003 Farm and Ranch Irrigation Survey." Washington, DC: USDA-NASS. Table 20.

**Table 3-30. Number of On-Farm Pumps of Irrigation Water by Type of Energy: 1998 and 2003**

| Fuel Type | 1998 | 2003 | Percentage Change |
|---|---|---|---|
| Electricity | 308,579 | 319,102 | 3% |
| Natural gas | 58,880 | 41,771 | –29% |
| LP gas, propane, butane | 23,964 | 17,792 | –26% |
| Diesel fuel | 108,339 | 112,600 | 4% |
| Gasoline and gasohol | 8,965 | 6,178 | –31% |
| Total | 508,727 | 497,443 | –2% |

Source: U.S. Department of Agriculture, National Agricultural Statistics Service. 2004. "2003 Farm and Ranch Irrigation Survey." Washington, DC: USDA-NASS. Table 20.

these patterns. Although no information is available on the use and construction of on-farm pumps specifically, their use is tied to the amount of agricultural land in production. USDA reports that planted acres of the eight major crops hit a 5-year high of 252 million acres in 2008 but will fall and level off to around 244 million acres over the next 2 to 4 years (USDA, 2008).

#### *3.5.2.2 Welding*

Welding is used in a wide variety of applications. One of the biggest manufacturers of welding products identifies the following key end-user segments:

- general metal fabrication;
- infrastructure including oil and gas pipelines and platforms, buildings, bridges, and power generation;

- transportation and defense industries (automotive, trucks, rail, ships, and aerospace);
- equipment manufacturers in construction, farming, and mining;
- retail resellers; and
- rental market (Lincoln Electric Holdings, 2006).

Lincoln Electric further describes the following key applications: power generation and process industries, offshore production of oil and gas, pipelines/pipemills, and heavy fabrication (earthmoving and construction equipment and agricultural and farm equipment.

### *3.5.3 Business Statistics*

In 2003, California and Texas each had more than 5 million irrigated acres (Figure 3-15). Midwest states like Arkansas and Nebraska had more than 2.5 million irrigated acres. Heavy and civil engineering construction establishments are spread throughout the United States, particularly in areas such as California, Texas, North Carolina, and Florida (Figure 3-16). Each of these states has more than 2,000 establishments.

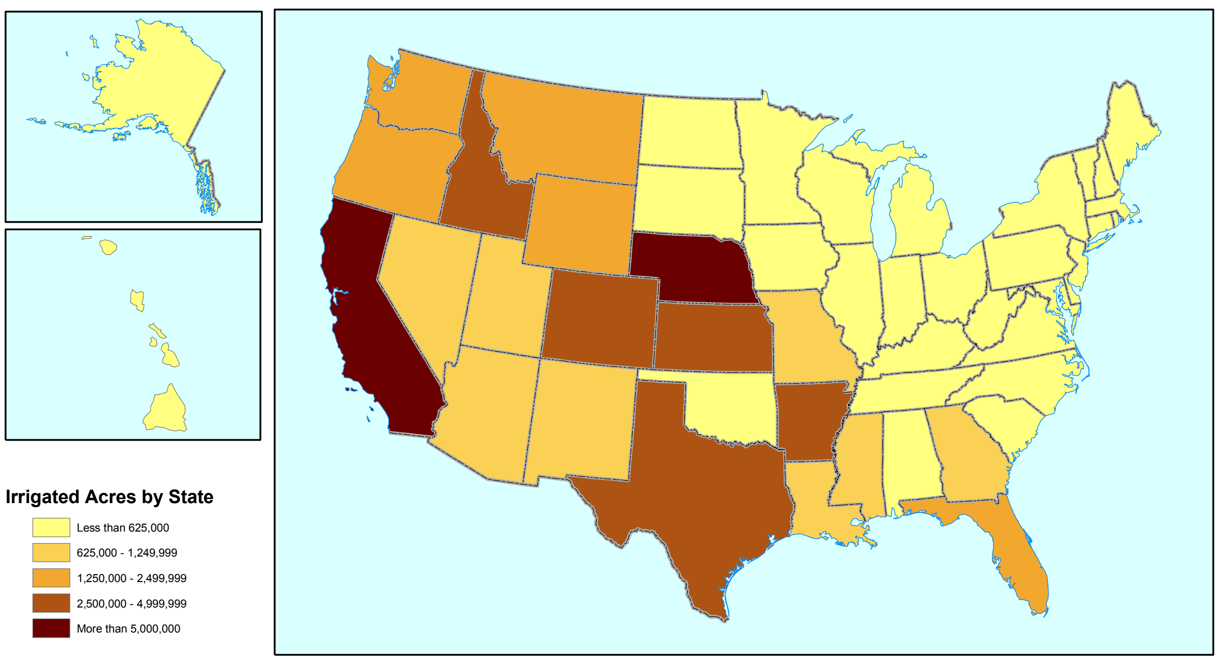



**Figure 3-15. 2003 Regional Distribution of Irrigated Acres**

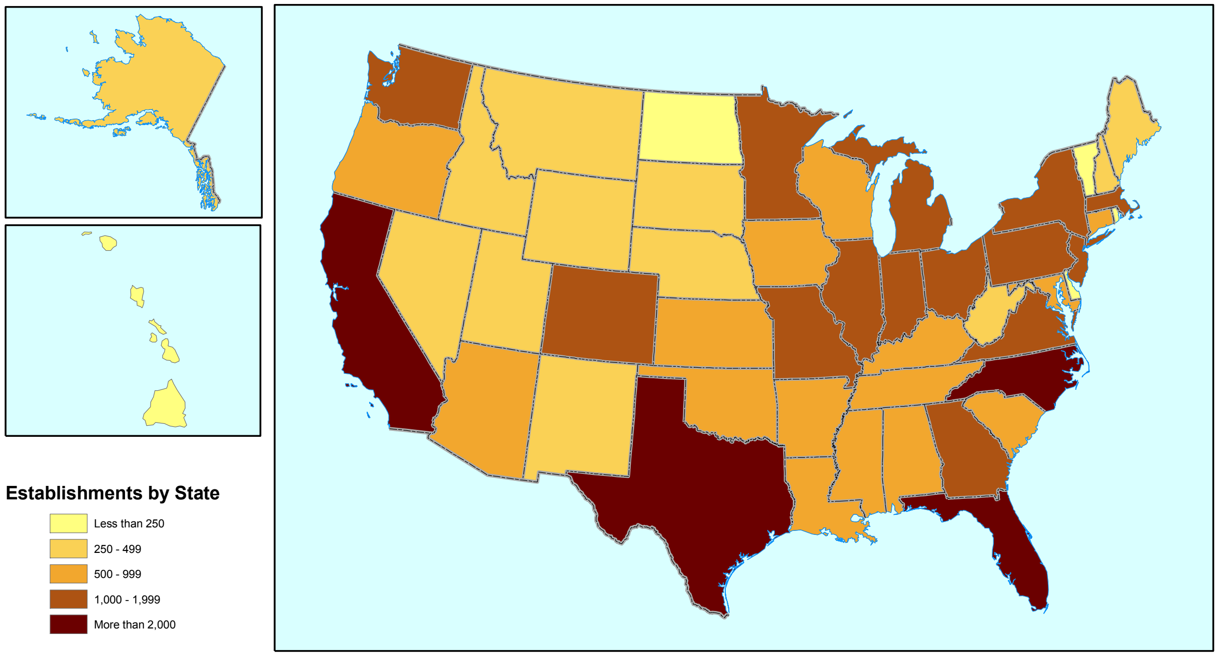



**Figure 3-16. 2002 Regional Distribution of Establishments: Heavy and Civil Engineering Construction (NAICS 237)**

As shown in Table 3-31, the market value of agriculture products sold was less than $25,000 per year on almost half the irrigated farms in the 2003 Farm and Ranch Irrigation Survey. Over 90% of the irrigated farms had agricultural product revenue below $750,000. It is not clear what fraction of these farms use stationary diesel engines or are owned by corporate farming operations. Thus, there is uncertainly about how many of these irrigated farms have stationary diesel engines that will be impacted by this rule. In addition, there is uncertainty about what fraction of these farms are small businesses. However, SUSB data also suggest 65% of firms in NAICS 11 have receipts less than $500,000 per year.

**Table 3-31. Distribution of Farm Statistics by Market Value of Agricultural Products Sold: 2003**

| Variable | All Farms | <$25K | $25–$49K | $50–$99K | $100–$250K | $250–$500K | $500–$999K | $1,000K or More |
|---|---|---|---|---|---|---|---|---|
| Farms | 220,163 | 48% | 10% | 11% | 13% | 8% | 5% | 4% |
| Land in farms (acres) | 196,515,390 | 8% | 6% | 9% | 21% | 17% | 16% | 23% |
| Acres irrigated | 52,583,431 | 5% | 4% | 7% | 18% | 18% | 19% | 29% |
| Irrigate cropland harvest (acres) | 48,626,955 | 4% | 3% | 7% | 18% | 19% | 20% | 30% |

Source: U.S. Department of Agriculture (USDA), National Agricultural Statistics Service (NASS). 2004. "2003 Farm and Ranch Irrigation Survey." Washington, DC: USDA-NASS. Table 34.

Enterprises within agriculture, construction, and mining machinery manufacturing (NAICS 3331) generated $118 billion of total receipts in 2006, while those in other general purpose machinery manufacturing (NAICS 3339) generated $69.8 billion. The average after-tax profit margin in these two industries was 6.9% and 4.7%, respectively (Table 3-32).

**Table 3-32. Aggregate Tax Data for Accounting Period 7/05–6/06: NAICS 3331,9**

| | Agriculture, Construction, & Mining Machinery Manufacturing | Other General Purpose Machinery Manufacturing |
|---|---|---|
| Number of enterprises[a] | 2,485 | 7,288 |
| Total receipts ($10^3$) | $118,369,636 | $69,813,244 |
| Net sales($10^3$) | $108,210,188 | $65,256,901 |
| Profit margin before tax | 9.1% | 6.1% |
| Profit Margin after tax | 6.9% | 4.7% |

[a] Includes corporations with and without net income.

Source: Troy, Leo. 2008. "Almanac of Business and Industrial Financial Ratios: 2009 Edition." CCH.

As noted earlier, welding equipment is used in heavy fabrication such as earthmoving and construction equipment. We focus on the size distribution for a representative sector in this section (NAICS 327, Heavy and Civil Engineering Construction); other subsections in Section 2 cover other sectors that potentially use equipment powered by diesel engines (e.g., power generation and offshore gas distribution). As shown in Table 3-33, SUSB data suggest 60% of firms in this industry have receipts less than $1 million per year; 90% are below the Small Business Administration (SBA) threshold on $50 million per year. However, it is not clear what fraction of these firms use stationary diesel engines.

## Table 3-33. Key Enterprise Statistics by Receipt Size for Heavy Construction: 2002[a]

| Variable | All Enterprises | Owned by Enterprises with 0–99K Receipts | 100–499.9K Receipts | 500–999.9K Receipts | 1,000–4,999.9K Receipts | 5,000,000–9,999,999K Receipts | <10,000K Receipts | 10,000–49,999K Receipts | 50,000–99,999K Receipts | 100,000K+ Receipts |
|---|---|---|---|---|---|---|---|---|---|---|
| Firms | 38,610 | 4,570 | 12,733 | 5,882 | 9,994 | 2,398 | 35,577 | 2,395 | 294 | 344 |
| Establishments | 39,949 | 4,570 | 12,733 | 5,883 | 10,025 | 2,427 | 35,638 | 2,561 | 405 | 1,345 |
| Employment | 856,312 | 5,219 | 35,592 | 37,498 | 156,941 | 87,858 | 323,108 | 199,532 | 64,681 | 268,991 |
| Receipts ($$10^3$) | $174,384,008 | $237,458 | $3,346,936 | $4,191,113 | $22,641,664 | $16,573,417 | $46,990,588 | $46,244,065 | $16,728,737 | $64,420,618 |
| Receipts/firm ($$10^3$) | $4,517 | $52 | $263 | $713 | $2,266 | $6,911 | $1,321 | $19,309 | $56,900 | $187,269 |
| Receipts/establishment ($$10^3$) | $4,365 | $52 | $263 | $712 | $2,259 | $6,829 | $1,319 | $18,057 | $41,306 | $47,896 |
| Receipts/employment ($) | $203,645 | $45,499 | $94,036 | $111,769 | $144,269 | $188,639 | $145,433 | $231,763 | $258,634 | $239,490 |

[a] 2002 SUSB NAICS 224. The most comparable 2002 NAICS code for this industry is 237.

Source: U.S. Census Bureau. 2008b. Firm Size Data from the Statistics of U.S. Businesses, U.S. All Industries Tabulated by Receipt Size: 2002. http://www2.census.gov/csd/susb/2002/usalli_r02.xls.

# SECTION 4
# REGULATORY ALTERNATIVES, COSTS, AND EMISSION IMPACTS

## 4.1 Background

This section of the RIA includes a discussion of the regulatory alternatives considered for the final rule, the costs associated with these regulatory alternatives, and the impacts on affected emissions (both HAP and non-HAP). All impacts presented are for the year of full implementation, 2013. Although the estimates presented are annualized, they should be understood as a "snapshot" in analyzing costs.

This action promulgates NESHAP for existing stationary CI RICE with a site rating of less than or equal to 500 hp located at major sources, existing non-emergency CI engines with a site rating greater than 500 hp at major sources, and existing stationary CI RICE of any power rating located at area sources. EPA is finalizing these requirements to meet its statutory obligation to address HAP emissions from these sources under sections 112(d), 112(c)(3) and 112(k) of the CAA. The final NESHAP for stationary CI RICE will be promulgated under 40 CFR part 63, subpart ZZZZ, which already contains standards applicable to new stationary RICE and some existing stationary RICE.

EPA promulgated NESHAP for existing, new, and reconstructed stationary RICE greater than 500 hp located at major sources on June 15, 2004 (69 FR 33474). EPA promulgated NESHAP for new and reconstructed stationary RICE that are located at area sources of HAP emissions and for new and reconstructed stationary RICE that have a site rating of less than or equal to 500 hp that are located at major sources of HAP emissions on January 18, 2008 (73 FR 3568). At that time, EPA did not promulgate final requirements for existing stationary RICE that are located at area sources of HAP emissions or for existing stationary RICE that have a site rating of less than or equal to 500 hp that are located at major sources of HAP emissions. Although EPA proposed requirements for these sources, EPA did not finalize these requirements due to comments received indicating that the proposed Maximum Achievable Control Technology (MACT) determinations for existing sources were inappropriate and because of a decision by the U.S. Court of Appeals for the District of Columbia Circuit on March 13, 2007, which vacated EPA's MACT standards for the Brick and Structural Clay Products Manufacturing source category (40 CFR part 63, subpart JJJJJ). Sierra Club v. EPA, 479 F.3d 875 (DC Cir 2007). Among other things, the D.C. Circuit found that EPA's no emission reduction MACT determination in the challenged rule was unlawful. Because in the proposed stationary RICE rule, EPA had used a MACT floor methodology similar to the methodology used in the Brick MACT, EPA decided to re-evaluate the MACT floors for existing major sources that have a site rating of less than or equal to 500 brake hp consistent with the Court's decision in the Brick MACT case. EPA has also re-evaluated the standards for existing area sources in light of the comments received on the proposed rule.

In addition, stakeholders have encouraged the Agency to review whether there are further ways to reduce emissions of pollutants from existing stationary diesel engines. In its comments on EPA's 2005 proposed rule for new stationary diesel engines (70 FR 39870), the Environmental Defense Fund (EDF) suggested several possible avenues for the regulation of existing stationary diesel engines, including use of diesel oxidation catalysts or catalyzed diesel particulate filters (CDPF), as well as the use of ultra low sulfur diesel (ULSD) fuel. EDF suggested that such controls can provide significant pollution reductions at reasonable cost. EPA issued an advance notice of proposed rulemaking (ANPRM) in January 2008, where it solicited comment on several issues concerning options to regulate emissions of pollutants from existing stationary diesel engines, generally, and specifically from larger, older stationary diesel engines. EPA solicited comment and collected information to aid decision-making related to the reduction of HAP emissions from existing stationary diesel engines and specifically from larger, older engines under Clean Air Act (CAA) section 112 authorities. The Agency sought comment on the larger, older engines because available data indicate that those engines emit the majority of particulate matter (PM) and toxic emissions from nonemergency stationary engines as a whole. A summary of comments and responses that were received on the ANPRM is included in docket EPA-HQ-OAR-2007-0995.

EPA has taken several actions over the past several years to reduce exhaust pollutants from stationary diesel engines, but believes that further reducing exhaust pollutants from stationary diesel engines, particularly existing stationary diesel engines that have not been subject to Federal standards, is justified. Therefore, EPA is finalizing emissions reductions from existing stationary diesel engines.

## 4.2 Summary of the Proposed Rule

### *4.2.1 What Is the Source Category Regulated by this Proposed Rule?*

This final rule addresses emissions from existing stationary CI engines less than or equal to 500 hp located at major sources and all existing stationary CI engines located at area sources. This final rule also addresses emissions from existing stationary nonemergency CI engines greater than 500 hp at major sources. A major source of HAP emissions is a stationary source that emits or has the potential to emit any single HAP at a rate of 10 tons (9.07 megagrams) or more per year or any combination of HAP at a rate of 25 tons (22.68 megagrams) or more per year, except that for oil and gas production facilities, a major source of HAP emissions is determined for each surface site. An area source of HAP emissions is a source that is not a major source.

This action revises the regulations at 40 CFR part 63, subpart ZZZZ, currently applicable to new and reconstructed stationary RICE and to existing stationary RICE greater than 500 hp located at major sources. Through this action, we are adding to subpart ZZZZ requirements for: existing CI stationary RICE less than or equal to 500 HP located at major sources and existing CI stationary RICE located at area sources. When the subpart ZZZZ regulations were promulgated (see 69 FR 33474, June 15, 2004), EPA deferred promulgating regulations with respect to stationary engines 500 hp or less at major sources until further information on the engines could be obtained and analyzed. EPA decided to regulate these smaller engines at the same time that it regulated engines located at area sources. EPA issued regulations for new stationary engines located at area sources of HAP emissions and new stationary engines located at major sources with a site rating of 500 hp or less in the rulemaking issued on January 18, 2008 (73 FR 3568), but did not promulgate a final regulation for existing stationary engines.

*4.2.1.1 Stationary CI RICE ≤500 hp at Major Sources*

This action revises 40 CFR part 63, subpart ZZZZ, to address HAP emissions from existing stationary CI RICE less than or equal to 500 hp located at major sources. For stationary engines less than or equal to 500 hp at major sources, EPA must determine what is the appropriate MACT for those engines under section 112(d) (2) and (d)(3) of the CAA.

EPA has divided stationary CI RICE into emergency and nonemergency engines in order to capture the unique differences between these types of engines.

*4.2.1.2 Stationary CI RICE at Area Sources*

This action revises 40 CFR part 63, subpart ZZZZ, in order to address HAP emissions from existing stationary RICE located at area sources. Section 112(d) of the Clean Air Act (CAA) requires EPA to establish national emission standards for hazardous air pollutants (NESHAP) for both major and area sources of HAP that are listed for regulation under CAA section 112(c).

Section 112(k)(3)(B) of the CAA calls for EPA to identify at least 30 HAP that, as a result of emissions of area sources, pose the greatest threat to public health in the largest number of urban areas. EPA implemented this provision in 1999 in the Integrated Urban Air Toxics

Strategy (64 FR 38715, July 19, 1999). Specifically, in the Strategy, EPA identified 30 HAP that pose the greatest potential health threat in urban areas, and these HAP are referred to as the "30 urban HAP." Section 112(c)(3) requires EPA to list sufficient categories or subcategories of area sources to ensure that area sources representing 90 percent of the emissions of the 30 urban HAP are subject to regulation. EPA implemented these requirements through the Integrated Urban Air Toxics Strategy (64 FR 38715, July 19, 1999). The area source stationary engine source category was one of the listed categories. A primary goal of the Strategy is to achieve a 75 percent reduction in cancer incidence attributable to HAP emitted from stationary sources.

Under CAA section 112(d)(5), EPA may elect to promulgate standards or requirements for area sources "which provide for the use of generally available control technologies or management practices by such sources to reduce emissions of hazardous air pollutants." Additional information on generally available control technologies (GACT)- or management practices is found in the Senate report on the legislation (Senate report Number 101-228, December 20, 1989), which describes GACT as:

> . . . methods, practices and techniques which are commercially available and appropriate for application by the sources in the category considering economic impacts and the technical capabilities of the firms to operate and maintain the emissions control systems.

Consistent with the legislative history, EPA can consider costs and economic impacts in determining GACT, which is particularly important when developing regulations for source categories, like this one, that have many small businesses.

Determining what constitutes GACT involves considering the control technologies and management practices that are generally available to the area sources in the source category. EPA also considers the standards applicable to major sources in the same industrial sector to determine if the control technologies and management practices are transferable and generally available to area sources. In appropriate circumstances, EPA may also consider technologies and practices at area and major sources in similar categories to determine whether such technologies and practices could be considered generally available for the area source category at issue. Finally, as EPA has already noted, in determining GACT for a particular area source category, EPA considers the costs and economic impacts of available control technologies and management practices on that category.

The urban HAP that must be regulated at stationary RICE to achieve the section 112(c)(3) requirement to regulate categories accounting for 90 percent of the urban HAP are: 7 PAH, formaldehyde, acetaldehyde, arsenic, benzene, beryllium compounds, and cadmium compounds. As explained below, EPA chose to select formaldehyde to serve as a surrogate for HAP emissions. Formaldehyde is the hazardous air pollutant present in the highest concentration from stationary engines. In addition, emissions data show that formaldehyde emission levels are related to other HAP emission levels. EPA has previously demonstrated that CO is an appropriate surrogate for formaldehyde from stationary CI engines and is consequently finalizing emission standards in terms of CO for existing stationary CI RICE at area sources.

Consistent with stationary CI RICE at major sources, EPA has also divided the stationary CI RICE at area sources into emergency and nonemergency engines in order to properly take into account the differences between these engines.

*4.2.1.3 Stationary Non-Emergency CI RICE >500 hp at Major Sources*

In addition, EPA is finalizing emission standards for non-emergency stationary CI engines greater than 500 hp at major sources under its authority to review and revise emission standards as necessary under section 112(d) of the CAA.

### *4.2.2 What Are the Pollutants Regulated by this Proposed Rule?*

The final rule regulates emissions of HAP. Available emissions data show that several HAP, which are formed during the combustion process or which are contained within the fuel burned, are emitted from stationary engines. The HAP which have been measured in emission tests conducted on diesel fired RICE include: 1,3-butadiene, acetaldehyde, acrolein, benzene, ethylbenzene, formaldehyde, n-hexane, naphthalene, polycyclic aromatic hydrocarbons, polycyclic organic matter, styrene, toluene, and xylene. Metallic HAP from diesel fired stationary RICE that have been measured are: cadmium, chromium, lead, manganese, mercury, nickel, and selenium.

EPA described the health effects of these HAP and other HAP emitted from the operation of stationary RICE in the preamble to 40 CFR part 63, subpart ZZZZ, published on June 15, 2004 (69 FR 33474). These HAP emissions are known to cause, or contribute significantly to air pollution, which may reasonably be anticipated to endanger public health or welfare. More details on the health effects of these HAP and other HAP emitted from operation of stationary RICE can be found in Section 7 of this RIA.

The final rule will limit emissions of HAP through emissions standards for CO for existing stationary CI RICE. Carbon monoxide has been shown to be an appropriate surrogate for HAP emissions from CI engines. For the NESHAP promulgated in 2004, EPA found that there is a relationship between CO emissions reductions and HAP emissions reductions from CI stationary engines. Therefore, because testing for CO emissions has many advantages over testing for HAP emissions, CO emissions were chosen as a surrogate for HAP emissions reductions for CI stationary engines.

For the standards being finalized in this action, EPA believes that previous decisions regarding the appropriateness of using CO in concentration (ppm) levels as has been done for stationary sources before as surrogates for HAP are still valid.[1] Consequently, EPA is finalizing emission standards for CO for CI engines in order to regulate HAP emissions. In addition, EPA is promulgating separate provisions relevant to emissions of metallic HAP from existing diesel engines, as discussed in section III.C. of the preamble.

In addition to reducing HAP and CO, the final rule will result in the reduction of PM emissions from existing diesel engines. The aftertreatment technologies expected to be used to reduce HAP and CO emissions also reduce emissions of PM from diesel engines. Also, the final rule requires the use of ULSD for diesel-fueled stationary nonemergency CI engines greater than 300 hp with a displacement of less than 30 liters per cylinder. This will result in lower emissions of sulfur oxides ($SO_x$) and sulfate particulate from these engines by reducing the sulfur content in the fuel.

### *4.2.3 What Are the Final Requirements?*

#### *4.2.3.1 Existing Stationary RICE at Major Sources*

The emission requirements that are being finalized in this action for stationary CI RICE less than or equal to 500 hp located at major sources and stationary nonemergency CI RICE greater than 500 hp located at major sources are shown in Table 4-1. The numerical emission standards are in units of ppm by volume, dry basis (ppmvd) or percent reduction.

In addition, certain existing stationary RICE located at major sources are subject to fuel requirements. Owners and operators of existing stationary nonemergency diesel-fueled CI engines greater than 300 hp with a displacement of less than 30 liters per cylinder located at major sources that use diesel fuel must use only diesel fuel meeting the requirements of 40 CFR 80.510(b). This section requires that diesel fuel have a maximum sulfur content of 15 parts per million (ppm) and either a minimum cetane index of 40 or a maximum aromatic content of 35 volume percent. These fuel requirements are being finalized in order to reduce the potential formation of sulfate compounds that are emitted when high sulfur diesel fuel is used in

[1] In contrast, mobile source emission standards for diesel engines (both nonroad and on-highway) are promulgated on a mass basis rather than concentration.

combination with oxidation catalysts and to assist in the efficient operation of the oxidation catalysts.

EPA is also including work practices in the final rule that will capture and collect metallic HAP emissions. Owners and operators of existing stationary nonemergency CI engines greater than 300 hp located at major sources must do one of the following if the engine is not already equipped with a closed crankcase ventilation system: 1) install a closed crankcase ventilation system that prevents crankcase emissions from being emitted to the atmosphere, or 2) install an open crankcase filtration emission control system that reduces emissions from the crankcase by filtering the exhaust stream to remove oil mist, particulates, and metals.

**Table 4-1. Requirements for Existing Stationary CI RICE Located at Major Sources**

| Subcategory | Except during Periods of Startup | During Periods of Startup |
|---|---|---|
| Emergency CI | Change oil and filter every 500 hours of operation or annually, whichever comes first[a]; inspect air cleaner every 1000 hours of operation or annually, whichever comes first; and inspect all hoses and belts every 500 hours of operation or annually, whichever comes first, and replace as necessary[b] | Minimize the engine's time spent at idle<br>and<br>minimize the engine's startup time at startup to a period needed for appropriate and safe loading of the engine, not to exceed 30 minutes, after which time the non-startup emission limitations apply.[c] |
| Nonemergency CI ≤100hp | • change oil and filter every 1000 hours of operation or annually, whichever comes first, except that sources can extend the period for changing the oil if the oil is part of an oil analysis program as discussed below and none of the condemning limits are exceeded;<br>• inspect air cleaner every 1000 hours of operation or annually, whichever comes first; and<br>• inspect all hoses and belts every 500 hours or annually, whichever comes first, and replace as necessary. | |
| Nonemergency CI 100≤hp≤300 | 230 ppmvd CO at 15% $O_2$ | |

| | | |
|---|---|---|
| Nonemergency CI 300<hp≤500 | 49 ppmvd CO at 15% $O_2$<br>or<br>70% CO reduction | |
| Nonemergency CI >500 hp | 23 ppmvd CO at 15% $O_2$<br>or<br>70% CO reduction | |

[a] Sources have the option to utilize an oil analysis program in order to extend the specified oil change requirement in Table 4-2. .

[b] Sources have the option to petition the Administrator for approval of alternative maintenance practices. The alternative maintenance practices must be at least as stringent as those specified in this Table 4-1.

[c] Sources have the option to petition the Administrator for a longer period of time for engine startup. Any petition must be based on specific factual information indicating the reason that a longer period is necessary for that engine.

Sources also have the option to use an oil change analysis program to extend the oil change frequencies specified above. The analysis program must at a minimum analyze the following three parameters: Total Base Number, viscosity, and percent water content. The analysis must be conducted at the same frequencies specified for changing the engine oil. If the condemning limits provided below are not exceeded, the engine owner or operator is not required to change the oil. If any of the condemning limits are exceeded, the engine owner or operator must change the oil before continuing to use the engine. The condemning limits are as follows:

- Total Base Number is less than 30 percent of the Total Base Number of the oil when new; or
- viscosity of the oil has changed by more than 20 percent from the viscosity of the oil when new; or
- percent water content (by volume) is greater than 0.5.

Pursuant to the provisions of 40 CFR 63.6(g), sources can also request that the Administrator approve alternative work practices.

*4.2.3.2 Existing Stationary RICE at Area Sources*

The emission requirements that are being finalized in this action for existing stationary CI RICE located at area sources are shown in Table 4-2. Existing stationary emergency engines at area sources located at residential, commercial, or institutional facilities are not part of the source category and therefore are not subject to any requirements under this final rule.

Existing stationary nonemergency CI RICE greater than 300 hp located at area sources in Alaska not accessible by the Federal Aid Highway System (FAHS) do not have to meet the CO emission standards specified in Table 4-2. Existing stationary nonemergency CI RICE greater than 300 hp located at area sources in Alaska not accessible by the FAHS must meet the maintenance practices that are shown for stationary nonemergency CI RICE less than or equal to 300 hp in Table 4-2.

Also, owners and operators of existing stationary nonemergency diesel-fueled CI engines greater than 300 hp with a displacement of less than 30 liters per cylinder located at area sources that use diesel fuel must use only diesel fuel meeting the requirements of 40 CFR 80.510(b). This section requires that diesel fuel have a maximum sulfur content of 15 ppm and either a minimum cetane index of 40 or a maximum aromatic content of 35 volume percent. Finally, in order to reduce metallic HAP emissions, existing stationary nonemergency CI engines greater than 300 hp located at area sources must do one of the following if the engine is not already equipped with a closed crankcase ventilation system: 1) install a closed crankcase ventilation system that prevents crankcase emissions from being emitted to the atmosphere, or 2) install an open crankcase filtration emission control system that reduces emissions from the crankcase by filtering the exhaust stream to remove oil mist, particulates, and metals.

**Table 4-2. Requirements for Existing Stationary RICE Located at Area Sources**

| Subcategory | Except during Periods of Startup | During Periods of Startup |
|---|---|---|
| Nonemergency CI ≤300 hp | Change oil and filter every 1000 hours of operation or annually, whichever comes first[a]; inspect air cleaner every 1000 hours of operation or annually, whichever comes first; and inspect all hoses and belts every 500 hours or annually, whichever comes first, and replace as necessary[b] | Minimize the engine's time spent at idle and<br>minimize the engine's startup to a period needed for appropriate and safe loading of the engine, not to exceed 30 minutes, after which time the non-startup emission limitations apply.[c] |
| Nonemergency CI 300<hp≤500 | 49 ppmvd CO at 15% $O_2$<br>or<br>70% CO reduction | |
| Nonemergency CI >500 hp | 23 ppmvd CO at 15% $O_2$<br>or<br>70% CO reduction | |

| | | |
|---|---|---|
| Emergency CI | Change oil and filter every 500 hours of operation or annually, whichever comes first[a]; inspect air cleaner every 1000 hours of operation or annually, whichever comes first; and inspect all hoses and belts every 500 hours of operation or annually, whichever comes first, and replace as necessary[b] | |

[a] Sources have the option to utilize an oil analysis program in order to extend the specified oil change requirement.

[b] Sources have the option to petition the Administrator for approval of alternative maintenance practices. The alternative maintenance practices must be at least as stringent as those specified in this Table 4-2.

[c] Sources have the option to petition the Administrator for a longer period of time for engine startup. Any petition must be based on specific factual information indicating the reason that a longer period is necessary for that engine.

#### *4.2.3.3 Operating Limitations for Nonemergency CI Engines >500 hp*

In addition to the standards discussed above, EPA is finalizing operating limitations for stationary nonemergency CI RICE that are greater than 500 hp. Owners and operators of engines that are equipped with oxidation catalyst must maintain the catalyst so that the pressure drop across the catalyst does not change by more than 2 inches of water from the pressure drop across the catalyst that was measured during the initial performance test. Owners and operators of these engines must also maintain the temperature of the stationary RICE exhaust so that the catalyst inlet temperature is between 450 and 1350 degrees Fahrenheit (°F) for engines with an oxidation catalyst. Owners and operators of engines that are not using oxidation catalyst must comply with any operating limitations approved by the Administrator.

#### *4.2.3.4 Startup Requirements*

As shown in Tables 4-1 and 4-2, the following stationary engines are subject to specific operational standards, during engine startup:

- Existing CI RICE less than or equal to 500 hp located at major sources,
- Existing nonemergency CI RICE greater than 500 hp located at major sources,
- Existing CI RICE located at area sources,
- New or reconstructed nonemergency 2SLB >500 hp located at a major source of HAP emissions,

- New or reconstructed nonemergency 4SLB >500 hp located at a major source of HAP emissions,
- Existing nonemergency 4SRB >500 hp located at a major source of HAP emissions,
- New or reconstructed nonemergency 4SRB >500 hp located at a major source of HAP emissions, and
- New or reconstructed nonemergency CI >500 hp located at a major source of HAP emissions.

Engine startup is defined as the time from initial start until applied load and engine and associated equipment reaches steady state or normal operation. For stationary engine with catalytic controls, engine startup means the time from initial start until applied load and engine and associated equipment reaches steady state, or normal operation, including the catalyst. Owners and operators must minimize the engine's time spent at idle and limit startup time to 30 minutes. These requirements will limit the HAP emissions during periods of engine startup. Pursuant to the provisions of 40 CFR 63.6(g), engines at major sources may petition the Administrator for an alternative work practice. An owner or operator of an engine at an area source can work with its state permitting authority pursuant to EPA's regulations at 40 CFR subpart E for approval of an alternative management practice. See 40 C.F.R. Subpart E (setting forth requirements for, among other things, equivalency by permit, rule substitution).

What Are the Operating Limitations?

In addition to the standards discussed above, EPA is finalizing operating limitations for stationary non-emergency CI RICE that are greater than 500 HP. Owners and operators of engines that are equipped with oxidation catalyst must maintain the catalyst so that the pressure drop across the catalyst does not change by more than 2 inches of water from the pressure drop across the catalyst that was measured during the initial performance test. Owners and operators of these engines must also maintain the temperature of the stationary RICE exhaust so that the catalyst inlet temperature is between 450 and 1350 degrees Fahrenheit (°F). Owners and operators may petition for a different temperature range; the petition must demonstrate why it is operationally necessary and appropriate to operate below the temperature range specified in the rule (see 40 CFR 63.8(f)). Owners and operators of engines that are not using oxidation catalyst must comply with any operating limitations approved by the Administrator.

Owners and operators of existing stationary non-emergency CI engines greater than 300 HP meeting the requirement to use open or closed crankcases must follow the manufacturer's specified maintenance requirements for operating and maintaining the open or closed crankcase ventilation systems and replacing the crankcase filters, or can request the Administrator to approve different maintenance requirements that are as protective as manufacturer requirements.

*4.2.3.5 Fuel Requirements*

In addition to emission standards and management practices, certain stationary CI RICE located at existing area sources are subject to fuel requirements. These fuel requirements are being finalized in order to reduce the potential formation of sulfate compounds that are emitted when high sulfur diesel fuel is used in combination with oxidation catalysts and to assist in the efficient operation of the oxidation catalysts. Thus, owners and operators of stationary nonemergency diesel-fueled CI engines greater than 300 hp with a displacement of less than 30 liters per cylinder located at existing area sources must only use diesel fuel meeting the requirements of 40 CFR 80.510(b), which requires that diesel fuel have a maximum sulfur content of 15 ppm and either a minimum cetane index of 40 or a maximum aromatic content of 35 volume percent.

### ***4.2.4 What Are the Requirements for Demonstrating Compliance?***

The following sections describe the requirements for demonstrating compliance under the final rule.

*4.2.4.1 Existing Stationary CI RICE at Major Sources*

Owners and operators of existing stationary nonemergency CI RICE located at major sources that are less than 100 hp and stationary emergency CI RICE located at major sources must operate and maintain their stationary RICE and after-treatment control device (if any) according to the manufacturer’s emission-related written instructions or develop their own maintenance plan. Owners and operators of existing stationary nonemergency CI RICE located at major sources that are less than 100 hp and existing stationary emergency CI RICE located at major sources do not have to conduct any performance testing because they are not subject to numerical emission standards.

Owners and operators of existing stationary nonemergency CI RICE located at major sources that are greater than or equal to 100 hp and less than or equal to 500 hp must conduct an initial performance test to demonstrate that they are achieving the required emission standards.

Owners and operators of existing stationary nonemergency CI RICE greater than 500 hp located at major sources must conduct an initial performance test and must test every 8,760 hours of operation or 3 years, whichever comes first, to demonstrate that they are achieving the required emission standards.

Owners and operators of stationary nonemergency CI RICE that are greater than 500 hp and are located at a major source must continuously monitor and record the catalyst inlet temperature if an oxidation catalyst is being used on the engine. The pressure drop across the catalyst must also be measured monthly. If an oxidation catalyst is not being used on the engine, the owner or operator must continuously monitor and record the operating parameters (if any) approved by the Administrator.

*4.2.4.2 Existing Stationary RICE at Area Sources*

Owners and operators of existing stationary RICE located at area sources that are subject to management practices, as shown in Table 4-2, must develop a maintenance plan that specifies how the management practices will be met. Owners and operators of existing stationary RICE that are subject to management practices do not have to conduct any performance testing.

Owners and operators of existing stationary nonemergency CI RICE greater than 300 hp that are located at area sources must conduct an initial performance test to demonstrate that they are achieving the required emission standards.

Owners and operators of existing stationary nonemergency RICE that are greater than 500 hp and located at area sources must conduct an initial performance test and must test every 8,760 hours of operation or 3 years, whichever comes first, to demonstrate that they are achieving the required emission standards.

Owners and operators of existing stationary nonemergency CI RICE that are greater than 500 hp and are located at an area source must continuously monitor and record the catalyst inlet temperature if an oxidation catalyst is being used on the engine. The pressure drop across the catalyst must also be measured monthly. If an oxidation catalyst is not being used on the engine, the owner or operator must continuously monitor and record the operating parameters (if any) approved by the Administrator.

On October 9, 2008 (73 FR 59956), EPA proposed performance specification requirements for continuous parametric monitoring systems (CPMS). Currently there are no performance specifications for the CPMS that are required for continuously monitoring the catalyst inlet temperature. The timetable for finalizing the proposed performance specification requirements is uncertain; therefore, EPA plans to finalize performance specification requirements in 40 CFR part 63, subpart ZZZZ for the CPMS systems used for continuous catalyst inlet temperature monitoring when the final requirements are promulgated for existing SI engines in August 2010.

2. Existing Stationary RICE at Area Sources

Owners and operators of existing stationary RICE located at area sources that are subject to management practices, as shown in Table 4-2, must develop a maintenance plan that specifies how the management practices will be met. Owners and operators of existing stationary RICE that are subject to management practices do not have to conduct any performance testing.

Owners and operators of existing stationary non-emergency CI RICE that are greater than 300 HP and located at area sources and are not limited use stationary RICE must conduct an initial performance test to demonstrate that they are achieving the required emission standards. Owners and operators of existing stationary non-emergency CI RICE that are greater than 500 HP and located at area sources and are limited use stationary RICE must conduct an initial performance test and must test every 8,760 hours of operation or 5 years, whichever comes first, to demonstrate that they are achieving the required emission standards.

Owners and operators of existing stationary non-emergency RICE that are greater than 500 HP and located at area sources must conduct an initial performance test and must test every 8,760 hours of operation or 3 years, whichever comes first, to demonstrate that they are achieving the required emission standards.

Owners and operators of existing stationary non-emergency CI RICE that are greater than 500 HP and are located at an area source must continuously monitor and record the catalyst inlet temperature if an oxidation catalyst is being used on the engine. The pressure drop across the catalyst must also be measured monthly. If an oxidation catalyst is not being used on the engine, the owner or operator must continuously monitor and record the operating parameters (if any) approved by the Administrator.

### *4.2.5 What Are the Reporting and Recordkeeping Requirements?*

The following sections describe the reporting and recordkeeping requirements that are required under the final rule.

Owners and operators of existing stationary emergency RICE that do not meet the requirements for nonemergency engines are required to keep records of their hours of operation. Owners and operators of existing stationary emergency RICE must install a non-resettable hour meter on their engines to record the necessary information. The information must include how many hours are spent for emergency operation, including what classified the operation as emergency and how many hours are spent for nonemergency operation.

Emergency stationary RICE may be operated for the purpose of maintenance checks and readiness testing, provided that the tests are recommended by the Federal, State or local government, the manufacturer, the vendor, or the insurance company associated with the engine. Maintenance checks and readiness testing of such units are limited to 100 hours per year. Owners and operators can petition the Administrator for additional hours, beyond the allowed 100 hours per year, if such additional hours should prove to be necessary for maintenance and testing reasons. A petition is not required if the engine is mandated by regulation such as State or local requirements to run more than 100 hours per year for maintenance and testing purposes. There is no time limit on the use of emergency stationary engines in emergency situations; however, the owner or operator is required to record the length of operation and the reason the engine was in operation during that time. Records must be maintained documenting why the engine was operating to ensure the 100 hours per year limit for maintenance and testing operation is not exceeded. In addition, owners and operators are allowed to operate their stationary emergency RICE for nonemergency purposes for 50 hours per year, but those 50 hours are counted towards the total 100 hours provided for operation other than for true emergencies and owners and operators may not engage in income-generating activities during those 50 hours. The 50 hours per year for nonemergency purposes cannot be used to generate income for a facility, for example, to supply power to an electric grid or otherwise supply power as part of a financial arrangement with another entity. However, owners and operators may operate the emergency engine for a maximum of 15 hours per year as part of an emergency demand response program if the utility distribution company has determined that a blackout is imminent. The engine operation must be terminated immediately after the utility distribution company advises that a blackout is no longer imminent. The 15 hours per year of emergency demand response operation are counted as part of the 50 hours of operation per year provided for nonemergency situations. Owners and operators must keep records showing how they were notified of the emergency condition and by whom, and the time that the engine was operated as part of demand response.

Owners and operators of existing stationary RICE located at area sources that are subject to management practices as shown in Table 4-2, are required to keep records that show that management practices that are required are being met. These records must include, at a minimum: oil and filter change dates, oil amounts added and corresponding hour on the hour meter, fuel consumption rates, air filter (if applicable) change dates, records of repairs and other maintenance performed.

Owners and operators of existing non-emergency stationary CI RICE greater than 300 HP must keep records of the manufacturer's recommended maintenance procedures for the closed crankcase ventilation system or open crankcase filtration system and records of the maintenance performed on the system.

In terms of reporting requirements, owners and operators of existing stationary RICE, except stationary RICE that are less than 100 hp, existing emergency stationary RICE, and existing stationary RICE that are not subject to numerical emission standards, must submit all of the applicable notifications as listed in the NESHAP General Provisions (40 CFR part 63, subpart A), including an initial notification, notification of performance test, and a notification of compliance for each stationary RICE which must comply with the specified emission limitations.

## 4.3 Summary of Significant Changes Since Proposal

Most of the rationale used to develop the proposed rule remains the same for the final rule. Therefore, the rationale previously provided in the preamble to the proposed rule is not repeated in the final rule, and the rationale sections of the rule, as proposed, should be referred to. Major changes that have been made to the rule since proposal are discussed in this section with rationale following in the Summary of Responses to Comments report that is in the docket for this rulemaking.

### *4.3.1 Applicability*

EPA proposed to regulate HAP emissions from existing stationary engines less than or equal to 500 hp located at major sources and all existing stationary engines located at area sources. EPA also proposed NESHAP for existing stationary CI engines greater than 500 hp that are located at major sources.

In the final rule, EPA is only regulating HAP emissions from existing stationary CI engines. EPA will address HAP emissions from existing stationary SI engines in a separate rulemaking later this year.

Another change from the proposal is that the final rule is not applicable to existing stationary emergency engines at area sources that are located at residential, commercial, or institutional facilities. These engines are not subject to any requirements under the final rule because they are not part of the regulated source category. EPA has found that existing emergency engines located at residential, commercial, and institutional facilities were not included in the original Urban Air Toxics Strategy inventory and were not included in the listing of urban area sources. More information on this issue can be found in the memorandum entitled "Analysis of the Types of Engines Used to Estimate the CAA Section 112(k) Area Source Inventory for Stationary Reciprocating Internal Combustion Engines," available from the rulemaking docket.

### *4.3.2 Final Emission Limits*

#### *4.3.2.1 Existing Stationary CI Engines <100 hp Located at Major Sources*

For the proposed rule, EPA required existing stationary engines less than 50 hp that are located at major sources to meet a formaldehyde emission standard that was based on the levels achievable without aftertreatment. Based on comments received including the feasibility of being able to achieve the proposed emission standard and being able to measure formaldehyde emissions of that magnitude, EPA is not finalizing a formaldehyde emission standard for this group of engines. In addition, in light of several comments asserting that the cutoff for requiring emission standards for engines less than 50 hp at major sources was inappropriate, EPA is finalizing a threshold of 100 hp.

In the proposed rule, existing stationary CI engines less than 100 HP located at major sources were required to meet a 40 ppmvd CO at 15 percent oxygen ($O_2$) standard. In the final rule, all existing stationary CI engines less than 100 HP located at major sources must meet work practices. These work practices are described in section III.C. of the preamble. EPA believes that work practices are appropriate and justified for this group of stationary engines because the application of measurement methodology is not practicable due to technological and economic limitations. Further information on EPA's decision can be found in the memorandum entitled "MACT Floor Determination for Existing Stationary Non-Emergency CI RICE Less Than 100 HP and Existing Stationary Emergency CI RICE Located at Major Sources and GACT for Existing Stationary CI RICE Located at Area Sources," which is available from the rulemaking docket.

#### *4.3.2.2 Existing Stationary Nonemergency CI Engines 100≤hp≤300 Located at Major Sources*

EPA is finalizing a CO emission standard for existing nonemergency CI engines greater than or equal to 100 hp and less than or equal to 300 hp located at major sources based on levels achieved without add-on control. All existing stationary CI engines less than or equal to 300 hp located at major sources must meet a 157 ppmvd CO at 15 percent $O_2$ standard. EPA revised the proposed CO standard for this group of engines based on additional information received after the proposal, which led to a reevaluation of the MACT floor for these engines. A discussion of the final MACT floor determination can be found in the memo entitled "Subcategorization and MACT Floor Determination for Existing Stationary CI Reciprocating Internal Combustion Engines at Major Sources," which is available from the rulemaking docket. All existing stationary CI engines less than or equal to 300 hp located at area sources, both emergency and nonemergency, are subject to management practice standards under the final rule, as was proposed.

*4.3.2.3 Existing Stationary Nonemergency CI Engines >300 hp*

EPA proposed that existing stationary nonemergency CI engines greater than 300 hp meet a 4 ppmvd at 15 percent $O_2$ CO standard or a 90 percent CO reduction standard. Numerous commenters indicated that EPA's dataset was insufficient and urged EPA to gather more data to obtain a more complete representation of emissions from existing stationary CI engines. Commenters also questioned the emission standard setting approach that EPA used at proposal and claimed that the proposed standards did not take into account emissions variability and may not be achievable. For the final rule EPA has obtained additional test data for existing stationary CI engines and has included this additional in the MACT floor analysis. EPA is also using an approach that better considers emissions variability as well.

In the final rule, EPA is providing owners and operators the option of meeting either a CO concentration or a CO percent reduction standard. Owners and operators of existing stationary non-emergency CI engines greater than 300 HP and less than or equal to 500 HP located at major and area sources must either reduce CO emissions by at least 70 percent or limit the concentration of CO in the engine exhaust to 49 ppmvd, at 15 percent $O_2$. Owners and operators of existing stationary non-emergency CI engines greater than 500 HP located at major and area sources must either reduce CO emissions by at least 70 percent or limit the concentration of CO in the engine exhaust to 23 ppmvd, at 15 percent $O_2$. EPA's review of the data indicate that it is appropriate to base the MACT standard on a reduction level of 70 percent, which takes into account the variability of the emission reduction efficiency of aftertreatment under various operational conditions.

*4.3.2.4 Existing Stationary Emergency CI Engines 100≤hp≤500 Located at Major Sources*

For existing stationary emergency engines located at major sources, we proposed that these engines be subject to a 40 ppmvd CO at 15 percent $O_2$ standard. In the final rule, existing stationary emergency CI engines greater than or equal to 100 HP and less than or equal to 500 HP and located at major sources must meet work practices. These work practices are described in section III.C. of the preamble. EPA believes that work practices are appropriate and justified for this group of stationary engines because the application of measurement methodology is not practicable due to technological and economic limitations. Further information on EPA's decision can be found in the memorandum entitled "MACT Floor Determination for Existing Stationary Non-Emergency CI RICE Less Than 100 HP and Existing Stationary Emergency CI RICE Located at Major Sources and GACT for Existing Stationary CI RICE Located at Area Sources," which is available from the rulemaking docket.

*4.3.2.5 Existing Stationary Emergency CI Engines >500 hp Located at Area Sources*

For existing stationary emergency engines located at area sources, EPA reevaluated the information available for emergency engines and considered extensive input received from industry and other groups who asserted that the proposed standards were not GACT for emergency engines at area sources.

In the final rule, all existing stationary emergency CI engines located at area sources must meet management practice standards.

### *4.3.3 Management Practices*

EPA proposed management practices for several subcategories of engines located at area sources. EPA explained that the proposed management practices would be expected to ensure that emission control systems are working properly and would help minimize HAP emissions from the engines. EPA proposed specific maintenance practices and asked for comments on the need and appropriateness for those procedures. Based on feedback received during the public comment period, which included information submitted in comment letters and additional information EPA specifically asked for following the close of the comment period from different industry groups, EPA is finalizing management practices for existing stationary nonemergency CI engines less than or equal to 300 hp located at area sources and all existing emergency stationary CI engines located at area sources.

Existing stationary nonemergency CI engines less than or equal to 300 hp located at area sources are required to change the oil and filter every 1,000 hours of operation or annually, whichever comes first, inspect air cleaner every 1,000 hours of operation or annually, whichever comes first, and inspect all hoses and belts every 500 hours of operation or annually, whichever comes first, and replace as necessary. EPA is adding an option for sources to use an oil change analysis program to extend the oil change frequencies specified above. The analysis program must at a minimum analyze the following three parameters: Total Base Number, viscosity, and percent water content. If any of the limits below are exceeded, the engine owner or operator must change the oil before continuing to operate the engine. The condemning limits are as follows:

- Total Base Number is less than 30 percent of the Total Base Number of the oil when new; or
- viscosity of the oil has changed by more than 20 percent from the viscosity of the oil when new; or
- percent water content (by volume) is greater than 0.5.

Owners and operators of all engines subject to management practices also have the option work with state permitting authorities pursuant to EPA's regulations at 40 CFR subpart E for alternative maintenance practices to be used instead of the specific maintenance practices promulgated in this rule. The maintenance practices must be at least as stringent as those specified in the final rule.

The final rule specifies that in situations where an emergency engine is operating during an emergency and it is not possible to shut down the engine in order to perform the work or management practice requirements on the schedule required in the final rule, or if performing the work or management practice on the required schedule would otherwise pose an unacceptable risk under federal, state, or local law, the maintenance activity can be delayed until the emergency is over or the unacceptable risk under federal, state, or local law has abated. The maintenance should be performed as soon as practicable after the emergency has ended or the unacceptable risk under federal, state, or local law has abated. Sources must report any failure to perform the work practice on the schedule required and the federal, state or local law under which the risk was deemed unacceptable.

#### *4.3.3.1 Startup, Shutdown and Malfunction*

EPA proposed formaldehyde and CO emission standards for existing stationary engines at major sources to apply during periods of startup and malfunction. EPA also proposed certain standards for existing stationary engines at area sources that would apply during startup and malfunction. Based on various comments and concerns with the proposed emission standards for periods of startup, EPA has determined that it is not feasible to finalize numerical emission standards that would apply during startup because the application of measurement methodology to this operation is not practicable due to technological and economic limitations. As a result, EPA is promulgating operational standards during startup that specify that owners and operators must limit the engine startup time to no more than 30 minutes and must minimize the engine's time spent at idle during startup. Based on information reviewed by EPA, engine startup typically requires no more than 30 minutes. We received comments indicating that there are conditions where it may take more than 30 minutes to startup the engine, for example for cold starts or where the ambient conditions are very cold. However, commenters did not provide enough specificity in their comments, nor did commenters provide data, to determine whether any scenarios were appropriate to allow a longer startup period. Owners and operators of engines at major sources have the option to petition the Administrator pursuant to 40 CFR 63.6(g) for alternative work practices. Any petition must be based on specific factual information indicating the reason the alternative work practice is necessary for that engine and is no less stringent than start-up requirements in the rule. An owner or operator of an engine at an area source can work with its state permitting authority pursuant to EPA's regulations at 40 CFR subpart E for approval of an alternative management practice, based on specific factual information indicating the reason that a longer period is necessary for that engine. Such alternative management practice must be demonstrated to be no less stringent than EPA promulgated standards.

As discussed further below, EPA is not setting separate standards for malfunctions in this rule. Therefore, the standards that apply during normal operation also apply during malfunction. EPA believes that any emissions occurring during a malfunction would be of such a short duration compared to the emissions averaged during overall testing time (three one-hour runs) that the engine would still be able to comply with the emission standard. In addition, EPA does not view malfunction as a distinct operating mode and, therefore, any emissions that occur at such times do not need to be taken into account in setting CAA section 112(d) standards. Further, as is explained in more detail in Section V.D. of the preamble, even if malfunctions were considered a distinct operating mode, we believe it would be impracticable to take into account malfunctions in setting CAA section 112(d) standards.

*4.3.3.2 Other*

EPA is including an additional requirement in the final rule that will reduce metallic HAP emissions. Owners and operators of existing stationary non-emergency CI engines greater than 300 HP must do one of the following if the engine is not already equipped with a closed crankcase ventilation system: 1) install a closed crankcase ventilation system that prevents crankcase emissions from being emitted to the atmosphere, or 2) install an open crankcase filtration emission control system that reduces the crankcase emissions by filtering the exhaust stream to remove oil mist, particulates, and metals. Owners and operators must follow the manufacturer's specified maintenance requirements for operating and maintaining the open or closed crankcase ventilation systems and replacing the crankcase filters, or can request the Administrator to approve different maintenance requirements that are as protective as manufacturer requirements.

EPA is including special provisions in the final rule for existing stationary non-emergency CI RICE greater than 300 HP located at area sources in Alaska not accessible by the FAHS. Owners and operators of these engines do not have to meet the CO emission standards specified in Table 4-2, but must instead meet the management practices that are described for stationary non-emergency CI RICE less than or equal to 300 HP in section III.C. of the preamble.

The final rule specifies that stationary CI engines that are used to startup combustion turbines should meet the same requirements as stationary emergency CI engines.

## 4.4 Cost Impacts

### *4.4.1 Introduction*

The cost impacts associated with the final rule consist of different types of costs, which include the annual and capital costs of controls, costs associated with keeping records of information necessary to demonstrate compliance, costs associated with reporting requirements under the General Provisions of 40 CFR part 63, subpart A, costs of purchasing and operating equipment associated with continuous parametric monitoring, and the cost of conducting performance testing to demonstrate compliance with the emission standards. The capital and annual costs presented in this section are calculated based on the control cost methodology presented in the EPA (2002) Air Pollution Control Cost Manual prepared by the U.S. Environmental Protection Agency.[2] This methodology sets out a procedure by which capital and annualized costs are defined and estimated, and this procedure is often used to estimate the costs of rulemakings such as this one. The capital costs presented in this section are annualized using a 7% interest rate, a rate that is consistent with the guidance provided in the Office of Management and Budget's (OMB's) (2003) Circular A-4.[3] The following sections describe how the various cost elements were estimated.

[2] Available on the Internet at http://epa.gov/ttn/catc/products.html#cccinfo.
[3] Available on the Internet at http://www.whitehouse.gov/omb/circulars/a004/a-4.pdf.

*4.4.1.1 Control Costs*

For engines that will need to add control technology to meet the emission standards, the following equations were used to estimate capital and annual control costs as shown in Table 4-3:

**Table 4-3**: **CI RICE Control Technologies and Costs**

| Technology | Capital Cost ($2008) | Annual Cost ($2008) |
|---|---|---|
| Diesel oxidation catalyst (DOC) | $27.4 x hp − $939 | $4.99 x hp + $480 |
| Open crankcase ventilation (OCV) | $0.26 x hp + $997 | $0.065 x hp + $254 |

The control costs for DOC were calculated using cost data obtained from a California Air Resources Board (CARB) study.[4] The study provided cost ranges for diesel engines ranging from 40 hp to 1400 hp. The average cost from the range was selected and was adjusted to 2008 dollars. The capital and annual cost were calculated using maintenance data from the CARB study and cost assumptions from the EPA Air Pollution Control Cost Manual. The control costs for the OCV system were calculated using 2008 cost data obtained from a diesel engine equipment vendor. An equipment life of 10 years was used to calculate the capital recovery factor (CRF) for developing the annual cost for each of the control devices. A linear regression equation was developed for the capital cost of the DOC and OCV using the capital cost data and the engine size in horsepower (hp). This approach was used to develop a linear regression equation for annual cost.

*4.4.1.2 Recordkeeping*

No recordkeeping costs were attributed to the requirement of following the manufacturer’s emission-related operation and maintenance (O&M) requirements or the owner or operator’s own maintenance plan. It is expected that the majority of owners and operators are already following some type of O&M requirements and minimal to no additional burden is expected. Labor costs associated with recording the hours of operation of emergency engines are based on a technical labor rate of $68 per hour which was obtained from the Department of Labor Statistics web site.[5] The final total wage rate was based on the 2005 compensation rates for professional staff and adjusted by an overhead and profit rate of 167 percent. The year 2005 was used for consistency in order to have the same basis for all costs. All costs were later converted to 2008 dollars for purposes of presenting costs associated with the rule in present day

[4]Diesel PM Control Technologies, Appendix IX, California Air Resource Board, October 2000. http://www.arb.ca.gov/diesel/documents/rrpapp9.pdf

[5]U.S. Department of Labor, Employer Costs for Employee Compensation, http://www.bls.gov/news.release/ecec.toc.htm

terms. One hour per year is expected to be sufficient to record hours of operation for stationary emergency engines. No cost is attributed to purchasing and installing an hour-meter since the majority of stationary engines already come equipped with such equipment. For owner/operators of nonemergency CI engines, EPA assumed that one hour per year was sufficient for recordkeeping for these engines.

*4.4.1.3 Reporting*

Most engines affected by this rule will be subject to reporting requirements such as reading instructions, training personnel, submitting an initial notification, submitting a notification of performance test(s), and submitting a compliance report. . However, owners and operators of engines less than 100 HP, existing stationary emergency engines, and existing stationary engines less than 300 HP located at area sources are not subject to any specific reporting requirements. . For stationary non-emergency limited use CI engines that operate less than 100 hours per year, EPA is finalizing less burdensome reporting requirements by requiring these engines to submit compliance reports on an annual basis, as opposed to semiannually as is required for other engines subject to numerical emission limitations. The reporting requirements are based on $68 per hour for technical labor to comply with the reporting requirements. It is estimated that a total of 14 hours will be needed, and 13 hours for limited use engines.

*4.4.1.4 Monitoring*

The cost of monitoring includes the purchase of a continuous parametric monitoring system (CPMS). Nonemergency engines greater than 500 hp that have add-on controls are required to use a CPMS to monitor the catalyst inlet temperature and pressure drop across the catalyst to ensure those parameters do not exceed the operating limitations. The cost of purchasing and operating a CPMS was obtained from vendor quotes received for previous rulemaking and adjusted to 2008 dollars.[6] The capital cost of a CPMS for a large engine facility is $531. It is estimated that 30 hours per year is necessary to operate and maintain the CPMS and that 6 hours per year (or 0.5 hours per month) is needed to record information from the CPMS. It is assumed that all engines subject to continuous monitoring would be located at large engine facilities.

*4.4.1.5 Performance Testing*

Initial performance testing is required for nonemergency engines greater than 100 hp at major sources and nonemergency engines greater than 300 hp located at area sources. The cost of

[6]Part A of the Supporting Statement for Standard Form 83 Stationary Reciprocating Internal Combustion Engines, November 17, 2003.

conducting a performance test on a CI engine is based on cost information gathered for previous rulemakings.[7] The performance testing cost is based the use of a portable analyzer and was estimated to cost $1,000 per day of testing. This daily performance test cost was adjusted to 2008 dollars and was estimated to be $1,165. Because the regulation requires three-1 hour runs, EPA assumed that two engines could be tested at each facility in one day. Therefore, the estimated impacts performance testing cost will be assumed to be $583 per engine (or half of the $1,165 daily cost) using a portable analyzer.

*4.4.1.6 Work Practices*

The costs for performing work practices for CI engines less than 100 hp located at a major source was assumed to be negligible and were not included in these impact calculations. The work practices are based on engine maintenance procedures that the owner/operators perform regardless of the regulation. These work practices include:

- Changing the oil and filter;
- Inspecting the air cleaner;
- Inspecting all hoses and belts, and replacing as necessary.

EPA believes that these work practices will limit HAP emissions from these engines, because these work practices ensure that the engine is operating efficiently. Owner/operators of these engines regularly perform these work practices as part of the preventive maintenance schedule for the engine. Therefore, EPA believes that it is appropriate to not include these work practice costs in the impacts determination.

*4.4.1.7 Management Practices*

The costs for performing management practices for nonemergency CI engines less than or equal to 300 hp located at area sources and all emergency engines located at area sources was assumed to be negligible and were not included in these impact calculations. The management practices are based on engine maintenance procedures that the owner/operators perform regardless of the regulation. These management practices include:

- Changing the oil and filter;
- Inspecting the air cleaner; and
- Inspecting all hoses and belts, and replacing as necessary.

---

[7]Memorandum from Bradley Nelson, Alpha-Gamma Technologies, Inc. to Sims Roy, EPA/OAQPS/ESD/Combustion Group, Portable Emissions Analyzer Cost Information, August 31, 2005.

EPA believes that these work practices will limit HAP emissions from these engines, because these work practices ensure that the engine is operating efficiently. Owner/operators of these engines regularly perform these work practices as part of the preventive maintenance schedule for the engine. Therefore, EPA believes that it is appropriate to not include these work practice costs in the impacts determination.

### *4.4.2 Major Sources*

The cost impacts for stationary RICE vary depending on the engine type and size. The following sections describe the specific costs that apply to each subcategory of CI engines located at major sources.

#### *4.4.2.1 All CI Engines hp < 100*

The costs associated with CI engines less than 100 hp include minimal requirements. Owners and operators of engines less than 100 hp are required to follow the manufacturer's emission-related O&M requirements or must develop their own maintenance plan to follow. Emergency engines must record the hours of operation, which is estimated at one hour per year at $72 per hour.

#### *4.4.2.2 Nonemergency CI Engines 100 ≤ hp ≤ 300 hp*

The costs associated with nonemergency CI engines greater than or equal to 100 hp and less than or equal to 300 hp include the cost of an initial test, recordkeeping, and reporting. In addition, EPA assumes that some of these engines will be required to install a control device to meet the emissions standard. To estimate the number of CI engines that would be required to install control technology, EPA compared the emission rate of the test that was used to determine the MACT floor with the CI nonroad emission factors.[8] EPA found that only the emission factors for Tier 0 CI engines were greater than the 1.2 g/hp-hr value that was used to set the MACT floor. Therefore, it was assumed that Tier 1 engines and greater would be able to meet the final emission standard. The model year for Tier 1 engines begins in 1997 for 100 to 175 CI engines, and 1996 for 175 to 300 hp CI engines. Using the model year data in the population memorandum, EPA estimated that 35 percent of the existing CI engines greater than or equal to 100 hp and less than or equal to 300 hp are Tier 0 engines and would need to install control technology to meet the emission standard. The cost estimates for this subcategory of engines do not account for possible fuel price increases that may result from using ultra-low sulfur diesel (ULSD). EPA estimated the cost of lubricity additives to ULSD would increase the cost of the

[8] Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling--Compression-Ignition, U.S. EPA, Office of Transportation and Air Quality, Assessment and Standards Division, EPA420-P-04-009, Revised April 2004. http://www.epa.gov/oms/models/nonrdmdl/nonrdmdl2004/420p04009.pdf

fuel by 0.2 cents per gallon,[9] which EPA believes is negligible. In addition, there are no additional maintenance requirements for owner/operators using ULSD in existing diesel engines. Many owner/operators have found that time between oil changes can be extended for engines using ULSD fuel, which would decrease the overall cost of switching to ULSD fuel. Therefore, EPA believes that it is appropriate to not include any costs for switching to ULSD in the impacts for this NESHAP.

*4.4.2.2 Nonemergency CI Engines > 300 hp*

The costs associated with nonemergency CI engines above 300 hp include the cost of installing and operating an oxidation catalyst for reducing HAP, as well as the cost of installing an open crankcase ventilation system. Nonemergency CI engines greater than 500 hp are also subject to continuous monitoring requirements. In addition, owners and operators must conduct an initial performance test to demonstrate compliance with the emission limitation. Owners and operators of engines above 500 hp must conduct subsequent performance testing every 8,760 hours or 3 years, whichever comes first to demonstrate compliance. The cost estimates for this subcategory of engines do not account for possible fuel price increases that may result from using ultra-low sulfur diesel (ULSD). EPA estimated the cost of lubricity additives to ULSD would increase the cost of the fuel by 0.2 cents per gallon,[10] which EPA believes is negligible. In addition, there are no additional maintenance requirements for owner/operators using ULSD in existing diesel engines. Many owner/operators have found that time between oil changes can be extended for engines using ULSD fuel, which would decrease the overall cost of switching to ULSD fuel. Therefore, EPA believes that it is appropriate to not include any costs for switching to ULSD in the impacts for this NESHAP.

*4.4.2.3 Emergency CI Engines*

The costs associated with emergency CI engines greater than 300 hp and less than or equal to 500 hp (emergency CI engines above 500 hp were subject to an earlier rule and are not subject to further regulation in this rule) include minimal recordkeeping requirements. The owners and operators must follow the manufacturer's emission-related operating and maintenance (O&M) requirements or must develop their own maintenance plan to follow and must also keep records of the hours of operation. It is estimated that one hour per year at $68 per hour would be sufficient to record the hours of operation. No costs were included in the impacts

[9] Memorandum from Melanie Taylor and Brad Nelson, AGTI to Sims Roy, EPA OAQPS ESD Combustion Group, Lubricity of Ultra Low Sulfur Diesel Fuel, June 2, 2004.

[10] Memorandum from Melanie Taylor and Brad Nelson, AGTI to Sims Roy, EPA OAQPS ESD Combustion Group, Lubricity of Ultra Low Sulfur Diesel Fuel, June 2, 2004.

for following the manufacturer's emission-related O&M plan, because it is expected that owner/operators will follow this plan regardless of the regulation.

### *4.4.3 Area Sources*

#### *4.4.3.1 All Emergency CI Engines*

The costs associated with emergency CI engines include recordkeeping requirements for tracking the hours of operation, but these engines are not subject to any performance testing. The owners and operators must follow the manufacturer's emission-related O&M requirements or must develop their own maintenance plan to follow. It is estimated that one hour per year at $68 per hour would be sufficient to record the hours of operation. Emergency CI engines at areas sources will be subject to management practices, rather numerical emission limits. The management practices do not require aftertreatment controls. Therefore, no control costs have been estimated for these engines. These engines will be subject to management practices which are not included in the costs, because it is assumed that these management practices are performed regardless of the regulation.

#### *4.4.3.2 Nonemergency CI Engines ≤ 300 hp*

The costs associated with nonemergency CI engines less than or equal to 300 hp are minimal and only include following the manufacturer's emission-related O&M requirements or the owner or operator's own maintenance plan. These engines are not subject to any numerical emission limitations, therefore no control costs apply and no performance testing is required. These engines will be subject to management practices which are not included in the costs, because it is assumed that these management practices are done regardless of the regulation.

#### *4.4.3.3 Nonemergency CI Engines > 300 hp*

The costs associated with nonemergency CI engines above 300 hp include the cost of installing and operating an oxidation catalyst for reducing HAP, as well as the cost of installing an open crankcase ventilation system. Nonemergency CI engines greater than 500 hp are also subject to continuous monitoring requirements. In addition, owners and operators must conduct an initial performance test to demonstrate compliance with the emission limitation and engines above 500 hp must conduct subsequent performance testing every 8,760 hours or 3 years, whichever comes first. The cost estimates for this subcategory of engines do not account for possible fuel price increases that may result from using ultra-low sulfur diesel. The cost estimates for this subcategory of engines do not account for possible fuel price increases that may result from using ultra-low sulfur diesel (ULSD). EPA estimated the cost of lubricity additives to ULSD would increase the cost of the fuel by 0.2 cents per gallon, which EPA believes is negligible. In addition, there are no additional maintenance requirements for owner/operators using ULSD in existing diesel engines. Many owner/operators have found that time between oil changes can be extended for engines using ULSD fuel, which would decrease the overall cost of switching to ULSD fuel. Therefore, EPA believes that it is appropriate to not include any costs for switching to ULSD in the impacts for this NESHAP.

A summary of the total costs associated with the rule by major source and area source categories is found in Table 4-4. A summary of the costs by NAICS codes is found in Table 4-5. Table 4-6 provides a summary of costs by engine size, and a presentation of the number of engines by engine size is in Table 4-7. All cost estimates are from "Impacts Associated with NESHAP for Existing Stationary CI RICE," prepared by Bradley Nelson, Ec/R, Inc. for Melanie King, U.S. EPA, Office of Air Quality Planning and Standards, February 17, 2010.

## Table 4-4. Summary of Major Source and Area Source Costs for the CI RICE NESHAP[a]

| Size Range (hp) | Non-Emergency CI Capital Control Cost | Non-Emergency CI Annual Control Cost | Initial Test | Recordkeeping | Reporting | Monitoring – Capital Cost | Monitoring – Annual Cost | Total Annual Costs | Total Capital Costs |
|---|---|---|---|---|---|---|---|---|---|
| **Major Sources** | | | | | | | | | |
| 50–100 | $0 | $0 | $0 | $6,654,888 | $0 | $0 | $0 | $6,654,888 | $0 |
| 100–175 | $24,057,778 | $9,918,465 | $14,150,269 | $8,719,731 | $6,103,812 | $0 | $0 | $38,892,276 | $24,057,778 |
| 175–300 | $35,917,270 | $10,740,189 | $10,730,759 | $6,612,548 | $4,628,784 | $0 | $0 | $32,712,281 | $35,917,270 |
| 300–500 | $107,841,136 | $26,722,727 | $5,645,923 | $3,479,152 | $2,435,406 | $0 | $0 | $38,283,208 | $107,841,136 |
| 500–600 | $13,126,952 | $3,020,849 | $500,530 | $61,688 | $215,907 | $481,765 | $2,220,755 | $6,019,729 | $13,608,716 |
| 600–750 | $8,240,540 | $1,824,295 | $256,204 | $31,576 | $110,515 | $246,599 | $1,136,729 | $3,359,319 | $8,487,139 |
| >750 | $26,903,091 | $5,618,803 | $565,163 | $69,653 | $243,787 | $543,975 | $2,507,521 | $9,004,927 | $27,447,066 |
| Total | $216,086,768 | $57,845,329 | $31,848,848 | $25,629,236 | $13,738,210 | $1,272,338 | $5,865,005 | $134,926,628 | $217,359,106 |
| **Area Sources** | | | | | | | | | |
| 50–100 | $0 | $0 | $0 | $9,183,746 | $0 | $0 | $0 | $9,183,746 | $0 |
| 100–175 | $0 | $0 | $0 | $12,033,196 | $9,155,692 | $0 | $0 | $17,265,000 | $0 |
| 175–300 | $0 | $0 | $0 | $9,125,316 | $6,943,176 | $0 | $0 | $13,092,845 | $0 |
| 300–600 | $272,814,082 | $65,640,094 | $12,703,298 | $7,201,827 | $5,362,230 | $4,075,682 | $18,787,376 | $109,694,825 | $276,889,764 |
| 600–750 | $68,490,125 | $15,162,379 | $2,129,405 | $1,207,215 | $898,850 | $683,191 | $8,952,336 | $28,350,186 | $69,173,315 |
| >750 | $179,573,835 | $37,504,615 | $3,772,372 | $2,138,655 | $1,592,368 | $1,210,315 | $15,859,613 | $60,867,624 | $180,784,150 |
| Total | $520,878,041 | $118,307,088 | $18,605,076 | $40,889,956 | $17,052,802 | $5,969,187 | $43,599,324 | $238,454,245 | $526,847,229 |
| **Grand Total** | | | | | | | | | |
| **Total** | **$736,964,809** | **$176,152,417** | **$50,453,924** | **$66,519,191** | **$30,496,622** | **$7,241,526** | **$49,464,330** | **$373,086,483** | **$744,206,335** |

[a] Costs are presented in 2008 dollars.

## Table 4-5. Summary of Major Source and Area Source NAICS Costs for the CI RICE NESHAP[a]

| NAICS | Major Source | | Area Source | | Total (Major + Area) | |
|---|---|---|---|---|---|---|
| | Capital Cost | Annual Cost | Capital Cost | Annual Cost | Capital Cost | Annual Cost |
| Electric Power Generation (2211) | $161,766,376 | $90,982,105 | $471,230,478 | $203,529,267 | $632,996,854 | $294,511,373 |
| Hospitals (622110) | $20,220,797 | $11,372,763 | $0 | $0 | $20,220,797 | $11,372,763 |
| Crude Petroleum & NG Production (211111) | $2,374,401 | $3,807,478 | $1,611,601 | $2,599,033 | $3,986,003 | $6,406,510 |
| Natural Gas Liquid Producers (211112) | $2,374,401 | $3,807,478 | $1,611,601 | $2,599,033 | $3,986,003 | $6,406,510 |
| National Security (92811) | $20,220,797 | $11,372,763 | $52,358,942 | $22,614,363 | $72,579,739 | $33,987,126 |
| Hydro Power Units (335312) | $0 | $16,637 | $0 | $22,959 | $0 | $39,597 |
| Irrigation Sets (335312) | $10,294,073 | $11,791,567 | $34,606 | $5,208,210 | $10,328,679 | $16,999,777 |
| Welders (333992) | $108,260 | $1,481,447 | $0 | $1,881,380 | $108,260 | $3,362,827 |
| **Total** | **$217,359,106** | **$134,632,238** | **$526,847,229** | **$238,454,245** | **$744,206,335** | **$373,086,483** |

[a] Costs are presented in 2008 dollars.

## Table 4-6. Summary of Major Source and Area Source NAICS Costs for the CI RICE NESHAP – by Size[a]

| NAICS | Major Source | | Area Source | | Total (Major + Area) | |
|---|---|---|---|---|---|---|
| | Capital Cost | Annual Cost | Capital Cost | Annual Cost | Capital Cost | Annual Cost |
| **Electric Power Generation (2211)** | | | | | | |
| 50–100 hp | $0 | $3,396,123 | $0 | $5,272,480 | $0 | $8,668,603 |
| 100–175 hp | $13,406,919 | $21,600,998 | $0 | $10,824,132 | $13,406,919 | $32,425,129 |
| 175–300 hp | $23,012,914 | $20,895,861 | $0 | $9,437,454 | $23,012,914 | $30,333,314 |
| 300–600 hp | $96,907,266 | $35,304,866 | $248,552,865 | $98,468,656 | $345,460,132 | $133,773,522 |
| 600–750 hp | $6,789,032 | $2,685,292 | $62,249,758 | $25,512,616 | $69,038,790 | $28,197,908 |
| >750 hp | $21,650,245 | $7,098,966 | $160,427,854 | $54,013,930 | $182,078,100 | $61,112,896 |
| **Total 2211** | **$161,766,376** | **$90,982,105** | **$471,230,478** | **$203,529,267** | **$632,996,854** | **$294,511,373** |
| **Hospitals (622110)** | | | | | | |
| 50–100 hp | $0 | $424,515 | $0 | $0 | $0 | $424,515 |
| 100–175 hp | $1,675,865 | $2,709,236 | $0 | $0 | $1,675,865 | $2,700,125 |
| 175–300 hp | $2,876,614 | $2,619,927 | $0 | $0 | $2,876,614 | $2,611,983 |
| 300–600 hp | $12,113,408 | $4,418,775 | $0 | $0 | $12,113,408 | $4,413,108 |
| 600–750 hp | $848,629 | $335,898 | $0 | $0 | $848,629 | $335,662 |
| >750 hp | $2,706,281 | $887,886 | $0 | $0 | $2,706,281 | $887,371 |
| **Total 622110** | **$20,220,797** | **$11,396,237** | **$0** | **$0** | **$20,220,797** | **$11,372,763** |
| **Crude Petroleum & NG Production (211111)** | | | | | | |
| 50–100 hp | $0 | $420,256 | $0 | $579,954 | $0 | $1,000,210 |
| 100–175 hp | $2,026,868 | $3,265,655 | $0 | $1,454,578 | $2,026,868 | $4,720,233 |
| 175–300 hp | $3,592 | $3,261 | $0 | $1,309 | $3,592 | $4,571 |
| 300–600 hp | $151,812 | $55,308 | $346,112 | $137,119 | $497,925 | $192,426 |
| 600–750 hp | $0 | $0 | $0 | 0 | $0 | $0 |
| >750 hp | $192,129 | $62,998 | $1,265,489 | $426,073 | $1,457,619 | $489,071 |
| **Total 211111** | **$2,374,401** | **$3,807,478** | **$1,611,601** | **$2,599,033** | **$3,986,003** | **$6,406,510** |

(continued)

Table 4-6. Summary of Major Source and Area Source NAICS Costs for the CI RICE NESHAP – by Size[a] (continued)

| NAICS | Major Source | | Area Source | | Total (Major + Area) | |
|---|---|---|---|---|---|---|
| | Capital Cost | Annual Cost | Capital Cost | Annual Cost | Capital Cost | Annual Cost |
| **Natural Gas Liquid Producers (211112)** | | | | | | |
| 50–100 hp | $0 | $420,256 | $0 | $579,954 | $0 | $1,000,210 |
| 100–175 hp | $2,026,868 | $3,265,655 | $0 | $1,454,578 | $2,026,868 | $4,720,233 |
| 175–300 hp | $3,592 | $3,261 | $0 | $1,309 | $3,592 | $4,571 |
| 300–600 hp | $151,812 | $55,308 | $346,112 | $137,119 | $497,925 | $192,426 |
| 600–750 hp | 0 | 0 | 0 | 0 | $0 | $0 |
| >750 hp | $192,129 | $62,998 | $1,265,489 | $426,073 | $1,457,619 | $489,071 |
| **Total 211112** | **$2,374,401** | **$3,807,478** | **$1,611,601** | **$2,599,033** | **$3,986,003** | **$6,406,510** |
| **National Security (92811)** | | | | | | |
| 50–100 hp | $0 | $424,515 | $0 | $585,831 | $0 | $1,010,346 |
| 100–175 hp | $1,675,865 | $2,700,125 | $0 | $1,202,681 | $1,675,865 | $3,902,806 |
| 175–300 hp | $2,876,614 | $2,611,983 | $0 | $1,048,606 | $2,876,614 | $3,660,589 |
| 300–600 hp | $12,113,408 | $4,413,108 | $27,616,985 | $10,940,962 | $39,730,393 | $15,354,070 |
| 600–750 hp | $848,629 | $335,662 | $6,916,640 | $2,834,735 | $7,765,269 | $3,170,397 |
| >750 hp | $2,706,281 | $887,371 | $17,825,317 | $6,001,548 | $20,531,598 | $6,888,919 |
| **Total 92811** | **$20,220,797** | **$11,372,763** | **$52,358,942** | **$22,614,363** | **$72,579,739** | **$33,987,126** |
| **Hydro Power Units (335312)** | | | | | | |
| 50–100 hp | $0 | $16,637 | $0 | $22,959 | $0 | $39,597 |
| 100–175 hp | $0 | $0 | $0 | $0 | $0 | $0 |
| 175–300 hp | $0 | $0 | $0 | $0 | $0 | $0 |
| 300–600 hp | $0 | $0 | $0 | $0 | $0 | $0 |
| 600–750 hp | $0 | $0 | $0 | $0 | $0 | $0 |
| >750 hp | $0 | $0 | $0 | $0 | $0 | $0 |
| **Total 335312** | **$0** | **$16,637** | **$0** | **$22,959** | **$0** | **$39,597** |

(continued)

## Table 4-6. Summary of Major Source and Area Source NAICS Costs for the CI RICE NESHAP – by Size[a] (continued)

| | Major Source | | Area Source | | Total (Major + Area) | |
|---|---|---|---|---|---|---|
| **NAICS** | **Capital Cost** | **Annual Cost** | **Capital Cost** | **Annual Cost** | **Capital Cost** | **Annual Cost** |
| **Irrigation Sets (335312)** | | | | | | |
| 50–100 hp | $0 | $245,565 | $0 | $338,880 | $0 | $584,446 |
| 100–175 hp | $3,137,134 | $5,054,497 | $0 | $2,251,359 | $3,137,134 | $7,305,856 |
| 175–300 hp | $7,143,945 | $6,486,744 | $0 | $2,604,167 | $7,143,945 | $9,090,911 |
| 300–600 hp | $12,145 | $4,425 | $27,689 | $10,969 | $39,834 | $15,394 |
| 600–750 hp | $849 | $336 | $6,917 | $2,835 | $7,766 | $3,171 |
| >750 hp | $0 | $0 | $0 | $0 | $0 | $0 |
| **Total 335312** | **$10,294,073** | **$11,791,567** | **$34,606** | **$5,208,210** | **$10,328,679** | **$16,999,777** |
| **Welders (333992)** | | | | | | |
| 50–100 hp | $0 | $1,307,020 | $0 | $1,803,688 | $0 | $3,110,708 |
| 100–175 hp | $108,260 | $174,427 | $0 | $77,693 | $108,260 | $252,119 |
| 175–300 hp | $0 | $0 | $0 | $0 | $0 | $0 |
| 300–600 hp | $0 | $0 | $0 | $0 | $0 | $0 |
| 600–750 hp | $0 | $0 | $0 | $0 | $0 | $0 |
| >750 hp | $0 | $0 | $0 | $0 | $0 | $0 |
| **Total 333992** | **$108,260** | **$1,481,447** | **$0** | **$1,881,380** | **$108,260** | **$3,362,827** |
| **Grand Total** | | | | | | |
| **Total** | **$217,359,106** | **$134,632,238** | **$526,847,229** | **$238,454,245** | **$744,206,335** | **$373,086,483**$ |

[a] Costs are presented in 2008 dollars.

## Table 4-7. Summary of Major Source and Area Source NAICS Costs for the CI RICE NESHAP – by Number of Engines[a]

| NAICS | Number of Engines | | | Total (Major + Area) | |
|---|---|---|---|---|---|
| | Major | Area | Total | Capital Cost | Annual Cost |
| **Electric Power Generation (2211)** | | | | | |
| 50–100 hp | 47,324 | 79,859 | 127,183 | $0 | $8,668,603 |
| 100–175 hp | 67,713 | 114,266 | 181,980 | $13,406,919 | $32,498,019 |
| 175–300 hp | 59,039 | 99,627 | 158,666 | $23,012,914 | $30,396,866 |
| 300–600 hp | 42,113 | 97,919 | 140,032 | $345,460,132 | $133,924,260 |
| 600–750 hp | 1,760 | 16,455 | 18,215 | $69,038,790 | $28,217,515 |
| >750 hp | 3,828 | 28,746 | 32,574 | $182,078,100 | $61,147,960 |
| **Total 2211** | **221,777** | **436,872** | **658,649** | **$632,996,854** | **$294,853,223** |
| **Hospitals (622110)** | | | | | |
| 50–100 hp | 5,916 | 0 | 5,916 | $0 | $424,515 |
| 100–175 hp | 8,464 | 0 | 8,464 | $1,675,865 | $2,709,236 |
| 175–300 hp | 7,380 | 0 | 7,380 | $2,876,614 | $2,619,927 |
| 300–600 hp | 5,264 | 0 | 5,264 | $12,113,408 | $4,418,775 |
| 600–750 hp | 220 | 0 | 220 | $848,629 | $335,898 |
| >750 hp | 479 | 0 | 479 | $2,706,281 | $887,886 |
| **Total 622110** | **27,722** | **0** | **27,722** | **$20,220,797** | **$11,396,237** |
| **Crude Petroleum & NG Production (211111)** | | | | | |
| 50–100 hp | 5,856 | 8,784 | 14,640 | $0 | $1,000,210 |
| 100–175 hp | 10,237 | 15,355 | 25,592 | $2,026,868 | $4,731,252 |
| 175–300 hp | 9 | 14 | 23 | $3,592 | $4,581 |
| 300–600 hp | 66 | 136 | 202 | $497,925 | $192,644 |
| 600–750 hp | 0 | 0 | 0 | $0 | $0 |
| >750 hp | 34 | 227 | 261 | $1,457,619 | $489,352 |
| **Total 211111** | **16,202** | **24,517** | **40,719** | **$3,986,003** | **$6,418,038** |

(continued)

## Table 4-7. Summary of Major Source and Area Source NAICS Costs for the CI RICE NESHAP – by Number of Engines[a] (continued)

| NAICS | Number of Engines | | | Total (Major + Area) | |
|---|---|---|---|---|---|
| | Major | Area | Total | Capital Cost | Annual Cost |
| **Natural Gas Liquid Producers (211112)** | | | | | |
| 50–100 hp | 5,856 | 8,784 | 14,640 | $0 | $1,000,210 |
| 100–175 hp | 10,237 | 15,355 | 25,592 | $2,026,868 | $4,720,233 |
| 175–300 hp | 9 | 14 | 23 | $3,592 | $4,571 |
| 300–600 hp | 66 | 136 | 202 | $497,925 | $192,426 |
| 600–750 hp | 0 | 0 | 0 | $0 | $0 |
| >750 hp | 34 | 227 | 261 | $1,457,619 | $489,071 |
| **Total 211112** | **16,202** | **24,517** | **40,719** | **$3,986,003** | **$6,406,510** |
| **National Security (92811)** | | | | | |
| 50–100 hp | 5,916 | 8,873 | 14,789 | $0 | $1,010,346 |
| 100–175 hp | 8,464 | 12,696 | 21,160 | $1,675,865 | $3,902,806 |
| 175–300 hp | 7,380 | 11,070 | 18,450 | $2,876,614 | $3,660,589 |
| 300–600 hp | 5,264 | 10,880 | 16,144 | $39,730,393 | $15,354,070 |
| 600–750 hp | 220 | 1,828 | 2,048 | $7,765,269 | $3,170,397 |
| >750 hp | 479 | 3,194 | 3,672 | $20,531,598 | $6,888,919 |
| **Total 92811** | **27,722** | **48,541** | **76,263** | **$72,579,739** | **$33,987,126** |
| **Hydro Power Units (335312)** | | | | | |
| 50–100 hp | 232 | 348 | 580 | $0 | $39,597 |
| 100–175 hp | 0 | 0 | 0 | $0 | $0 |
| 175–300 hp | 0 | 0 | 0 | $0 | $0 |
| 300–600 hp | 0 | 0 | 0 | $0 | $0 |
| 600–750 hp | 0 | 0 | 0 | $0 | $0 |
| >750 hp | 0 | 0 | 0 | $0 | $0 |
| **Total 335312** | **232** | **348** | **580** | **$0** | **$39,597** |

(continued)

## Table 4-7. Summary of Major Source and Area Source NAICS Costs for the CI RICE NESHAP – by Number of Engines[a] (continued)

| NAICS | Number of Engines | | | Total (Major + Area) | |
|---|---|---|---|---|---|
| | Major | Area | Total | Capital Cost | Annual Cost |
| **Irrigation Sets (335312)** | | | | | |
| 50–100 hp | 3,422 | 5,133 | 8,555 | $0 | $584,446 |
| 100–175 hp | 15,845 | 23,767 | 39,611 | $3,137,134 | $7,305,856 |
| 175–300 hp | 18,327 | 27,491 | 45,819 | $7,143,945 | $9,090,911 |
| 300–600 hp | 5 | 11 | 16 | $39,834 | $15,394 |
| 600–750 hp | 0 | 2 | 2 | $7,766 | $3,171 |
| >750 hp | 0 | 0 | 0 | $0 | $0 |
| **Total 335312** | **37,599** | **56,403** | **94,003** | **$10,328,679** | **$16,999,777** |
| **Welders (333992)** | | | | | |
| 50–100 hp | 18,213 | 27,319 | 45,532 | $0 | $3,110,708 |
| 100–175 hp | 547 | 820 | 1,367 | $108,260 | $252,119 |
| 175–300 hp | 0 | 0 | 0 | $0 | $0 |
| 300–600 hp | 0 | 0 | 0 | $0 | $0 |
| 600–750 hp | 0 | 0 | 0 | $0 | $0 |
| >750 hp | 0 | 0 | 0 | $0 | $0 |
| **Total 333992** | **18,760** | **28,140** | **46,899** | **$108,260** | **$3,362,827** |
| **Grand Total** | | | | | |
| **Total** | **366,217** | **619,337** | **957,832** | **$744,206,335** | **$373,086,483** |

[a] Costs are presented in 2008 dollars.

### 4.5 Emissions and Emission Reductions

The emissions reductions associated with the final rule are based on requiring emission standards that are based on applying add-on controls to non-emergency CI engines greater than 300 HP. Baseline emissions from the current population of stationary RICE less than or equal to 500 HP at major sources and existing stationary RICE at area sources were calculated based on non-emergency CI engines operating 1,000 hrs/yr, and emergency CI engines operating 50 hrs/yr. The following additional assumptions were used:

**Emission Factors:**

| Engine | HAP (lb/hp-hr) | CO (lb/hr) | PM (lb/hp-hr) | $SO_2$ (lb/hp-hr) |
|---|---|---|---|---|
| CI | $1.07x10^{-4}$ | $6.96x10^{-1}$ | $7.00x10^{-4}$ | $0.00809xS_1$* |

*Obtained from AP-42, section 3.4 where $S_1$ is sulfur content.

**Control Efficiencies:**

| Technology | HAP | CO | PM |
|---|---|---|---|
| Oxidation catalyst | 70% | 70% | 30% |

Based on the above assumptions and the existing population of engines shown earlier in this section, the HAP, CO, and PM baseline emissions and reductions were calculated. In addition to the final rule reducing HAP, CO, and PM, the rule will also lead to reductions in sulfur dioxide ($SO_2$) emissions by requiring existing non-emergency CI engines greater than 300 HP that use diesel fuel to use diesel fuel containing no more than 15 parts per million (ppm) of sulfur. We have not quantified the $SO_x$ reductions that would occur as a result of engines switching to ULSD because we are unable to estimate the number of engines that already use ULSD and therefore we are unable to estimate the percentage of engines that may switch to ULSD due to this rule. If none of the affected engines would use ULSD without this rule, then we estimate the $SO_x$ reductions are 31,000 tpy in the year 2013. If all of the affected engines would use ULSD regardless of the rule, then the additional $SO_x$ reductions would be zero.

The estimated reductions in tons per year (tpy) as a result of the final rule are shown in Table 4-8. In addition, it is expected that additional PM reductions will be achieved by the requirement to use ULSD for CI engines that install a DOC. The use of ULSD reduces the formation of sulfates in the exhaust gas, therefore reducing the emission of these sulfate PM emissions from the exhaust. EPA has estimated that the use of ULSD can reduce PM emissions by 5-30 percent depending on the sulfur concentration of the diesel fuel that is being replaced. Because EPA has no information on the type of fuel that CI engines are currently using, the PM reductions from switching to ULSD were not quantified and included in this summary.

The work practice requirement of using an open crankcase ventilation system to control metallic HAP emissions is expected to achieve additional HAP reductions from CI engines. However, the metallic HAP emission reduction cannot be quantified because of the difficulty of measuring metallic HAP from the crankcase exhaust. Therefore, the metallic HAP reductions are not included in the total emission reductions.

**Table 4-8. Summary of Major Source and Area Source Emissions Reductions for the CI RICE NESHAP in 2013**

| Size Range (HP) | Emission Reductions (tpy) | | | |
|---|---|---|---|---|
| | **HAP** | **CO** | **PM** | **VOC** |
| 50-100 | 0 | 0 | 0 | 0 |
| 100-175 | 44 | 2,072 | 123 | 1,183 |
| 175-300 | 57 | 1,571 | 161 | 1,549 |
| 300-500 | 145 | 2,362 | 407 | 3,923 |
| 500-600 | 18 | 209 | 50 | 478 |
| 600-750 | 11 | 107 | 31 | 300 |
| >750 | 36 | 236 | 102 | 982 |
| Total | 312 | 6,558 | 874 | 8,416 |
| 50-100 | 0 | 0 | 0 | 0 |
| 100-175 | 0 | 0 | 0 | 0 |
| 175-300 | 0 | 0 | 0 | 0 |
| 300-600 | 368 | 5,314 | 1,031 | 9,930 |
| 600-750 | 92 | 891 | 259 | 2,497 |
| >750 | 243 | 1,578 | 680 | 6,553 |
| Total | 703 | 7,784 | 1,970 | 18,980 |
| **Grand Total** | **1,014** | **14,342** | **2,844** | **27,395** |

Note: All emission reduction estimates are from "Impacts Associated with NESHAP for Existing Stationary CI RICE," prepared by Bradley Nelson, Ec/R, Inc. for Melanie King, U.S. EPA, Office of Air Quality Planning and Standards, February 17, 2010.

# SECTION 5
# ECONOMIC IMPACT ANALYSIS, ENERGY IMPACTS, AND SOCIAL COSTS

The EIA provides decision makers with social cost estimates and enhances understanding of how the costs may be distributed across stakeholders (EPA, 2000). Although several economic frameworks can be used to estimate social costs for regulations of this size and sector scope, OAQPS has typically used partial equilibrium market models. However, the current data do not provide sufficient details to develop a market model; the data that are available have little or no sector/firm detail and are reported at the national level. In addition, some sectors have unique market characteristics (e.g., hospitals) that make developing partial equilibrium models difficult. Given these constraints, we believed the direct compliance costs as a reasonable approximation of total social costs. In addition, we also provide a qualitative analysis of the final rule's economic impact on stakeholder decisions, a qualitative discussion on if unfunded mandates occur as a result of this final rule, and a qualitative discussion of the potential distribution of social costs between consumers and producers.

## 5.1 Compliance Costs of the Final Rule

For the year 2013, EPA's engineering cost analysis estimates the total annualized costs of the final rule are $373 million (in 2008 dollars) (Nelson, 2010).

As shown in Figure 5-1, the majority of the costs fall on the electric power sector (79%), followed by national security (9%). The remaining industries each account for 5% or less of the total annualized cost. The industrial classification for each engine is taken from the Power Systems Research (PSR) database, which is the major source of data for the engines affected by the final rule. The PSR database used as a basis for the analyses in this RIA contains information on both mobile and stationary onroad and nonroad engines, among other data, and does so not only for the U.S. but worldwide. PSR has collected such data for more than 30 years. The Office of Transportation and Air Quality (OTAQ) uses this database frequently in the development of their mobile source rules.

The annualized compliance costs per engine vary by the engine size (see Figure 5-2). For 300 hp engines or less, the annualized per-engine costs are below $215 per engine. Per-engine costs for higher horsepower (hp) engines range between $950 and $1,900.

The final rule will affect approximately one million existing stationary diesel engines. As shown in Figure 5-3, most of the affected engines fall within the 100 to 175 hp category (31%).

The next highest categories are 50 to 100 hp (24%) and 175 to 300 hp (23%). The remaining engines are concentrated in the 300 to 600 hp category (16%).

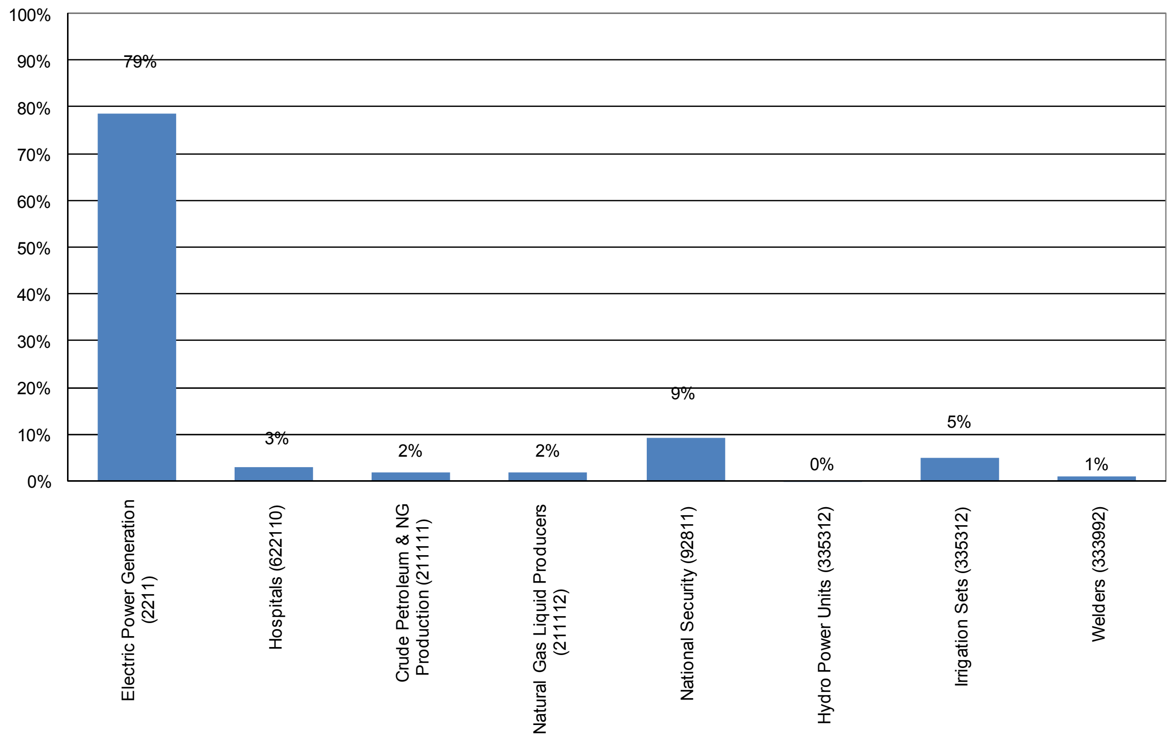



**Figure 5-1. Distribution of Annualized Direct Compliance Costs by Industry: 2013**

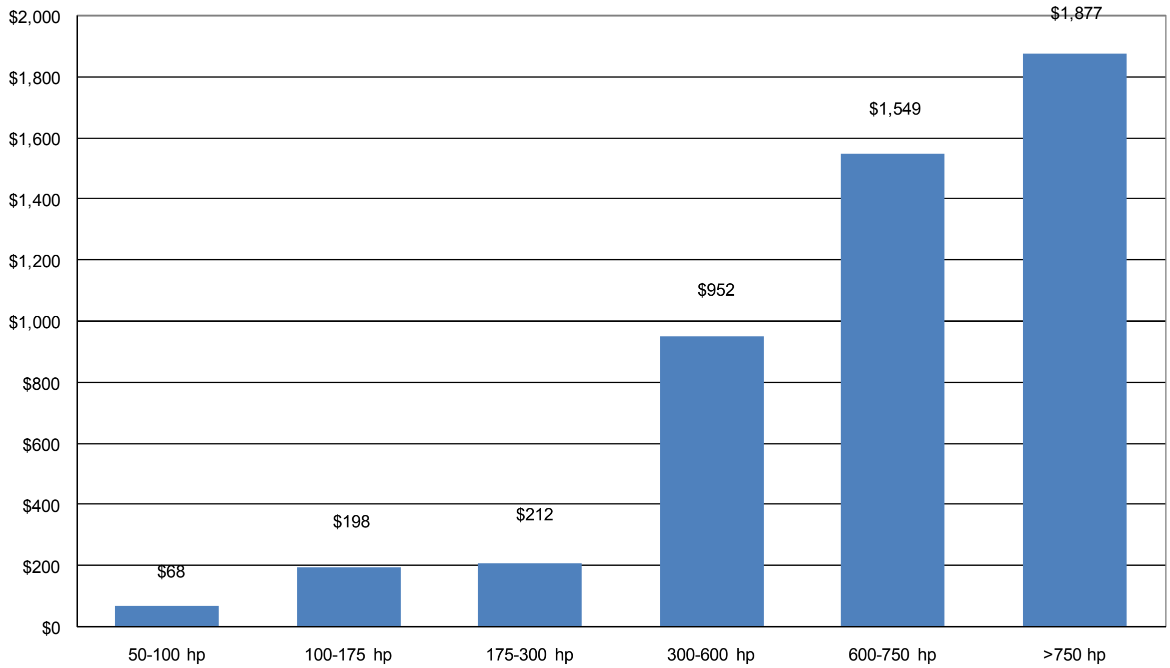



**Figure 5-2. Average Annualized Cost per Engine by Horsepower Group: 2013 ($2008)**

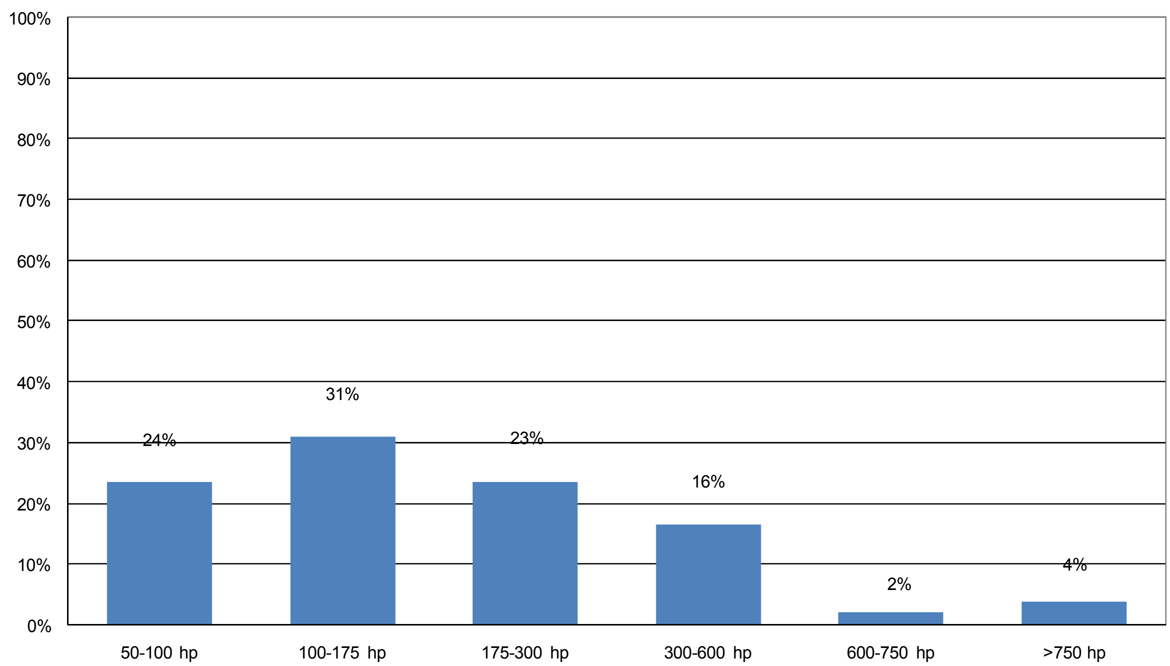



**Figure 5-3. Distribution of Engine Population by Horsepower Group: 2013**

To assess the size of the compliance cost relative to the value of the goods and services for industries using affected engines, we collected Census data for selected industries. At the industry level, the annualized costs represent a very small fraction of revenue (less than 0.07%) (Table 5-1). These industry level cost-to-sales ratios can be interpreted as an average impact on potentially affected firms in these industries. Based on the cost-to-sales ratios, we can conclude that the annualized cost of this rule should be no higher than 1% of the sales on average for a firm in each of these industries.

**Table 5-1. Selected Industry-Level Annualized Compliance Costs as a Fraction of Total Industry Revenue: 2008**

| Industry (NAICS) | Industry Name | Total Annualized Costs ($ million)[a] | Sales, Shipments, Receipt, or Revenue ($Billion) | | Cost-to-Sales Ratio |
|---|---|---|---|---|---|
| | | | ($2007) | ($2008) | |
| 2211 | Electric Power Generation | $299.5 | $440.4 | $449.8 | 0.07% |
| 622110 | Hospitals | $11.4 | $663.6 | $677.8 | 0.00% |
| 211111 | Crude Petroleum & NG Production | $6.7 | $214.2 | $218.8 | 0.00% |
| 211112 | Natural Gas Liquid Producers | $6.7 | $42.4 | $43.3 | 0.02% |
| 92811 | National Security | $34.5 | #N/A | #N/A | #N/A |
| 333992 | Welders | $3.4 | $5.2 | $5.3 | 0.06% |
| 111 and 112 | Agriculture using irrigation systems[a] | $18.1 | $27.9 | $28.5 | 0.06% |

[a] Irrigation engine costs assumed to be passed on to agricultural sectors that use irrigation systems.

N/A: receipts are Not Available for National Security

Sources: U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 00: All sectors: Geographic Area Series: Economy-Wide Key Statistics: 2007" <http://factfinder.census.gov>; (January 4th , 2010).

U.S. Department of Agriculture (USDA), National Agricultural Statistics Service (NASS). 2009. "2008 Farm and Ranch Irrigation Survey." Washington, DC: USDA-NASS.

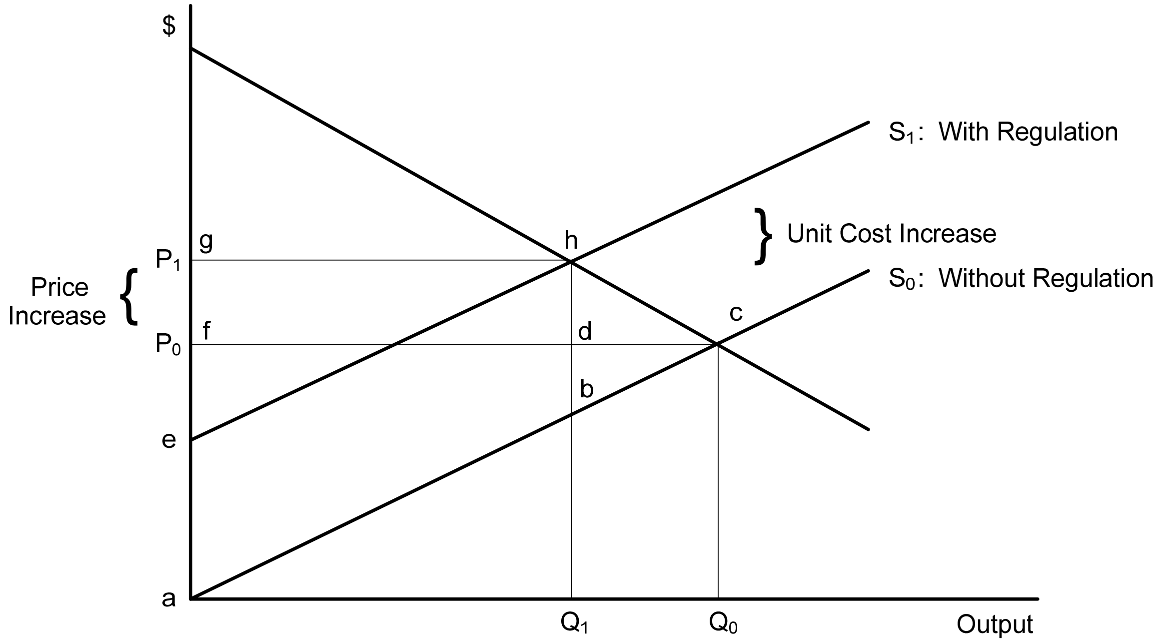
Nelson, B., EC/R Inc. January 7, 2010. Memorandum to Melanie King, U.S. Environmental Protection Agency. Impacts Associated with NESHAP for Existing Stationary CI RICE.

## 5.2 How Might People and Firms Respond? A Partial Equilibrium Analysis

Markets are composed of people as consumers and producers trying to maximize utility (consumers) and maximize profits (producers) they can given their economic circumstances. One way economists illustrate behavioral responses to pollution control costs is by using market supply and demand diagrams. The market supply curve describes how much of a good or service firms are willing and able to sell to people at a particular price; this curve is typically upward sloping because some production resources are fixed. As a result, the cost of producing an additional unit typically rises as more units are made. The market demand curve describes how much of a good or service consumers are willing and able to buy at some price. Holding other factors constant, the quantity demand is assumed to fall when prices rise. In a perfectly competitive market, equilibrium price ($P_0$) and quantity ($Q_0$) is determined by the intersection of the supply and demand curves (see Figure 5-4).

### *5.2.1 Changes in Market Prices and Quantities*

To qualitatively assess how the regulation may influence the equilibrium price and quantity in the affected markets, we assumed the market supply function shifts up by the additional cost of producing the good or service; the unit cost increase is typically calculated by dividing the annual compliance cost estimate by the baseline quantity ($Q_0$) (see Figure 5-4). As shown, this model makes two predictions: the price of the affected goods and services are likely to rise and the consumption/production levels are likely to fall.




consumer surplus = –[fghd + dhc]

producer surplus = [fghd – aehb] – bdc

total surplus = consumer surplus + producer surplus = –[aehb + dhc + bdc]

**Figure 5-4. Market Demand and Supply Model: With and Without Regulation**

The size of these changes depends on two factors: the size of the unit production cost increase (supply shift) and differences in how each side of the market (supply and demand) responds to changes in price. Economists measure responses using the concept of price elasticity, which represents the percentage change in quantity divided by the percentage change in price. This dependence has been expressed in the following formula:[1]

$$\textit{Share of per-unit production}\,\mathbf{cost} = \frac{\text{Price Elasticity of Supply}}{(\text{Price Elasticity of Supply - Price Elasticity of Demand})}$$

As a general rule, a higher share of the per-unit cost increases will be passed on to consumers in markets where

- goods and services are necessities and people do not have good substitutes that they can switch to easily (demand is inelastic) and

[1]For examples of similar mathematical models in the public finance literature, see Nicholson (1998), pages 444–447, or Fullerton and Metcalf (2002).

- suppliers have excess capacity and can easily adjust production levels at minimal costs, or the time period of analysis is long enough that suppliers can change their fixed resources; supply is more elastic over longer periods.

Short-run demand elasticities for energy goods (electricity and natural gas), agricultural products, and construction are often inelastic. Specific estimates of short-run demand elasticities for these products can be obtained from existing literature. For the short-run demand of energy products, the National Energy Modeling System (NEMS) buildings module uses values between 0.1 and 0.3; a 1% increase in price leads to a 0.1 to 0.3% decrease in energy demand (Wade, 2003). For the short-run demand of agriculture and construction, the EPA has estimated elasticities to be 0.2 for agriculture and approximately 1 for construction (EPA, 2004). As a result, a 1% increase in the prices of agriculture products would lead to a 0.2% decrease in demand for those products, while a 1% increase in construction prices would lead to approximately a 1% decrease in demand for construction. Given these demand elasticity scenarios (shaded in gray), approximately a 1% increase unit costs would result in a price increase of 0.1 to 1% (Table 5-2). As a result, 10 to 100% of the unit cost increase could be passed on to consumers in the form of higher goods/services prices. This price increase would correspond to a 0.1 to 0.8% decline in consumption in these markets (Table 5-3).

**Table 5-2. Hypothetical Price Increases for a 1% Increase in Unit Costs**

| Market Demand Elasticity | Market Supply Elasticity | | | | | | |
|---|---|---|---|---|---|---|---|
| | **0.1** | **0.3** | **0.5** | **0.7** | **1** | **1.5** | **3** |
| −0.1 | **0.5%** | 0.8% | 0.8% | 0.9% | 0.9% | 0.9% | 1.0% |
| −0.3 | 0.3% | **0.5%** | 0.6% | 0.7% | 0.8% | 0.8% | 0.9% |
| −0.5 | 0.2% | 0.4% | **0.5%** | 0.6% | 0.7% | 0.8% | 0.9% |
| −0.7 | 0.1% | 0.3% | 0.4% | **0.5%** | 0.6% | 0.7% | 0.8% |
| −1.0 | 0.1% | 0.2% | 0.3% | 0.4% | **0.5%** | 0.6% | 0.8% |
| −1.5 | 0.1% | 0.2% | 0.3% | 0.3% | 0.4% | **0.5%** | 0.7% |
| −3.0 | 0.0% | 0.1% | 0.1% | 0.2% | 0.3% | 0.3% | **0.5%** |

### *5.2.2 Regulated Markets: The Electric Power Generation, Transmission, and Distribution Sector*

Given that the electric power sector bears majority of the estimated compliance costs (Figure 5-1) and the industry is also among the last major regulated energy industries in the United States (EIA, 2000), the competitive model is not necessarily applicable for this industry.

**Table 5-3. Hypothetical Consumption Decreases for a 1% Increase in Unit Costs**

| Market Demand Elasticity | Market Supply Elasticity | | | | | | |
|---|---|---|---|---|---|---|---|
| | **0.1** | **0.3** | **0.5** | **0.7** | **1** | **1.5** | **3** |
| −0.1 | **−0.1%** | −0.1% | −0.1% | −0.1% | −0.1% | −0.1% | −0.1% |
| −0.3 | −0.1% | **−0.2%** | −0.2% | −0.2% | −0.2% | −0.3% | −0.3% |
| −0.5 | −0.1% | −0.2% | **−0.3%** | −0.3% | −0.3% | −0.4% | −0.4% |
| −0.7 | −0.1% | −0.2% | −0.3% | **−0.4%** | −0.4% | −0.5% | −0.6% |
| −1.0 | −0.1% | −0.2% | −0.3% | −0.4% | **−0.5%** | −0.6% | −0.8% |
| −1.5 | −0.1% | −0.3% | −0.4% | −0.5% | −0.6% | **−0.8%** | −1.0% |
| −3.0 | −0.1% | −0.3% | −0.4% | −0.6% | −0.8% | −1.0% | **−1.5%** |

Although the electricity industry continues to go through a process of restructuring, whereby the industry is moving toward a more competitive framework (see Figure 5-5 for the status of restructuring by state),[2] in many states, electricity prices continue to be fully regulated by Public Service Commissions. As a result, the rules and processes outlined by these agencies would ultimately determine how these additional regulatory costs would be recovered by affected entities.

### *5.2.3 Partial Equilibrium Measures of Social Cost: Changes Consumer and Producer Surplus*

In partial equilibrium analysis, the social costs are estimated by measuring the changes in consumer and producer surplus, and these values can be determined using the market supply and demand model (Figure 5-4). The change in consumer surplus is measured as follows:

$$\Delta CS = -[\Delta Q_1 \times \Delta p] + [0.5 \times \Delta Q \times \Delta p]. \qquad (5.1)$$

Higher market prices and lower quantities lead to consumer welfare losses. Similarly, the change in producer surplus is measured as follows:

$$\Delta PS = [\Delta Q_1 \times \Delta p] - [\Delta Q_1 \times \mathrm{t}] - [0.5 \times \Delta Q \times (\Delta p - t)]. \qquad (5.2)$$

Higher unit costs and lower production level reduce producer surplus because the net price change ($\Delta$p – t) is negative. However, these losses are mitigated because market prices tend to rise.

[2] http://tonto.eia.doe.gov/energy_in_brief/print_pages/electricity.pdf.

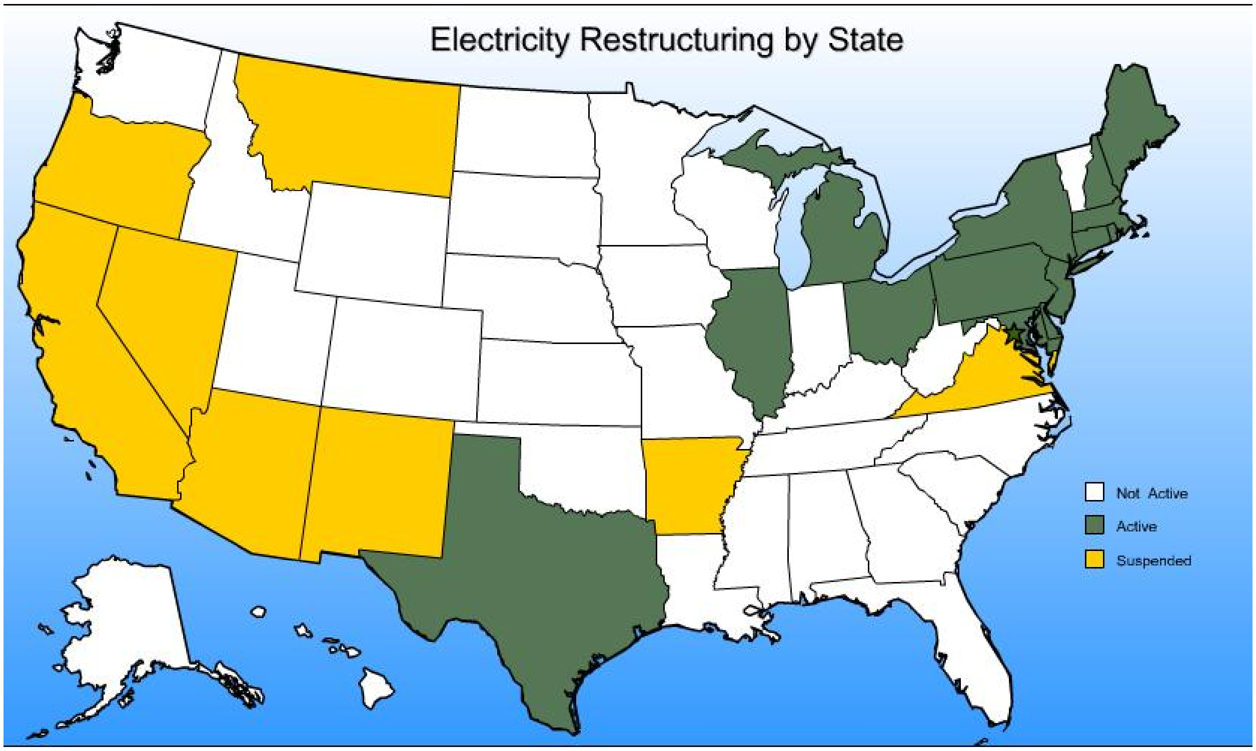



**Figure 5-5. Electricity Restructuring by State**

Source. U.S. Energy Information Administration. 2008a. <http://www.eia.doe.gov/cneaf/electricity/page/restructuring/restructure_elect.html>. Last updated September 2008.

## 5.3 Social Cost Estimate

As shown in Table 5-1 the compliance costs are only a small fraction of the affected product value; this suggests that shift of the supply curve may also be small and result in small changes in market prices and consumption. EPA believes the national annualized compliance cost estimates provide a reasonable approximation of the social cost of this final rule. EPA believes this approximation is better for industries whose markets are well characterized as perfectly competitive. This approximation is less well understood for industries where the characterization of markets is not always perfectly competitive such as electric power generation .whose legal incidence of this rule is approximately 80 percent of the annualized compliance cost. However, given the data limitation noted earlier, EPA believes the accounting for compliance cost is a reasonable approximation to inform policy discussion in this rulemaking. To shed more light on this issue, EPA ran hypothetical analyses and the results are in Tables 5-2 and 5-3.

## 5.4 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, Office of Management and Budget, 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 final rule or regulation, including notices of inquiry, advance notices of proposed rulemaking, and notices of proposed 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 as follows below.

With respect to energy supply and prices, the analysis in Table 5-1 suggests at the industry level, the annualized costs represent a very small fraction of revenue (less than 0.7%). As a result, we can conclude supply and price impacts should be small.

To enhance understanding regarding the regulation's influence on energy consumption, we examined publicly available data describing energy consumption for the electric power sector that will be affected by this rule. The Annual Energy Outlook 2010 (EIA, 2009) provides energy consumption data. As shown in Table 5-4, this industry account for less than 0.5% of the U.S. total liquid fuels and less than 5.2% of natural gas. As a result, any energy consumption changes attributable to the regulatory program should not significantly influence the supply, distribution, or use of energy.

## 5.5 Unfunded Mandates

Title II of the Unfunded Mandates Reform Act of 1995 (UMRA), 2 U.S.C. 1531-1538, requires Federal agencies, unless otherwise prohibited by law, to assess the effects of their regulatory actions on State, local, and tribal governments and the private sector. This rule contains a Federal mandate that may result in expenditures of $100 million or more for State, local, and tribal governments, in the aggregate, or the private sector in any one year.

Accordingly, EPA has prepared under section 202 of the UMRA a written statement which is summarized below in this section.

**Table 5-4. U.S. Electric Power[a] Sector Energy Consumption (Quadrillion BTUs): 2013**

| | Quantity | Share of Total Energy Use |
|---|---|---|
| Distillate fuel oil | 0.12 | 0.1% |
| Residual fuel oil | 0.34 | 0.3% |
| Liquid fuels subtotal | 0.45 | 0.5% |
| Natural gas | 5.17 | 5.1% |
| Steam coal | 20.69 | 20.6% |
| Nuclear power | 8.59 | 8.5% |
| Renewable energy[b] | 6.06 | 6.0% |
| Electricity Imports | 0.09 | 0.1% |
| Total Electric Power Energy Consumption[c] | 41.18 | 40.9% |
| Delivered Energy Use | 72.41 | 72.0% |
| Total Energy Use | 100.59 | 100.0% |

[a]Includes consumption of energy by electricity-only and combined heat and power plants whose primary business is to sell electricity, or electricity and heat, to the public. Includes small power producers and exempt wholesale generators.

[b]Includes conventional hydroelectric, geothermal, wood and wood waste, biogenic municipal solid waste, other biomass, petroleum coke, wind, photovoltaic and solar thermal sources. Excludes net electricity imports.

[c]Includes non-biogenic municipal waste not included above.

Source: U.S. Energy Information Administration. 2009a. Supplemental Tables to the Annual Energy Outlook 2010. Table 2. Available at: <http://www.eia.doe.gov/oiaf/aeo/aeoref_tab.html>.

### *5.5.1 Future and Disproportionate Costs*

The UMRA requires that we estimate, where accurate estimation is reasonably feasible, future compliance costs imposed by the rule and any disproportionate budgetary effects. Our estimates of the future compliance costs of the final rule are discussed previously in Section 4 of this RIA. We do not believe that there will be any disproportionate budgetary effects of the final rule on any particular areas of the country, State or local governments, types of communities (e.g., urban, rural), or particular industry segments.

### *5.5.2 Effects on the National Economy*

The UMRA requires that we estimate the effect of the final rule on the national economy. To the extent feasible, we must estimate the effect on productivity, economic growth, full employment, creation of productive jobs, and international competitiveness of the U.S. goods and services if we determine that accurate estimates are reasonably feasible and that such effect is relevant and material. The nationwide economic impact of the final rule is presented earlier in this RIA chapter. This analysis provides estimates of the effect of the final rule on most of the categories mentioned above, and these estimates are presented earlier in this RIA chapter. In addition, we have determined that the final rule contains no regulatory requirements that might significantly or uniquely affect small governments. Therefore, today's rule is not subject to the requirements of section 203 of the UMRA.

## 5.6 Environmental Justice

Executive Order (EO) 12898 (59 FR 7629 (Feb. 16, 1994)) establishes federal executive policy on environmental justice. Its main provision directs federal agencies, to the greatest extent practicable and permitted by law, to make environmental justice part of their mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of their programs, policies, and activities on minority populations and low-income populations in the United States.

EPA has determined that this final rule will not have disproportionately high and adverse human health or environmental effects on minority or low-income populations because it increases the level of environmental protection for all affected populations without having any disproportionately high and adverse human health or environmental effects on any population, including any minority or low-income population. This rule is a nationwide standard that reduces air toxics emissions from existing stationary CI engines, thus decreasing the amount of such emissions to which all affected populations are exposed.

## SECTION 6
## SMALL ENTITY SCREENING 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 as defined by the Small Business Administration (SBA) include small businesses, small governmental jurisdictions, and small not-for-profit enterprises.

After considering the economic impact of the final rule on small entities, the screening analysis indicates that this final rule will not have a significant economic impact on a substantial number of small entities (or “SISNOSE”). Under the primary cost analyses EPA considered, sales and revenue tests for establishments owned by model small entities are less than 3% and only one group of establishments (irrigated farms with receipts less than $25,000) has a ratio exceeding 1%.

### 6.1 Small Entity Data Set

The industry sectors covered by the final rule were identified during the development of the cost analysis (Nelson, 2009). The SUSB provides national information on the distribution of economic variables by industry and enterprise size (U.S. Census, 2006a, b).[1] The Census Bureau and the Office of Advocacy of the SBA supported and developed these files for use in a broad range of economic analyses.[2] 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.

The Census Bureau’s definitions used in the SUSB, which are stated in Section 3 and restated here for clarity of presentation, are as follows:

- *Establishmen*t: An establishment is a single physical location where business is conducted or where services or industrial operations are performed.
- *Receipts*: Receipts (net of taxes) are defined as the revenue for goods produced, distributed, or services provided, including revenue earned from premiums,

[1]The SUSB data do not provide establishment information for the national security NAICS code (92811) or irrigated farms. Since most national security installations are owned by the federal government (e.g., military bases), EPA assumes these entities would not be considered small. For irrigated farms, we relied on receipt data provided in the 2008 Farm and Irrigation Survey (USDA, 2009).

[2]See http://www.census.gov/csd/susb/ and http://www.sba.gov/advo/research/data.html for additional details.

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 multiestablishment company forms one enterprise—the enterprise employment and annual payroll are summed from the associated establishments. Enterprise size designations are determined by the summed 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 "enterprise" 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.

## 6.2 Small Entity Economic Impact Measures

The analysis generated a set of establishment sales tests (represented as cost-to-receipt ratios)[3] for NAICS codes associated with sectors listed in Table 6-1. Although the appropriate SBA size definition should be applied at the parent company (enterprise) level, we can only compute and compare ratios for a model establishment owned by an enterprise within an SUSB size range (employment or receipts). Using the SUSB size range helps us account for receipt differences between establishments owned by large and small enterprises and also allows us to consider the variation in small business definitions across affected industries. Using establishment receipts is also a conservative approach, because an establishment's parent company (the "enterprise") may have other economic resources that could be used to cover the costs of the final rule.

### *6.2.1 Model Establishment Receipts and Annual Compliance Costs*

The sales test compares a representative establishment's total annual engine costs to the average establishment receipts for enterprises in several size categories.[4] For industries with SBA

[3]The following metrics for other small entity economic impact measures (if applicable) would potentially include

- small governments (if applicable): "revenue" test; annualized compliance cost as a percentage of annual government revenues and
- small nonprofits (if applicable): "expenditure" test; annualized compliance cost as a percentage of annual operating expenses,

[4]For the 1 to 20 employee category, we excluded SUSB data for enterprises with zero employees. These enterprises did not operate the entire year.

employment size standards, we calculated average establishment receipts for each enterprise employment range (Table 6-2).[5] For industries with SBA receipt size standards, we calculated

**Table 6-1. Final NESHAP for Existing Stationary CI Reciprocating Internal Combustion Engines (RICE): Affected Sectors and SBA Small Business Size Standards**

| Industry Description | Corresponding NAICS | SBA Size Standard for Businesses (effective March 11, 2008) | Type of Small Entity |
|---|---|---|---|
| Electric power generation | 2211 | [a] | Business and government |
| General medical & surgical hospitals | 622110 | $34.5 million in annual receipts | Business and government |
| Crude petroleum and natural gas production | 211111 | 500 employees | Business |
| Natural gas liquid producers | 211112 | 500 employees | Business |
| National security | 92811 | NA | Government |
| Hydro power units | See NAICS 2211 | 1,000 employees | Business and government |
| Irrigation sets | Affects NAICS 111 and 112 | Generally $750,000 or less in annual receipts | Business |
| Welders | Affects industries that use heavy equipment such as construction, mining, farming | Varies by 6-digit NAICS code; Example industry: NAICS 238 = $14 million in annual receipts | Business |

[a]NAICS codes 221111, 221112, 221113, 221119, 221121, 221122: A firm is small if, including its affiliates, it is primarily engaged in the generation, transmission, and/or distribution of electric energy for sale and its total electric output for the preceding fiscal year did not exceed 4 million megawatt hours.

Source: U.S. Small Business Administration (SBA). 2008. "Table of Small Business Size Standards Matched to North American Industry Classification System Codes." Effective August 22nd, 2008. Downloaded 1/11/10.

average establishment receipts for each enterprise receipt range (Table 6-3). We included the utility sector in the second group, although the SBA size standard for this industry is defined in terms of physical units (megawatt hours) versus receipts. Crop and animal production (NAICS 111 and 112) also have an SBA receipt size standard that defines a small business as receiving $750,000 or less in receipts per year. However, SUSB data were not available for these industries. Therefore, we conducted the sales test using the following range of establishment receipts: farms with annual receipts of $25,000 or less, farms with annual receipts of $100,000 or

[5]We use 2002 Economic Census data in estimating number of establishments by industry instead of using 2007 Economic Census since this data was not available in time for use in our analysis. The release schedules for different types of 2007 Economic Census data are at http://www.census.gov/econ/census07/pdf/EconCensusScheduleByDate.pdf.

less, farms with annual receipts of $500,000 or less, and farms with annual receipts of $750,000 or less.

## Table 6-2. Average Receipts for Affected Industry by Enterprise: 2002 ($2008 Million/establishment)

| NAICS | NAICS Description | SBA Size Standard for Businesses (effective August 22, 2008) | All Enterprises | Owned By Enterprises with Employee Range: | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 1–20 Employees | 20–99 Employees | 100–499 Employees | 500–749 Employees | 750–999 Employees | 1,000–1,499 Employees |
| 211111 | Crude petroleum & natural gas extraction | 500 employees | $14.59 | $0.53 | $6.71 | $9.51 | NA | NA | NA |
| 211112 | Natural gas liquid extraction | 500 employees | $172.81 | $0.30 | NA | $11.88 | NA | NA | NA |
| 335312 | Motor & generator mfg | 1,000 employees | $18.58 | $1.37 | $6.14 | $15.96 | $29.47 | NA | NA |
| 333992 | Welding & soldering equipment mfg | 500 employees | $18.51 | $1.56 | $6.60 | $33.25 | NA | NA | $114.55 |

NA = Not available.

Source: U.S. Census Bureau. 2006a. "Firm Size Data from the Statistics of U.S. Businesses: U.S. Detail Employment Sizes: 2002." <http://www.census.gov/csd/susb/download_susb02.htm>. Downloaded 1/11/10.

## Table 6-3. Average Receipts for Affected Industry by Enterprise Receipt Range: 2002 ($2008 /establishment)

| NAICS | NAICS Description | SBA Size Standard for Businesses (effective August 22nd, 2008) | All Enterprises | 0–99K Receipts | Owned By Enterprises with Receipt Range: | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 100–499.9K Receipts | 500–999.9K Receipts | 1,000–4,999.9K Receipts | 5,000,000–9,999,999K Receipts | <10,000K Receipts | 10,000–49,999K Receipts | 50,000–99,999K Receipts | 100,000K+ Receipts |
| 2211 | Electric Power Generation | [a] | $39.8 | $0.1 | $0.3 | $0.8 | $3.0 | $6.6 | $2.7 | $14.7 | $22.2 | $49.2 |
| 622110 | Hospitals | $34.5 million in annual receipts | $92.30 | NA | NA | $0.84 | $3.59 | $8.21 | $5.03 | $25.49 | $65.89 | $148.57 |
| 234110 | Highway & street construction | $33.5 million in Annual Receipts | $7.74 | $0.06 | $0.32 | $0.84 | $2.74 | $8.11 | $2.00 | $22.62 | $56.48 | $56.81 |
| 234120 | Bridge & tunnel construction | $33.5 million in Annual Receipts | $14.09 | $0.05 | $0.30 | $0.89 | $2.90 | $8.08 | $2.53 | $25.25 | $57.00 | $79.62 |
| 234910 | Water, sewer, & pipeline construction | $33.5 million in Annual Receipts | $3.89 | $0.06 | $0.32 | $0.85 | $2.73 | $8.17 | $1.84 | $20.62 | $45.05 | $47.27 |
| 234920 | Power & communication transmission line construction | $33.5 million in Annual Receipts | $3.39 | $0.06 | $0.31 | $0.83 | $2.52 | $7.75 | $1.32 | $16.84 | $34.50 | $23.86 |
| 234930 | Industrial nonbuilding structure construction | $33.5 million in Annual Receipts | $35.93 | $0.05 | $0.30 | $0.85 | $2.71 | $8.38 | $1.73 | $22.34 | $30.90 | $174.38 |
| 234990 | All other heavy construction | $33.5 million in Annual Receipts | $2.66 | $0.06 | $0.30 | $0.83 | $2.48 | $7.76 | $0.99 | $18.72 | $40.53 | $42.35 |
| 92811 | National Security | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

Notes: Note: Industries in green were included for consistency with the analysis done for proposed rule (Under direction from EPA - to investigate if rule affects downstream users of engines).
National Security is included in this table but does not have size standards.

[a] NAICS codes 221111, 221112, 221113, 221119, 221121, 221122: A firm in these industries is defined as small by SBA if, including its affiliates, it is primarily engaged in the generation, transmission, and/or distribution of electric energy for sale and its total electric output for the preceding fiscal year did not exceed 4 million megawatt hours.

NA = Not available. SUSB did not report this data for disclosure or other reasons.

Source: U.S. Census Bureau. 2006a. "Firm Size Data from the Statistics of U.S. Businesses: U.S. Detail Employment Sizes: 2002." <http://www.census.gov/csd/susb/download_susb02.htm>.

Annual entity compliance costs vary depending on the size of the diesel engines used at the affected establishment. Absent facility-specific information, we computed per-entity compliance costs based for three different cases based on representative establishments—Cases 1, 2, and 3 (see Table 6-4). Each representative establishment differs based on the size and number of diesel engines being used. Compliance costs are calculated by summing the total annualized compliance costs for the relevant engine categories, dividing the sum by the total existing population of those engines, and multiplying the average engine cost by the number of engines assumed to be at the establishment. Since NAICS 2211 and 622110 are fundamentally different than other industries considered in this analysis, we used different assumptions about what constitutes the representative establishment and report these assumptions separately.

- Case 1: The representative establishment for all industries uses three 750+ hp engines with an average compliance cost of $1,877 per engine, resulting in a total annualized compliance cost of approximately $5,631 for this representative establishment.
- Case 2: The representative establishment in NACIS 2211 and 622110 uses two 50 to 750+ hp engines with an average compliance cost of $437 per engine, resulting in a total annualized compliance cost of $874 for this representative establishment. For all other industries, the representative establishment uses two 50 to 300 hp engines with an average compliance cost of $155 per engine, resulting in a total compliance cost of $310 for this representative establishment.
- Case 3: The representative establishment for all industries uses two 50 to 100 hp engines with an average compliance cost of $68 per engine, resulting in a total compliance cost of $137 for this representative establishment.

EPA believes that small entities are most likely to face costs similar to Case 2 (columns shaded in gray in Table 6-4) because most of the engines to be affected by this proposal in NAICS 335312, 333992, 211111, and 211112 are under 300 hp capacity, and most small entities in these industries will own engines of this size or smaller. This is corroborated by Figure 6-1 and 6-2 which shows the distribution of engine population and compliance costs by engine size for all industries. However, it is difficult to make a similar claim for NAICS 2211 and 622110 based on the existing distribution of engines in these industries.[6] As noted earlier in the RIA, only 20 percent of the existing distribution of engines is expected to be classified as non-emergency.

[6]This claim also cannot be made for NAICS 92811: National Security. However, since most national security installations are owned by the federal government (e.g., military bases), EPA assumes these entities would not be considered small.

For the sales test, we divided the representative establishment compliance costs reported in Table 6-4 by the representative establishment receipts reported in Tables 6-2 and 6-3. This is known as the cost-to-receipt (i.e., sales) ratio, or the "sales test." The "sales test" is the impact

**Table 6-4. Representative Establishment Costs Used for Small Entity Analysis ($2008)**

| | Case 1 | | Case 2 | | Case 3 | |
|---|---|---|---|---|---|---|
| | NAICS 2211, 622110 (+750 hp only) | All Other NAICS (+750 hp only) | NAICS 2211, 622110 (50–750+ hp) | All Other NAICS (50–300 hp) | NAICS 2211, 622110 (50–100 hp only) | All Other NAICS (50–100 hp only) |
| Total Annualized Costs ($) | $62,035,845 | $7,871,576 | $317,603,287 | $42,778,499 | $9,093,118 | $6,745,516 |
| Engine Population | 33,052 | 4,194 | 727,090 | 276,374 | 133,099 | 98,736 |
| Average Engine Cost ($/engine) | $1,877 | $1,877 | $437 | $155 | $68 | $68 |
| Assumed Engines Per Establishment | 3 | 3 | 2 | 2 | 2 | 2 |
| Total Annualized Costs per Establishment | $5,631 | $5,631 | $874 | $310 | $137 | $137 |

* Engine population estimates taken from "Impacts Associated with NESHAP for Existing Stationary CI RICE," prepared by Bradley Nelson, Ec/R, Inc. for Melanie King, U.S. EPA, Office of Air Quality Planning and Standards, February 10, 2010.

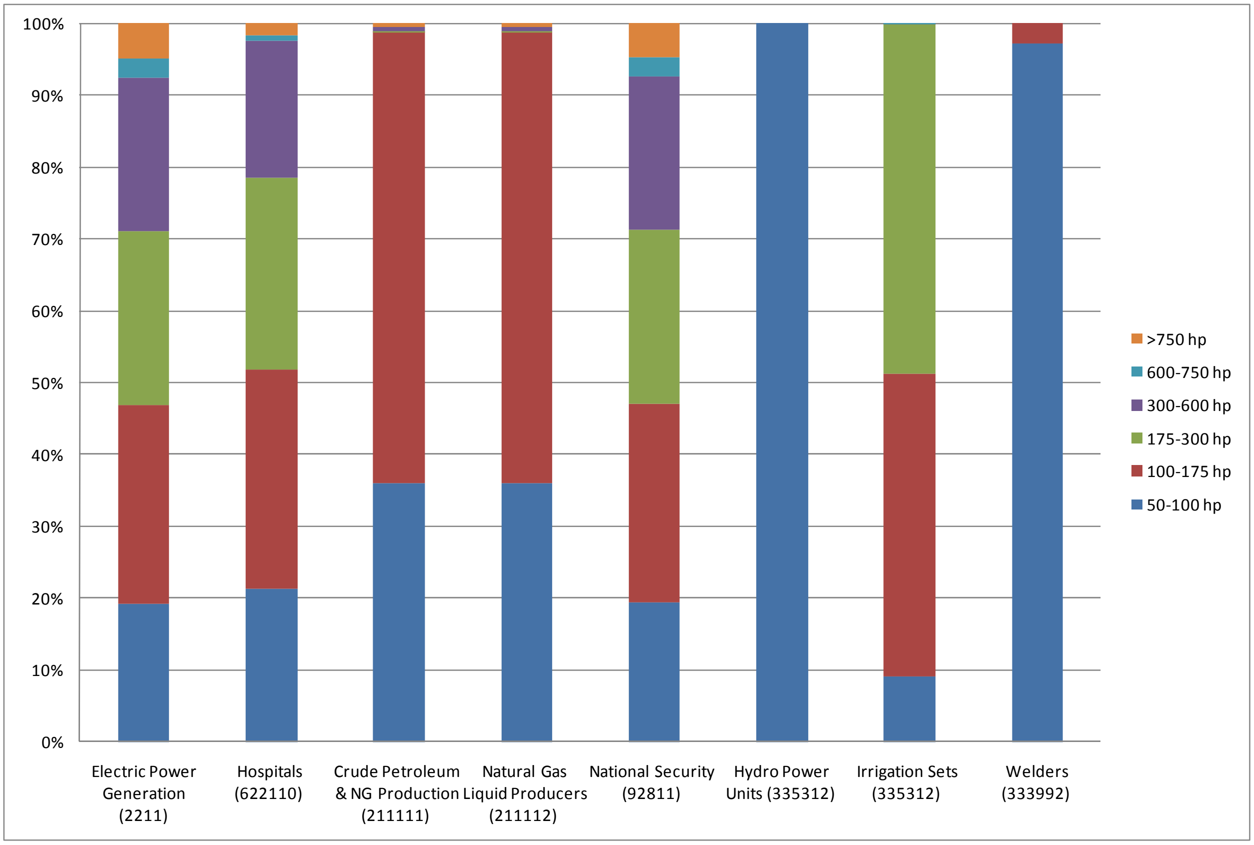



**Figure 6-1. Distribution of Engine Population by Size for All Industries**

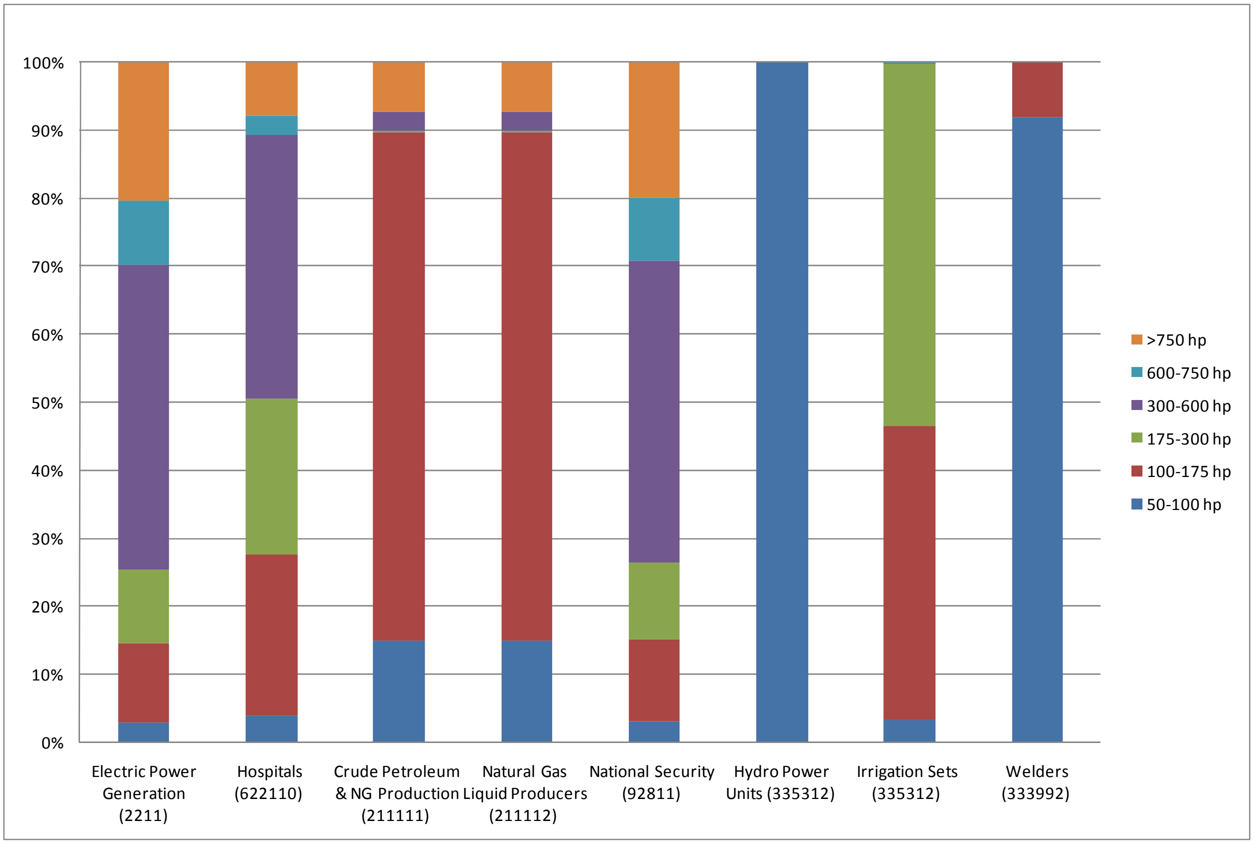



**Figure 6-2. Distribution of Compliance Costs by Engine Size for All Industries**

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.

This is because revenues or sales data are commonly available data for entities normally 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 usually 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[7] and is consistent with guidance published by the U.S. SBA's Office of Advocacy that suggests that cost as a

[7]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/rfafinalguidance06.pdf, pp. 24-25.

percentage of total revenues is a metric for evaluating cost increases on small entities in relation to increases on large entities.[8]

If the cost-to-receipt ratio is less than 1%, then we consider the final rule to not have a significant impact on the establishment company in question. We summarize the industries with cost-to-receipt ratios exceeding 1% below:

*Primary Analysis:*

- *Case 2*: NAICS 2211 with receipts less than $100,000 per year
- *Case 3*: No industries

*Sensitivity Analysis (unlikely):*

- *Case 1*: NAICS 211111, 211112, with less than 20 employees, NAICS 2211 with receipts less than $500,000 per year, NAICS 234 with receipts less than $500,000 per year, and irrigated farms with receipts of $500,000 or less per year

In the Case 2 primary analysis, only establishments in NAICS 2211 with receipts less than $100,000 per year have cost-to-receipt ratios above 1%. These establishments represent less than 5 percent of affected small establishments. However, establishments earning this level of receipts are likely to be using smaller engines than those assumed in Case 2, such as 50 to 100 hp engines. The results of our Case 3 analysis demonstrate that these establishments are not significantly impacted when taking this engine size into account.

## 6.3 Small Government Entities

The rule also covers sectors that include entities owned by small and large governments. However, given the uncertainty and data limitations associated with identifying and appropriately classifying these entities, we computed a "revenue" test for a model small government, where the annualized compliance cost is a percentage of annual government revenues (U.S. Census, 2005a, b). The use of a "revenue test" for estimating impacts to small governments for a rulemaking such as this one is consistent with guidance offered by EPA on compliance with SBREFA,[9] and is consistent with guidance published by the US SBA's Office of Advocacy.[10] For example, from the 2002 Census (in 2008 dollars), the average revenue for

[8] 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, May 2003.

[9] The SBREFA 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/rfafinalguidance06.pdf, pp. 24-25.

[10] 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, May 2003.

small governments (counties and municipalities) with populations fewer than 10,000 are $3 million per entity, and the average revenue for local governments with populations fewer than 50,000 is $8 million per entity. For the smallest group of local governments (<10,000 people), the cost-to-revenue ratio would be 0.2% or less under each case. For the larger group of governments (<50,000 people), the cost-to-revenue ratio is 0.1% or less under all cases.

## SECTION 7
## HUMAN HEALTH BENEFITS OF EMISSIONS REDUCTIONS

### 7.1 Synopsis

In this section, we provide an estimate of the particulate matter (PM) co-benefits for the final NESHAP for existing stationary compression ignition (RICE). Specifically, we calculated the benefits of this rule in terms of the co-benefits associated with reducing PM rather than calculating the benefits associated with reducing hazardous air pollutants (HAPs). These PM reductions are a consequence of the technologies installed to reduce HAP emissions from RICE. These estimates reflect the monetized human health co-benefits of reducing cases of morbidity and premature mortality associated with reducing exposure to the $PM_{2.5}$ precursors from the current RICE technology. We estimate the total monetized $PM_{2.5}$ co-benefits to be $940 million to $2.3 billion (2008$) at a 3% discount rate and $850 million to $2.1 billion at a 7% discount rate in the year of full implementation (2013). Data, resource, and methodological limitations prevented EPA from quantifying or monetizing the benefits from several important benefit categories, including benefits from reducing carbon monoxide (CO) and HAPs, ecosystem effects, and visibility impairment. The benefits from reducing 1,014 tons of hazardous air pollutants each year have not been monetized in this analysis.

These estimates of the reduction in particulate matter-related health effects reflect EPA's most current interpretation of the scientific literature and include four key updates: (1) a no-threshold model for $PM_{2.5}$ that calculates incremental co-benefits down to the lowest modeled air quality levels; (2) a revised Value of a Statistical Life (VSL); (3) two technical updates to the population dataset and aggregation method; (4) presentation of results derived from Pope et al. (2002) and Laden et al. (2006) instead of using the extremes of EPA's Expert Elicitation on PM Mortality (Roman et al., 2008). Higher or lower estimates of co-benefits are possible using other assumptions; examples of this are provided in Figure 7-2.

### 7.2 Calculation of $PM_{2.5}$ Human Health Co-benefits

This rulemaking would reduce emissions of $PM_{2.5}$, $SO_2$, and VOCs. Because SOx and VOCs are also precursors to $PM_{2.5}$, reducing these emissions would also reduce $PM_{2.5}$ formation, human exposure and the incidence of $PM_{2.5}$-related health effects. In this analysis, we estimated the co-benefits of reducing $PM_{2.5}$ exposure for the alternative standards. Due to analytical limitations, it was not possible to provide a comprehensive estimate of $PM_{2.5}$-related co-benefits. Instead, we used the "benefit-per-ton" method to estimate these co-benefits (Fann et al., 2009). The $PM_{2.5}$ benefit-per-ton methodology incorporates key assumptions described in detail below.

These $PM_{2.5}$ benefit-per-ton estimates provide the total monetized human health co-benefits (the sum of premature mortality and premature morbidity) of reducing one ton of $PM_{2.5}$ from a specified source. EPA has used the benefit per-ton technique in previous RIAs, including the recent $SO_2$ NAAQS RIA (U.S. EPA, 2009b). Table 7-1 shows the quantified and unquantified co-benefits captured in those benefit-per-ton estimates.

**Table 7-1. Human Health and Welfare Effects of $PM_{2.5}$**

| Pollutant / Effect | Quantified and Monetized in Primary Estimates | Unquantified Effects Changes in: |
|---|---|---|
| $PM_{2.5}$ | Adult premature mortality | Subchronic bronchitis cases |
| | Bronchitis: chronic and acute | Low birth weight |
| | Hospital admissions: respiratory and cardiovascular | Pulmonary function |
| | Emergency room visits for asthma | Chronic respiratory diseases other than chronic bronchitis |
| | Nonfatal heart attacks (myocardial infarction) | Non-asthma respiratory emergency room visits |
| | Lower and upper respiratory illness | Visibility |
| | Minor restricted-activity days | Household soiling |
| | Work loss days | |
| | Asthma exacerbations (asthmatic population) | |
| | Infant mortality | |

Consistent with the Portland Cement NESHAP (U.S. EPA, 2009a), the co-benefits estimates utilize the concentration-response functions as reported in the epidemiology literature, as well as the 12 functions obtained in EPA's expert elicitation study as a sensitivity analysis.

- One estimate is based on the concentration-response (C-R) function developed from the extended analysis of American Cancer Society (ACS) cohort, as reported in Pope et al. (2002), a study that EPA has previously used to generate its primary PM co-benefits estimate. When calculating the estimate, EPA applied the effect coefficient as reported in the study without an adjustment for assumed concentration threshold of 10 µg/m3 as was done in recent (post-2006) Office of Air and Radiation RIAs.

- One estimate is based on the C-R function developed from the extended analysis of the Harvard Six Cities cohort, as reported by Laden et al (2006). This study, published after the completion of the Staff Paper for the 2006 PM2.5 NAAQS, has been used as an alternative estimate in the PM2.5 NAAQS RIA and PM2.5 co-benefits estimates in RIAs completed since the PM2.5 NAAQS. When calculating the estimate, EPA applied the effect coefficient as reported in the study without an adjustment for assumed concentration threshold of 10 µg/m3 as was done in recent (post 2006) RIAs.

- Twelve estimates are based on the C-R functions from EPA's expert elicitation study (Roman et al., 2008) on the PM2.5 -mortality relationship and interpreted for PM co-benefits analysis in EPA's final RIA for the PM2.5 NAAQS. For that study, twelve experts (labeled A through L) provided independent estimates of the PM2.5-mortality concentration-response function. EPA practice has been to develop independent estimates of PM2.5-mortality estimates corresponding to the concentration-response function provided by each of the twelve experts, to better characterize the degree of variability in the expert responses.

The effect coefficients are drawn from epidemiology studies examining two large population cohorts: the American Cancer Society cohort (Pope et al., 2002) and the Harvard Six Cities cohort (Laden et al., 2006).[1] These are logical choices for anchor points in our presentation because, while both studies are well designed and peer reviewed, there are strengths and weaknesses inherent in each, which we believe argues for using both studies to generate co-benefits estimates. Previously, EPA had calculated co-benefits based on these two empirical studies, but derived the range of co-benefits, including the minimum and maximum results, from an expert elicitation of the relationship between exposure to $PM_{2.5}$ and premature mortality (Roman et al., 2008).[2] Within this assessment, we include the co-benefits estimates derived from the concentration-response function provided by each of the twelve experts to better characterize the uncertainty in the concentration-response function for mortality and the degree of variability in the expert responses. Because the experts used these cohort studies to inform their concentration-response functions, co-benefits estimates using these functions generally fall between results using these epidemiology studies (see Figure 7-2). In general, the expert elicitation results support the conclusion that the co-benefits of $PM_{2.5}$ control are very likely to be substantial.

Readers interested in reviewing the methodology for creating the benefit-per-ton estimates used in this analysis should consult Fann et al. (2009). As described in the documentation for the benefit per-ton estimates cited above, national per-ton estimates are developed for selected pollutant/source category combinations. The per-ton values calculated therefore apply only to tons reduced from those specific pollutant/source combinations (e.g., $NO_2$ emitted from electric generating units; $NO_2$ emitted from mobile sources). Our estimate of $PM_{2.5}$ co-control benefits is therefore based on the total $PM_{2.5}$ emissions controlled by sector and multiplied by this per-ton value.

---

[1] These two studies specify multi-pollutant models that control for $SO_2$, among other co-pollutants.
[2] Please see the Section 5.2 of the Portland Cement RIA in Appendix 5A for more information regarding the change in the presentation of benefits estimates.

The underlying emissions modeling and air quality modeling account for the current distribution of emissions sources, including both urban and rural sources. In addition, the air quality modeling included 14 vertical layers to simulate the differences between ground-level emissions and higher stack emissions (U.S. EPA, 2006a). The distance that particles travel primarily depends on the size of the particle, the amount and release height of emissions, terrain, and meteorological conditions, such as wind speed and precipitation. Fine particles can have an atmospheric half-life of days to weeks and travel hundreds to thousands of kilometers, whereas ultrafine and coarse particles travel less than ten kilometers (U.S. EPA, 2009c). Because we have not undertaken a study specific to emissions at ground level from RICE, with regard to transport issues and to size fraction of $PM_{2.5}$ emissions (e.g., ultrafines and near ultrafines), there is uncertainty as to how far such emissions will travel and thus with regard to populations affected. Evidence from recent air quality modeling for mobile source rules with similar engines (U.S. EPA, 1999; U.S. EPA, 2000; U.S. EPA, 2004; U.S. EPA, 2008e; U.S. EPA, 2010c) shows that some fine particles can travel long distances in the atmosphere, but the proportion of such emissions from RICE that travel more than short distances is not yet definitively known.

The benefit-per-ton coefficients in this analysis were derived using modified versions of the health impact functions used in the PM NAAQS Regulatory Impact Analysis (U.S. EPA, 2006b). Specifically, this analysis uses the benefit-per-ton method first applied in the Portland Cement NESHAP RIA (U.S. EPA, 2009a), which incorporated three updates: a new population dataset, an expanded geographic scope of the benefit-per-ton calculation, and the functions directly from the epidemiology studies without an adjustment for an assumed threshold.[3] Removing the threshold assumption is a key difference between the method used in this analysis of PM co-benefits and the methods used in RIAs prior to that for the Portland Cement NESHAP, and we now calculate incremental co-benefits down to the lowest modeled $PM_{2.5}$ air quality levels.

EPA strives to use the best available science to support our benefits analyses, and we recognize that interpretation of the science regarding air pollution and health is dynamic and evolving. Based on our review of the body of scientific literature, EPA applied the no-threshold model in this analysis. EPA's Integrated Science Assessment for Particulate Matter (U.S. EPA, 2009c), which was recently reviewed by EPA's Clean Air Scientific Advisory Committee (U.S. EPA-SAB, 2009a; U.S. EPA-SAB, 2009b), concluded that the scientific literature consistently finds that a no-threshold log-linear model most adequately portrays the PM-mortality

[3] The benefit-per-ton estimates have also been updated since the Cement RIA to incorporate a revised VSL, as discussed on the next page.

concentration-response relationship while recognizing potential uncertainty about the exact shape of the concentration-response function.[4] Although this document does not necessarily represent agency policy, it provides a basis for reconsidering the application of thresholds in $PM_{2.5}$ concentration-response functions used in EPA's RIAs.[5]

Because the co-benefits are sensitive to the assumption of a threshold, we also provide a sensitivity analysis using the previous methodology (i.e., a threshold model at 10 $\mu g/m^3$ without the two technical updates) as a historical reference. Table 7-5 shows the sensitivity of an assumed threshold on the monetized results, with and without an assumed threshold at 10 $\mu g/m^3$.

As is the nature of Regulatory Impact Analyses (RIAs), the assumptions and methods used to estimate air quality benefits evolve over time to reflect the Agency's most current interpretation of the scientific and economic literature. For a period of time (2004–2008), the Office of Air and Radiation (OAR) valued mortality risk reductions using a value of statistical life (VSL) estimate derived from a limited analysis of some of the available studies. OAR arrived at a VSL using a range of $1 million to $10 million (2000$) consistent with two meta-analyses of the wage-risk literature. The $1 million value represented the lower end of the interquartile range from the Mrozek and Taylor (2002) meta-analysis of 33 studies. The $10 million value represented the upper end of the interquartile range from the Viscusi and Aldy (2003) meta-analysis of 43 studies. The mean estimate of $5.5 million (2000$)[6] was also consistent with the mean VSL of $5.4 million estimated in the Kochi et al. (2006) meta-analysis. However, the Agency neither changed its official guidance on the use of VSL in rule-makings nor subjected the interim estimate to a scientific peer-review process through the Science Advisory Board (SAB) or other peer-review group.

During this time, the Agency continued work to update its guidance on valuing mortality risk reductions, including commissioning a report from meta-analytic experts to evaluate methodological questions raised by EPA and the SAB on combining estimates from the various data sources. In addition, the Agency consulted several times with the Science Advisory Board Environmental Economics Advisory Committee (SAB-EEAC) on the issue. With input from the

[4] It is important to note that uncertainty regarding the shape of the concentration-response function is conceptually distinct from an assumed threshold. An assumed threshold (below which there are no health effects) is a discontinuity, which is a specific example of non-linearity.

[5] In the Portland Cement RIA (U.S. EPA, 2009a), EPA solicited comment on the use of the no-threshold model for benefits analysis within the preamble of that proposed rule. The comment period for the Portland Cement proposed NESHAP closed on September 4, 2009 (Docket ID No. EPA–HQ–OAR–2002–0051 available at http://www.regulations.gov). EPA is currently reviewing those comments.

[6] In this analysis, we adjust the VSL to account for a different currency year (2008$) and to account for income growth to 2015. After applying these adjustments to the $5.5 million value, the VSL is $7.9 million.

meta-analytic experts, the SAB-EEAC advised the Agency to update its guidance using specific, appropriate meta-analytic techniques to combine estimates from unique data sources and different studies, including those using different methodologies (i.e., wage-risk and stated preference) (U.S. EPA-SAB, 2007).

Until updated guidance is available, the Agency determined that a single, peer-reviewed estimate applied consistently best reflects the SAB-EEAC advice it has received. Therefore, the Agency has decided to apply the VSL that was vetted and endorsed by the SAB in the Guidelines for Preparing Economic Analyses (U.S. EPA, 2000)[7] while the Agency continues its efforts to update its guidance on this issue. This approach calculates a mean value across VSL estimates derived from 26 labor market and contingent valuation studies published between 1974 and 1991. The mean VSL across these studies is $6.3 million (2000$).[8] The Agency is committed to using scientifically sound, appropriately reviewed evidence in valuing mortality risk reductions and has made significant progress in responding to the SAB-EEAC's specific recommendations. The Agency anticipates presenting results from this effort to the SAB-EEAC in Spring 2010 and that draft guidance will be available shortly thereafter.

Figure 7-1 illustrates the relative breakdown of the monetized $PM_{2.5}$ health co-benefits.

[7] In the (draft) update of the Economic Guidelines (U.S. EPA, 2008), EPA retained the VSL endorsed by the SAB with the understanding that further updates to the mortality risk valuation guidance would be forthcoming in the near future. Therefore, this report does not represent final agency policy.

[8] In this analysis, we adjust the VSL to account for a different currency year (2008$) and to account for income growth to 2015. After applying these adjustments to the $6.3 million value, the VSL is $9.1m.

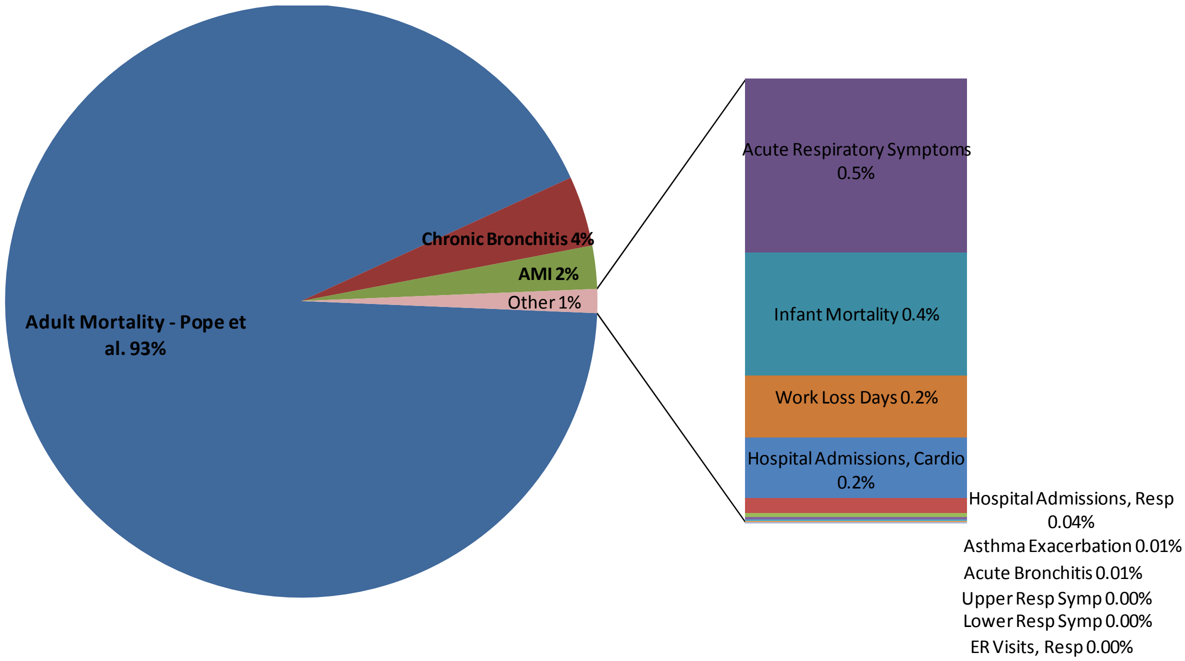



**Figure 7-1. Breakdown of Monetized PM2.5 Health Co-benefits using Mortality Function from Pope et al. (2002)[a]**

[a] This pie chart breakdown is illustrative, using the results based on Pope et al. (2002) as an example. Using the Laden et al. (2006) function for premature mortality, the percentage of total monetized $PM_{2.5}$ co-benefits due to adult premature mortality would be 97%. This chart shows the breakdown using a 3% discount rate, and the results would be similar if a 7% discount rate was used.

Table 7-2 provides a general summary of the results by pollutant, including the emission reductions and monetized benefits-per-ton at discount rates of 3% and 7%.[9]. Table 7-3 provides a summary of the reductions in health incidences as a result of the pollution reductions. In Table 7-4, we provide the co-benefits using our anchor points of Pope et al. and Laden et al. as well as the results from the expert elicitation on $PM_{2.5}$-related premature mortality. Figures 7-2 and 7-3 provide a visual representation of the range of co-benefits estimates and the pollutant breakdown of the monetized co-benefits.

---

[9] To comply with Circular A-4, EPA provides monetized benefits using discount rates of 3% and 7% (OMB, 2003). These benefits are estimated for a specific analysis year (i.e., 2013), and most of the PM co-benefits occur within that year with two exceptions: acute myocardial infarctions (AMIs) and premature mortality. For AMIs, we assume 5 years of follow-up medical costs and lost wages. For premature mortality, we assume that there is a "cessation" lag between PM exposures and the total realization of changes in health effects. Although the structure of the lag is uncertain, EPA follows the advice of the SAB-HES to assume a segmented lag structure characterized by 30% of mortality reductions in the first year, 50% over years 2 to 5, and 20% over the years 6 to 20 after the reduction in $PM_{2.5}$ (U.S. EPA-SAB, 2004). Changes in the lag assumptions do not change the total number of estimated deaths but rather the timing of those deaths. Therefore, discounting only affects the AMI costs after the analysis year and the valuation of premature mortalities that occur after the analysis year. As such, the monetized benefits using a 7% discount rate are only approximately 10% less than the monetized benefits using a 3% discount rate.

.

## Table 7-2. Summary of Monetized $PM_{2.5}$-related Co-benefits Estimates for RICE NESHAP for Compression Ignition in 2013 (2008$)[a]

| 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 Co-benefits (millions 2008$ at 3%) | Total Monetized Co-benefits (millions 2008$ at 7%) |
|---|---|---|---|---|---|---|---|
| Direct $PM_{2.5\ Major}$ | 874 | $230,000 | $560,000 | $210,000 | $500,000 | $200 to $490 | $180 to $440 |
| Direct $PM_{2.5\ Area}$ | 1,970 | $360,000 | $880,000 | $330,000 | $790,000 | $710 to $1,700 | $640 to $1,600 |
| $PM_{2.5}$ Precursors | | | | | | | |
| VOC | 27,395 | $1,200 | $3,000 | $1,100 | $2,700 | $33 to $82 | $30 to $74 |
| | | | | | **Total** | **$940 to $2,300** | **$850 to $2,100** |

[a] All estimates are for the analysis year (year of implementation, 2013), and are rounded to two significant figures so numbers may not sum across columns. All fine particles are assumed to have equivalent health effects, but the benefit per ton estimates vary because each ton of precursor reduced has a different propensity to become $PM_{2.5}$. The monetized co-benefits incorporate the conversion from precursor emissions to ambient fine particles.

## Table 7-3. Summary of Reductions in Health Incidences from $PM_{2.5}$ Co-benefits for RICE NESHAP in 2013[a]

| | |
|---|---|
| **Avoided Premature Mortality** | |
| Pope et al. | 110 |
| Laden et al. | 270 |
| **Avoided Morbidity** | |
| Chronic Bronchitis | 75 |
| Acute Myocardial Infarction | 170 |
| Hospital Admissions, Respiratory | 25 |
| Hospital Admissions, Cardiovascular | 53 |
| Emergency Room Visits, Respiratory | 84 |
| Acute Bronchitis | 180 |
| Work Loss Days | 15,000 |
| Asthma Exacerbation | 1,900 |
| Acute Respiratory Symptoms | 87,000 |
| Lower Respiratory Symptoms | 2,100 |
| Upper Respiratory Symptoms | 1,600 |

[a] All estimates are for the analysis year (2013) and are rounded to whole numbers with two significant figures. All fine particles are assumed to have equivalent health effects, but each $PM_{2.5}$ precursor pollutant has a different propensity to form $PM_{2.5}$. Confidence intervals are unavailable for this analysis because of the benefit-per-ton methodology.

**Table 7-4. All $PM_{2.5}$ Co-benefits Estimates for the RICE NESHAP at discount rates of 3% and 7% in 2013 (in millions of 2008$)[a]**

| | 3% | 7% |
|---|---|---|
| **Benefit-per-ton Coefficients Derived from Epidemiology Literature** | | |
| Pope et al. | $940 | $850 |
| Laden et al. | $2,300 | $2,100 |
| **Benefit-per-ton Coefficients Derived from Expert Elicitation** | | |
| Expert A | $2,400 | $2,200 |
| Expert B | $1,900 | $1,700 |
| Expert C | $1,900 | $1,700 |
| Expert D | $1,300 | $1,200 |
| Expert E | $3,000 | $2,700 |
| Expert F | $1,700 | $1,500 |
| Expert G | $1,100 | $1,000 |
| Expert H | $1,400 | $1,300 |
| Expert I | $1,800 | $1,700 |
| Expert J | $1,500 | $1,400 |
| Expert K | $380 | $350 |
| Expert L | $1,400 | $1,200 |

[a] All estimates are rounded to two significant figures. Estimates do not include confidence intervals because they were derived through the benefit-per-ton technique described above. The co-benefits estimates from the Expert Elicitation are provided as a reasonable characterization of the uncertainty in the mortality estimates associated with the concentration-response function. Confidence intervals are unavailable for this analysis because of the benefit-per-ton methodology.

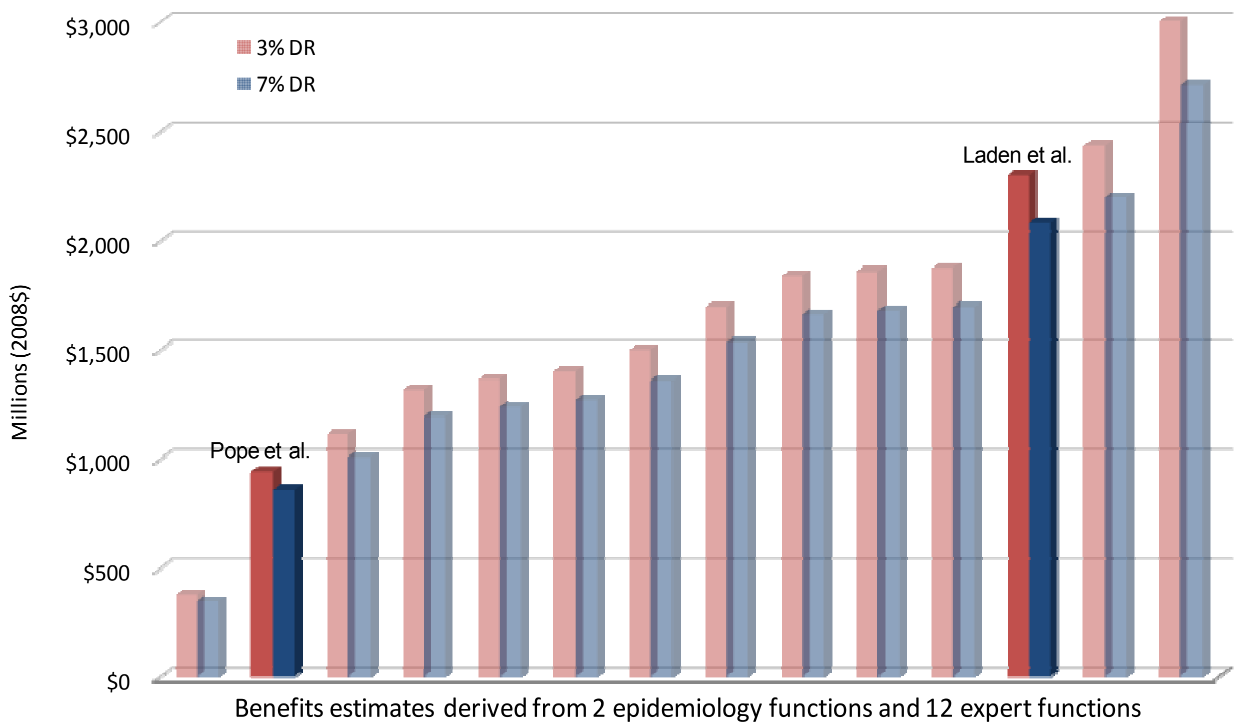



**Figure 7-2. Total Monetized PM2.5 Co-Benefits of RICE NESHAP in 2013[a]**

[a] This graph shows the estimated co-benefits at discount rates of 3% and 7% using effect coefficients derived from the Pope et al. study and the Laden et al. study, as well as 12 effect coefficients derived from EPA's expert elicitation on PM mortality. The results shown are not the direct results from the studies or expert elicitation; rather, the estimates are based in part on the concentration-response function provided in those studies.

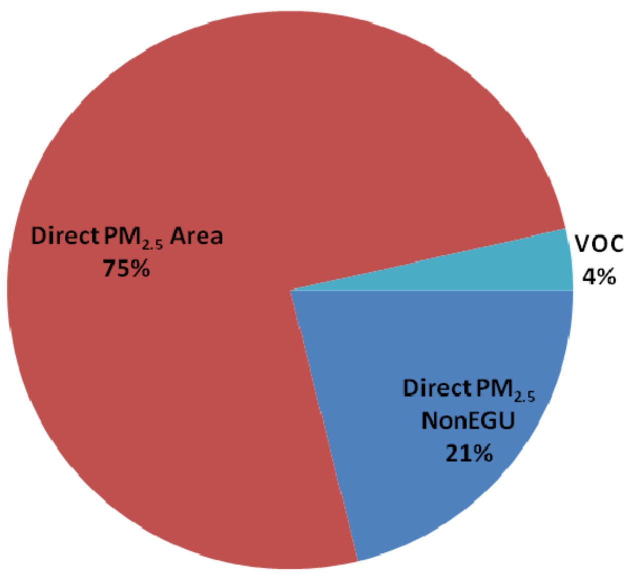



**Figure 7-3. Breakdown of Monetized Co-benefits for RICE NESHAP by $PM_{2.5}$ Precursor Pollutant and Source**

## 7.3 Unquantified Benefits

The monetized co-benefits estimated in this RIA only reflect the portion of benefits attributable to the health effect reductions associated with ambient fine particles. Data, resource, and methodological limitations prevented EPA from quantifying or monetizing the benefits from several important benefit categories, including benefits from reducing carbon monoxide and hazardous air pollutants, ecosystem effects, and visibility impairment. The health benefits from reducing 1,014 tons of hazardous air pollutants (HAPs) and the 14,000 tons of carbon monoxide each year have not been monetized in this analysis.

In this analysis, we have not quantified the benefits attributable to the $SO_2$ reductions that would occur as a result of these engines switching to ultra-low sulfur diesel (ULSD). Although we are confident that some $SO_2$ reductions would occur as a result of this rule, we are unable to estimate the percentage of engines that may switch to ULSD in the absence of this rule or the number of engines that already use ULSD. As a $PM_{2.5}$ precursor, these $SO_2$ emission reductions would lead to fewer $PM_{2.5}$-related health effects. Because of uncertainty in the magnitude of the attributable $SO_2$ reductions and to avoid the appearance of double-counting, we have chosen to not include these estimates in any of the results tables or graphics in this RIA. If none of the affected engines would use ULSD without this rule, then we estimate the additional monetized $PM_{2.5}$-related health co-benefits would be $720 million to $1.8 billion in 2013 (2008$, 3% discount rate). This is based on reductions of 31,000 tons of $SO_2$ emission reductions in the year 2013 that will take place if all affected engines would switch to ULSD for higher-sulfur diesel fuel (3000 ppm sulfur content) as mentioned in Section 4. If all of the affected engines would use ULSD regardless of the rule, then the monetized co-benefits from $SO_2$ reductions would be zero. In addition to being a $PM_{2.5}$ precursor, $SO_2$ emissions also contribute to adverse effects from acidic deposition in aquatic and terrestrial ecosystems as well as visibility impairment.

### *HAP benefits*

Due to data, resource, and methodology limitations, we were unable to estimate the benefits associated with the 1,014 tons of hazardous air pollutants that would be reduced as a result of this rule. Available emissions data show that several different HAPs are emitted from stationary engines, either contained within the fuel burned or formed during the combustion process.[10] Although numerous HAPs may be emitted from diesel stationary RICE, a few HAPs account for 80% of the total mass of HAPs emissions emitted. These HAPs are formaldehyde (25%), acetaldehyde (19%), polycyclic aromatic hydrocarbons (PAHs) (18%), naphthalene (9%), and acrolein (9%). Other HAPs from diesel stationary RICE represent less than 5% each of the total mass of HAP emissions, including 1,3-butadiene (4.4%), toluene (3.8%), styrene (3.5%) , benzene (2.8%), xylene (2.7%), hexane (1.8%), and ethylbenzene (0.3%). Metallic HAPs from diesel fired stationary RICE represent less than 0.3% each of total mass of HAP emissions, including cadmium, lead, nickel, chromium, selenium, and mercury. Below we describe the health effects associated with the top 5 HAPs by mass emitted from RICE.

*Formaldehyde*

Since 1987, EPA has classified formaldehyde as a probable human carcinogen based on evidence in humans and in rats, mice, hamsters, and monkeys.[11] EPA is currently reviewing recently published epidemiological data. For instance, research conducted by the National Cancer Institute (NCI) found an increased risk of nasopharyngeal cancer and lymphohematopoietic malignancies such as leukemia among workers exposed to formaldehyde.[12,13] In an analysis of the lymphohematopoietic cancer mortality from an extended follow-up of these workers, NCI confirmed an association between lymphohematopoietic cancer risk and peak exposures.[14] A recent National Institute of Occupational Safety and Health (NIOSH) study of garment workers also found increased risk of death due to leukemia among workers exposed to formaldehyde.[15] Extended follow-up of a cohort of British chemical workers did not find evidence of an increase in nasopharyngeal or lymphohematopoietic cancers, but a continuing statistically significant excess in lung cancers was reported.[16]

---

[10] Alpha-Gamma Technologies, Inc. 2004. Memo to U.S. EPA: Development of HAP Emission Factors for Small (<500 HP) Stationary Reciprocating Internal Combustion Engines (RICE). Attachment A. April 13. Available in the docket at EPA-HQ-OAR-2005-0030-0009 at www.regulations.gov.

[11] U.S. EPA. 1987. Assessment of Health Risks to Garment Workers and Certain Home Residents from Exposure to Formaldehyde, Office of Pesticides and Toxic Substances, April 1987.

[12] Hauptmann, M..; Lubin, J. H.; Stewart, P. A.; Hayes, R. B.; Blair, A. 2003. Mortality from lymphohematopoetic malignancies among workers in formaldehyde industries. Journal of the National Cancer Institute 95: 1615-1623.

[13] Hauptmann, M..; Lubin, J. H.; Stewart, P. A.; Hayes, R. B.; Blair, A. 2004. Mortality from solid cancers among workers in formaldehyde industries. American Journal of Epidemiology 159: 1117-1130.

[14] Beane Freeman, L. E.; Blair, A.; Lubin, J. H.; Stewart, P. A.; Hayes, R. B.; Hoover, R. N.; Hauptmann, M. 2009. Mortality from lymphohematopoietic malignancies among workers in formaldehyde industries: The National Cancer Institute cohort. J. National Cancer Inst. 101: 751-761.

[15] Pinkerton, L. E. 2004. Mortality among a cohort of garment workers exposed to formaldehyde: an update. Occup. Environ. Med. 61: 193-200.

[16] Coggon, D, EC Harris, J Poole, KT Palmer. 2003. Extended follow-up of a cohort of British chemical workers exposed to formaldehyde. J National Cancer Inst. 95:1608-1615.

In the past 15 years there has been substantial research on the inhalation dosimetry for formaldehyde in rodents and primates by the CIIT Centers for Health Research (formerly the Chemical Industry Institute of Toxicology), with a focus on use of rodent data for refinement of the quantitative cancer dose-response assessment.[17,18,19] CIIT's risk assessment of formaldehyde incorporated mechanistic and dosimetric information on formaldehyde. However, it should be noted that recent research published by EPA indicates that when two-stage modeling assumptions are varied, resulting dose-response estimates can vary by several orders of magnitude.[20,21,22,23] These findings are not supportive of interpreting the CIIT model results as providing a conservative (health protective) estimate of human risk.[24] EPA research also examined the contribution of the two-stage modeling for formaldehyde towards characterizing the relative weights of key events in the mode-of-action of a carcinogen. For example, the model-based inference in the published CIIT study that formaldehyde's direct mutagenic action is not relevant to the compound's tumorigenicity was found not to hold under variations of modeling assumptions.[25]

Based on the developments of the last decade, in 2004, the working group of the IARC concluded that formaldehyde is carcinogenic to humans (Group 1), on the basis of sufficient evidence in humans and sufficient evidence in experimental animals - a higher classification than previous IARC evaluations. After reviewing the currently available epidemiological evidence, the IARC (2006) characterized the human evidence for formaldehyde carcinogenicity as "sufficient," based upon the data on nasopharyngeal cancers; the epidemiologic evidence on

---

[17] Conolly, RB, JS Kimbell, D Janszen, PM Schlosser, D Kalisak, J Preston, and FJ Miller. 2003. Biologically motivated computational modeling of formaldehyde carcinogenicity in the F344 rat. Tox Sci 75: 432-447.

[18] Conolly, RB, JS Kimbell, D Janszen, PM Schlosser, D Kalisak, J Preston, and FJ Miller. 2004. Human respiratory tract cancer risks of inhaled formaldehyde: Dose-response predictions derived from biologically-motivated computational modeling of a combined rodent and human dataset. Tox Sci 82: 279-296.

[19] Chemical Industry Institute of Toxicology (CIIT).1999. Formaldehyde: Hazard characterization and dose-response assessment for carcinogenicity by the route of inhalation. CIIT, September 28, 1999. Research Triangle Park, NC.

[20] U.S. EPA. Analysis of the Sensitivity and Uncertainty in 2-Stage Clonal Growth Models for Formaldehyde with Relevance to Other Biologically-Based Dose Response (BBDR) Models. U.S. Environmental Protection Agency, Washington, D.C., EPA/600/R-08/103, 2008

[21] Subramaniam, R; Chen, C; Crump, K; .et .al. (2008) Uncertainties in biologically-based modeling of formaldehyde-induced cancer risk: identification of key issues. Risk Anal 28(4):907-923.

[22] Subramaniam, R; Chen, C; Crump, K; .et .al. (2007). Uncertainties in the CIIT 2-stage model for formaldehyde-induced nasal cancer in the F344 rat: a limited sensitivity analysis-I. Risk Anal 27:1237

[23] Crump, K; Chen, C; Fox, J; .et .al. (2008) Sensitivity analysis of biologically motivated model for formaldehyde-induced respiratory cancer in humans. Ann Occup Hyg 52:481-495.

[24] Crump, K; Chen, C; Fox, J; .et .al. (2008) Sensitivity analysis of biologically motivated model for formaldehyde-induced respiratory cancer in humans. Ann Occup Hyg 52:481-495.

[25] Subramaniam, R; Chen, C; Crump, K; .et .al. (2007). Uncertainties in the CIIT 2-stage model for formaldehyde-induced nasal cancer in the F344 rat: a limited sensitivity analysis-I. Risk Anal 27:1237

leukemia was characterized as “strong.”[26] EPA is reviewing the recent work cited above from the NCI and NIOSH, as well as the analysis by the CIIT Centers for Health Research and other studies, as part of a reassessment of the human hazard and dose-response associated with formaldehyde.

Formaldehyde exposure also causes a range of noncancer health effects, including irritation of the eyes (burning and watering of the eyes), nose and throat. Effects from repeated exposure in humans include respiratory tract irritation, chronic bronchitis and nasal epithelial lesions such as metaplasia and loss of cilia. Animal studies suggest that formaldehyde may also cause airway inflammation – including eosinophil infiltration into the airways. There are several studies that suggest that formaldehyde may increase the risk of asthma – particularly in the young.[27,28]

*Acetaldehyde*

Acetaldehyde is classified in EPA’s IRIS database as a probable human carcinogen, based on nasal tumors in rats, and is considered toxic by the inhalation, oral, and intravenous routes.[29] Acetaldehyde is reasonably anticipated to be a human carcinogen by the U.S. DHHS in the 11$^{th}$ Report on Carcinogens and is classified as possibly carcinogenic to humans (Group 2B) by the IARC.[30,31] EPA is currently conducting a reassessment of cancer risk from inhalation exposure to acetaldehyde.

The primary noncancer effects of exposure to acetaldehyde vapors include irritation of the eyes, skin, and respiratory tract.[32] In short-term (4 week) rat studies, degeneration of

---

26 International Agency for Research on Cancer (2006) Formaldehyde, 2-Butoxyethanol and 1-tert-Butoxypropan-2-ol. Monographs Volume 88. World Health Organization, Lyon, France.

27 Agency for Toxic Substances and Disease Registry (ATSDR). 1999. Toxicological profile for Formaldehyde. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service. http://www.atsdr.cdc.gov/toxprofiles/tp111.html

28 WHO (2002) Concise International Chemical Assessment Document 40: Formaldehyde. Published under the joint sponsorship of the United Nations Environment Programme, the International Labour Organization, and the World Health Organization, and produced within the framework of the Inter-Organization Programme for the Sound Management of Chemicals. Geneva.

29 U.S. EPA (1988). Integrated Risk Information System File of Acetaldehyde. Research and Development, National Center for Environmental Assessment, Washington, DC. This material is available electronically at http://www.epa.gov/iris/subst/0290.htm.

30 U.S. Department of Health and Human Services National Toxicology Program 11th Report on Carcinogens available at: http://ntp.niehs.nih.gov/go/16183.

31 International Agency for Research on Cancer (IARC). 1999. Re-evaluation of some organic chemicals, hydrazine, and hydrogen peroxide. IARC Monographs on the Evaluation of Carcinogenic Risk of Chemical to Humans, Vol 71. Lyon, France.

32 U.S. EPA (1988). Integrated Risk Information System File of Acetaldehyde. This material is available electronically at http://www.epa.gov/iris/subst/0290.htm.

olfactory epithelium was observed at various concentration levels of acetaldehyde exposure.[33,34] Data from these studies were used by EPA to develop an inhalation reference concentration. Some asthmatics have been shown to be a sensitive subpopulation to decrements in functional expiratory volume (FEV1 test) and bronchoconstriction upon acetaldehyde inhalation.[35] The agency is currently conducting a reassessment of the health hazards from inhalation exposure to acetaldehyde.

Polycyclic Aromatic Hydrocarbons (PAHs) At least eight PAH compounds are classified by EPA as probable human carcinogens based on animal data, including acenaphthene[36], benzo(a)anthracene[37], benzo(b)fluoranthene[38], benzo(k)fluoranthene[39], benzo(a)pyrene[40], chrysene[41], dibenz(a,h)anthracene[42], and indeno(1,2,3-cd)pyrene[43]. Recent studies have found that maternal exposures to PAHs in a population of pregnant women were associated with

---

33 U.S. EPA. 2003. Integrated Risk Information System File of Acrolein. Research and Development, National Center for Environmental Assessment, Washington, DC. This material is available electronically at http://www.epa.gov/iris/subst/0364.htm.

34 Appleman, L.M., R.A. Woutersen, and V.J. Feron. (1982). Inhalation toxicity of acetaldehyde in rats. I. Acute and subacute studies. Toxicology. 23: 293-297.

35 Myou, S.; Fujimura, M.; Nishi K.; Ohka, T.; and Matsuda, T. (1993) Aerosolized acetaldehyde induces histamine-mediated bronchoconstriction in asthmatics. Am. Rev. Respir.Dis.148(4 Pt 1): 940-943.

36 U.S. EPA (1997). Integrated Risk Information System File of acenaphthene. Research and Development, National Center for Environmental Assessment, Washington, DC. This material is available electronically at http://www.epa.gov/ncea/iris/subst/0442.htm.

37 U.S. EPA (1997). Integrated Risk Information System File of benzo(a)anthracene. Research and Development, National Center for Environmental Assessment, Washington, DC. This material is available electronically at http://www.epa.gov/ncea/iris/subst/0454.htm.

38 U.S. EPA (1997). Integrated Risk Information System File of benzo(b)fluoranthene. Research and Development, National Center for Environmental Assessment, Washington, DC. This material is available electronically at http://www.epa.gov/ncea/iris/subst/0452.htm

39 U.S. EPA (1997). Integrated Risk Information System File of benzo(k)fluoranthene. Research and Development, National Center for Environmental Assessment, Washington, DC. This material is available electronically at http://www.epa.gov/ncea/iris/subst/0452.htm.

40 U.S. EPA (1998). Integrated Risk Information System File of benzo(a)pyrene. Research and Development, National Center for Environmental Assessment, Washington, DC. This material is available electronically at http://www.epa.gov/ncea/iris/subst/0136.htm.

41 U.S. EPA (1997). Integrated Risk Information System File of chrysene. Research and Development, National Center for Environmental Assessment, Washington, DC. This material is available electronically at http://www.epa.gov/ncea/iris/subst/0455.htm

42 U.S. EPA (1997). Integrated Risk Information System File of dibenz(a,h)anthracene. Research and Development, National Center for Environmental Assessment, Washington, DC. This material is available electronically at http://www.epa.gov/ncea/iris/subst/0456.htm.

43 U.S. EPA (1997). Integrated Risk Information System File of indeno(1,2,3-cd)pyrene. Research and Development, National Center for Environmental Assessment, Washington, DC. This material is available electronically at http://www.epa.gov/ncea/iris/subst/0457.htm.

several adverse birth outcomes, including low birth weight and reduced length at birth, as well as impaired cognitive development at age three.[44,45] EPA has not yet evaluated these recent studies.

*Naphthalene*

Naphthalene is found in small quantities in gasoline and diesel fuels. Naphthalene emissions have been measured in larger quantities in both gasoline and diesel exhaust compared with evaporative emissions from mobile sources, indicating it is primarily a product of combustion. EPA released an external review draft of a reassessment of the inhalation carcinogenicity of naphthalene based on a number of recent animal carcinogenicity studies.[46] The draft reassessment completed external peer review.[47] Based on external peer review comments received, additional analyses are being undertaken. This external review draft does not represent official agency opinion and was released solely for the purposes of external peer review and public comment. The National Toxicology Program listed naphthalene as "reasonably anticipated to be a human carcinogen" in 2004 on the basis of bioassays reporting clear evidence of carcinogenicity in rats and some evidence of carcinogenicity in mice.[48] California EPA has released a new risk assessment for naphthalene, and the IARC has reevaluated naphthalene and re-classified it as Group 2B: possibly carcinogenic to humans.[49] Naphthalene also causes a number of chronic non-cancer effects in animals, including abnormal cell changes and growth in respiratory and nasal tissues.[50]

---

[44] Perera, F.P.; Rauh, V.; Tsai, W-Y.; et al. (2002) Effect of transplacental exposure to environmental pollutants on birth outcomes in a multiethnic population. Environ Health Perspect. 111: 201-205.

[45] Perera, F.P.; Rauh, V.; Whyatt, R.M.; Tsai, W.Y.; Tang, D.; Diaz, D.; Hoepner, L.; Barr, D.; Tu, Y.H.; Camann, D.; Kinney, P. (2006) Effect of prenatal exposure to airborne polycyclic aromatic hydrocarbons on neurodevelopment in the first 3 years of life among inner-city children. Environ Health Perspect 114: 1287-1292.

[46] U. S. EPA. 2004. Toxicological Review of Naphthalene (Reassessment of the Inhalation Cancer Risk), Environmental Protection Agency, Integrated Risk Information System, Research and Development, National Center for Environmental Assessment, Washington, DC. This material is available electronically at http://www.epa.gov/iris/subst/0436.htm.

[47] Oak Ridge Institute for Science and Education. (2004). External Peer Review for the IRIS Reassessment of the Inhalation Carcinogenicity of Naphthalene. August 2004. http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=84403

[48] National Toxicology Program (NTP). (2004). 11th Report on Carcinogens. Public Health Service, U.S. Department of Health and Human Services, Research Triangle Park, NC. Available from: http://ntp-server.niehs.nih.gov.

[49] International Agency for Research on Cancer (IARC). (2002). Monographs on the Evaluation of the Carcinogenic Risk of Chemicals for Humans. Vol. 82. Lyon, France.

[50] U. S. EPA. 1998. Toxicological Review of Naphthalene, Environmental Protection Agency, Integrated Risk Information System, Research and Development, National Center for Environmental Assessment, Washington, DC. This material is available electronically at http://www.epa.gov/iris/subst/0436.htm

*Acrolein*

EPA determined in 2003 that the human carcinogenic potential of acrolein could not be determined because the available data were inadequate. No information was available on the carcinogenic effects of acrolein in humans and the animal data provided inadequate evidence of carcinogenicity.[51] The IARC determined in 1995 that acrolein was not classifiable as to its carcinogenicity in humans.[52]

Acrolein is extremely acrid and irritating to humans when inhaled, with acute exposure resulting in upper respiratory tract irritation, mucus hypersecretion and congestion. The intense irritancy of this carbonyl has been demonstrated during controlled tests in human subjects, who suffer intolerable eye and nasal mucosal sensory reactions within minutes of exposure.[53] These data and additional studies regarding acute effects of human exposure to acrolein are summarized in EPA's 2003 IRIS Human Health Assessment for acrolein.[54] Evidence available from studies in humans indicate that levels as low as 0.09 ppm (0.21 $mg/m^3$) for five minutes may elicit subjective complaints of eye irritation with increasing concentrations leading to more extensive eye, nose and respiratory symptoms.[55] Lesions to the lungs and upper respiratory tract of rats, rabbits, and hamsters have been observed after subchronic exposure to acrolein.[56] Acute exposure effects in animal studies report bronchial hyper-responsiveness.[57] In a recent study, the acute respiratory irritant effects of exposure to 1.1 ppm acrolein were more pronounced in mice with allergic airway disease by comparison to non-diseased mice which also showed decreases in respiratory rate.[58] Based on these animal data and demonstration of similar effects in humans (i.e., reduction in respiratory rate), individuals with compromised respiratory function (e.g., emphysema, asthma) are expected to be at increased risk of developing adverse responses to

---

51 Integrated Risk Information System File of Acrolein. Research and Development, National Center for Environmental Assessment, Washington, DC. This material is available at http://www.epa.gov/iris/subst/0364.htm

52 International Agency for Research on Cancer (IARC). 1995. Monographs on the evaluation of carcinogenic risk of chemicals to humans, Volume 63, Dry cleaning, some chlorinated solvents and other industrial chemicals, World Health Organization, Lyon, France.

53 Sim VM, Pattle RE. Effect of possible smog irritants on human subjects JAMA165: 1980-2010, 1957.

54 U.S. EPA (U.S. Environmental Protection Agency). (2003) Toxicological review of acrolein in support of summary information on Integrated Risk Information System (IRIS) National Center for Environmental Assessment, Washington, DC. EPA/635/R-03/003. Available online at: http://www.epa.gov/ncea/iris.

55 Weber-Tschopp, A; Fischer, T; Gierer, R; et al. (1977) Experimentelle reizwirkungen von Acrolein auf den Menschen. Int Arch Occup Environ Hlth 40(2):117-130. In German

56 Integrated Risk Information System File of Acrolein. Office of Research and Development, National Center for Environmental Assessment, Washington, DC. This material is available at http://www.epa.gov/iris/subst/0364.htm

57 U.S. EPA (U.S. Environmental Protection Agency). (2003) Toxicological review of acrolein in support of summary information on Integrated Risk Information System (IRIS) National Center for Environmental Assessment, Washington, DC. EPA/635/R-03/003. Available online at: http://www.epa.gov/ncea/iris.

58 Morris JB, Symanowicz PT, Olsen JE, et al. 2003. Immediate sensory nerve-mediated respiratory responses to irritants in healthy and allergic airway-diseased mice. J Appl Physiol 94(4):1563-1571.

strong respiratory irritants such as acrolein.

*Other Air Toxics*

In addition to the compounds described above, other compounds in gaseous hydrocarbon and PM emissions from RICE engines would be affected by this rule. Information regarding the health effects of these compounds can be found in EPA's IRIS database.[59]

The distance that these HAPs travel away from the emission source depends on several factors. HAPs such as formaldehyde, acetaldehyde, PAHs, and acrolein are emitted as gases. Regional photochemical model simulations, examining particular scenarios, have shown that gaseous HAPs like formaldehyde and acetaldehyde can be transported hundreds of kilometers from their emissions source in distinct plumes (U.S. EPA, 2010b). Further, these emissions can contribute to regional airmasses with elevated concentrations of gaseous HAPs. These polluted airmasses can be transported thousands of kilometers and affect locations well distant from the original emissions source. Some gaseous HAPs with higher molecular weight, such as toluene, can transform into particles in the atmosphere. For engines examined in this rule, EPA does not have enough information to determine the extent of transport specific to the HAPs. In general, for HAPs emitted as particles, such as metals, the travel distance primarily depends on the size of the particle and meteorological conditions, such as wind speed and precipitation. Fine particles can have an atmospheric half-life of days to weeks and travel hundreds to thousands of kilometers, whereas ultrafine and coarse particles travel less than ten kilometers (U.S. EPA, 2009c).

***Carbon monoxide co-benefits***

Carbon monoxide (CO) exposure is associated with a variety of health effects. Without knowing the location of the emission reductions and the resulting ambient concentrations using fine-scale air quality modeling, we were unable to estimate the exposure to CO for nearby populations. Due to data limitations, we were unable to estimate the benefits associated with the 14,000 tons reductions in CO emissions that would occur as a result of this rule.

Carbon monoxide in ambient air is formed primarily by the incomplete combustion of carbon-containing fuels and photochemical reactions in the atmosphere. The amount of CO emitted from these reactions, relative to carbon dioxide ($CO_2$), is sensitive to conditions in the combustion zone, such as fuel oxygen content, burn temperature, or mixing time. Upon

[59] U.S. EPA Integrated Risk Information System (IRIS) database is available at: http://www.epa.gov/iris

inhalation, CO diffuses through the respiratory system to the blood, which can cause hypoxia (reduced oxygen availability). Carbon monoxide can elicit a broad range of effects in multiple tissues and organ systems that are dependent upon concentration and duration of exposure.

The Integrated Science Assessment for Carbon Monoxide (U.S. EPA, 2010a) concluded that short-term exposure to CO is "likely to have a causal relationship" with cardiovascular morbidity, particularly in individuals with coronary heart disease. Epidemiologic studies associate short-term CO exposure with increased risk of emergency department visits and hospital admissions. Coronary heart disease includes those who have angina pectoris (cardiac chest pain), as well as those who have experienced a heart attack. Other subpopulations potentially at risk include individuals with diseases such as chronic obstructive pulmonary disease (COPD), anemia, or diabetes, and individuals in very early or late life stages, such as older adults or the developing young. The evidence is suggestive of a causal relationship from short-term exposure to CO with respiratory morbidity and mortality, from long-term exposure to CO with adverse birth outcomes and developmental effects, and from short- and long-term exposure to CO with central nervous system effects.

***Other $SO_2$ co-benefits***

In addition to being a precursor to $PM_{2.5}$, $SO_2$ emissions are also associated with a variety of respiratory health effects. Unfortunately, we were unable to estimate the health benefits associated with reduced $SO_2$ exposure in this analysis because we do not have air quality modeling data available. Without knowing the location of the 31,000 tons of $SO_2$ emission reductions and the resulting ambient concentrations, we were unable to estimate the exposure to $SO_2$ for nearby populations. Therefore, this analysis only quantifies and monetizes the $PM_{2.5}$ co-benefits associated with those $SO_2$ emissions reductions.

Following an extensive evaluation of health evidence from epidemiologic and laboratory studies, the U.S. EPA has concluded that there is a causal relationship between respiratory health effects and short-term exposure to $SO_2$ (U.S. EPA, 2008b). The immediate effect of $SO_2$ on the respiratory system in humans is bronchoconstriction. Asthmatics are more sensitive to the effects of $SO_2$ likely resulting from preexisting inflammation associated with this disease. A clear concentration-response relationship has been demonstrated in laboratory studies following exposures to $SO_2$ at concentrations between 20 and 100 ppb, both in terms of increasing severity of effect and percentage of asthmatics adversely affected. The $SO_2$ ISA identified four short-term morbidity endpoints with a "causal relationship": asthma exacerbation, respiratory-related emergency department visits, and respiratory-related hospitalizations. The $SO_2$ ISA also concluded that the relationship between short-term $SO_2$ exposure and premature mortality was "suggestive of a causal relationship" because it is difficult to attribute the mortality risk effects to $SO_2$ alone. Although the $SO_2$ ISA stated that studies are generally consistent in reporting a relationship between $SO_2$ exposure and mortality, there was a lack of robustness of the observed associations to adjustment for co-pollutants. The differing evidence and associated strength of the evidence for these different effects is described in detail in the $SO_2$ ISA.

$SO_2$ emissions also contribute to adverse welfare effects from acidic deposition, mercury methylation, and visibility impairment. Sulfur deposition causes acidification, leading to a loss of biodiversity of fishes, zooplankton, and macro invertebrates in aquatic ecosystems, as well as a decline in sensitive tree species, such as red spruce (*Picea rubens*) and sugar maple (*Acer saccharum*) in terrestrial ecosystems. In the northeastern United States, the surface waters affected by acidification are a source of food for some recreational and subsistence fishermen and support several cultural services, including aesthetic and educational services and recreational fishing. Biological effects of acidification in terrestrial ecosystems are generally linked to aluminum toxicity, which can reduce root growth and restrict the ability of the plant to take up water and nutrients. These direct effects increase the sensitivity of these plants to stresses, such as droughts, cold temperatures, insect pests, and disease leading to increased mortality of canopy trees. Terrestrial acidification affects several important ecological services, including declines in forest productivity (provisioning), declines in habitat for threatened and endangered species (cultural), declines in forest aesthetics (cultural), and increases in forest soil erosion and reductions in water retention (cultural and regulating). (U.S. EPA, 2008c)

Mercury is a highly neurotoxic contaminant that enters the food web as a methylated compound, methylmercury (U.S. EPA, 2008c). The contaminant is concentrated in higher trophic levels, including fish eaten by humans. Experimental evidence has established that only inconsequential amounts of methylmercury can be produced in the absence of sulfate. Current evidence indicates that in watersheds where mercury is present, increased $SO_x$ deposition very likely results in methylmercury accumulation in fish (Drevnick et al., 2007; Munthe et al, 2007). The $SO_2$ ISA concluded that evidence is sufficient to infer a casual relationship between sulfur deposition and increased mercury methylation in wetlands and aquatic environments.

Reducing $SO_2$ emissions and the secondary formation of $PM_{2.5}$ would improve the level of visibility throughout the United States. Fine particles with significant light-extinction efficiencies include sulfates, nitrates, organic carbon, elemental carbon, and soil. These suspended particles and gases degrade visibility by scattering and absorbing light. Higher visibility impairment levels in the East are due to generally higher concentrations of fine particles, particularly sulfates, and higher average relative humidity levels. In fact, particulate sulfate is the largest contributor to regional haze in the eastern U.S. (i.e., 40% or more annually and 75% during summer). In the western U.S., particulate sulfate contributes to 20-50% of regional haze. Visibility has direct significance to people's enjoyment of daily activities and their overall sense of wellbeing. Good visibility increases the quality of life where individuals live and work, and where they engage in recreational activities. (U.S. EPA, 2009c)

## 7.4 Characterization of Uncertainty in the Monetized Co-benefits

In any complex analysis, there are likely to be many sources of uncertainty. Many inputs are used to derive the final estimate of economic benefits, including emission inventories, air quality models (with their associated parameters and inputs), epidemiological estimates of concentration-response (C-R) functions, estimates of values, population estimates, income estimates, and estimates of the future state of the world (i.e., regulations, technology, and human behavior). For some parameters or inputs it may be possible to provide a statistical representation of the underlying uncertainty distribution. For other parameters or inputs, the necessary information is not available.

The annual benefit estimates presented in this analysis are also inherently variable due to the processes that govern pollutant emissions and ambient air quality in a given year. Factors such as hours of equipment use and weather are constantly variable, regardless of our ability to measure them accurately. As discussed in the $PM_{2.5}$ NAAQS RIA (Table 5.5) (U.S. EPA, 2006), there are a variety of uncertainties associated with these PM co-benefits. Therefore, the estimates of annual co-benefits should be viewed as representative of the magnitude of co-benefits expected, rather than the actual benefits that would occur every year.

We performed a couple of sensitivity analyses on the benefits results to assess the sensitivity of the primary results to various data inputs and assumptions. We then changed each default input one at a time and recalculated the total monetized co-benefits to assess the percent change from the default. We present the results of this sensitivity analysis in Table 7-5. We indicated each input parameter, the value used as the default, and the values for the sensitivity analyses, and then we provide the total monetary co-benefits for each input and the percent change from the default value.

**Table 7-5. Sensitivity Analyses for Monetized $PM_{2.5}$-related Co-benefits (millions of 2008$)**

| | | Total $PM_{2.5}$ Co-benefits | % Change from Default |
|---|---|---|---|
| **Threshold Assumption (with Epidemiology Study)** | No Threshold (Pope) | $1,100 | N/A |
| | No Threshold (Laden) | $2,600 | N/A |
| | Threshold (Pope) | $860 | 28% |
| | Threshold (Laden) | $1,900 | 37% |
| **Discount Rate (with Epidemiology Study)** | 3% (Pope) | $1,100 | N/A |
| | 3% (Laden) | $2,600 | N/A |
| | 7% (Pope) | $1,000 | 10% |
| | 7% (Laden) | $2,300 | 11% |

Above we present the estimates of the total monetized co-benefits, based on our interpretation of the best available scientific literature and methods and supported by the SAB-HES and the NAS (NRC, 2002). The co-benefits estimates are subject to a number of assumptions and uncertainties. For example, for key assumptions underlying the estimates for premature mortality, which typically account for at least 90% of the total monetized benefits, we were able to quantify include the following:

1. $PM_{2.5}$ co-benefits were derived through benefit per-ton estimates, which do not 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 directly emitted fine particulates.

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 down to the lowest air quality levels modeled in this analysis. 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 (which typically accounts for 85% to 95% of total monetized benefits), 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. For more information on the uncertainties associated with $PM_{2.5}$ co-benefits, please consult the $PM_{2.5}$ NAAQS RIA (Table 5.5).

This RIA does not include the type of detailed uncertainty assessment found in the PM NAAQS RIA (U.S. EPA, 2006b) because we lack the necessary air quality input and monitoring data to run the benefits model. Moreover, it was not possible to develop benefit-per-ton metrics and associated estimates of uncertainty using the benefits estimates from the PM RIA because of the significant differences between the sources affected in that rule and those regulated here. However, the results of the Monte Carlo analyses of the health and welfare benefits presented in Chapter 5 of the PM RIA can provide some evidence of the uncertainty surrounding the co-benefits results presented in this analysis.

It is important to note that the monetized benefit-per-ton estimates used here reflect specific geographic patterns of emissions reductions and specific air quality and benefits modeling assumptions. For example, these estimates do not reflect local variability in population density, meteorology, exposure, baseline health incidence rates, or other local factors. Use of these $/ton values to estimate co-benefits associated with different emission control programs (e.g., for reducing emissions from large stationary sources like EGUs) may lead to higher or lower benefit estimates than if co-benefits were calculated based on direct air quality modeling. Great care should be taken in applying these estimates to emission reductions occurring in any specific location, as these are all based on national or broad regional emission reduction programs and therefore represent average benefits-per-ton over the entire United States. The benefits- per-ton for emission reductions in specific locations may be very different than the estimates presented here.

## 7.5 Comparison of Benefits and Costs

EPA estimates the range of co-benefits of this final rule to be $940 million to $2.3 billion (2008$) at a 3% discount rate and $850 million to $2.1 billion at a 7% discount rate in the year of implementation (2013). The annualized costs are $373 million (2008$) at a 7% interest rate.[60] Thus, net benefits are $570 million to $1.9 billion at a 3% discount rate for the benefits and $480 million to $1.7 billion at a 7% discount rate. Figures 7-4 and 7-5 show the full range of net

[60] For more information on the annualized costs, please refer to Section 4 of this RIA.

benefits estimates (i.e., annual co-benefits minus annualized costs) utilizing the 14 different $PM_{2.5}$ mortality functions at discount rates of 3% and 7%. In addition, the benefits from reducing 1,014 tons of hazardous air pollutants each year have not been included in these estimates. EPA believes that the benefits are likely to exceed the costs under this rulemaking even when taking into account uncertainties in the cost and benefit estimates.

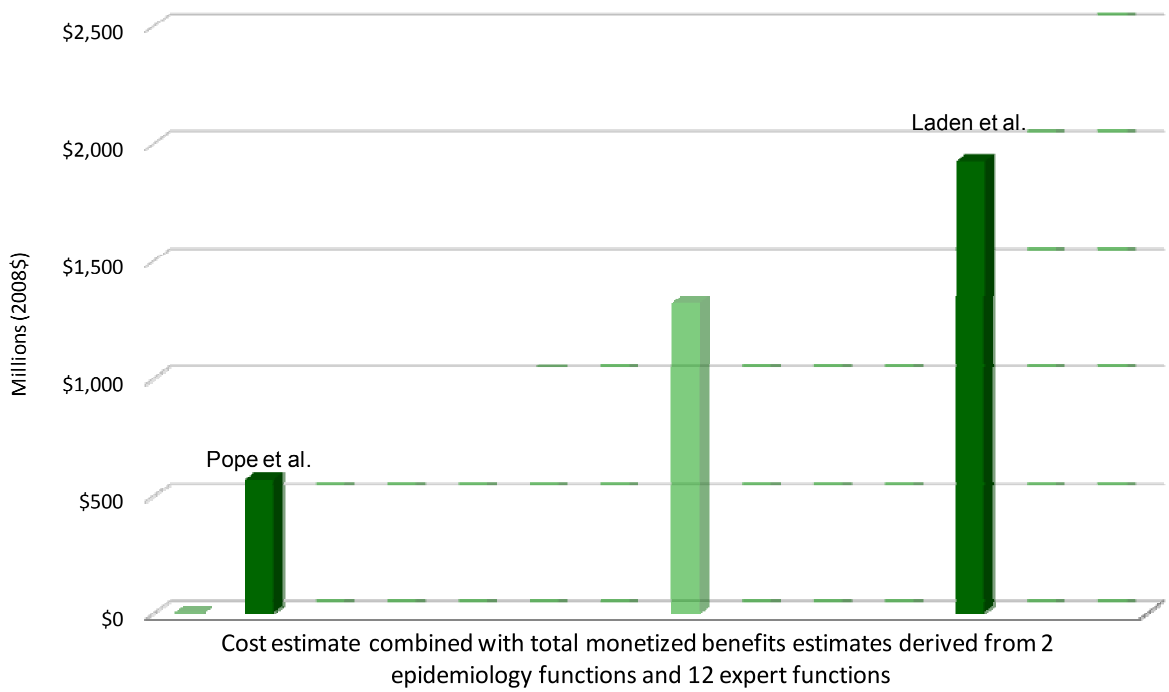



**Figure 7-4. Net Benefits for RICE NESHAP at 3% Discount Rate**

[a] Net benefits are quantified in terms of $PM_{2.5}$ co-benefits for the year of implementation. This graph shows 14 co-benefits estimates combined with the cost estimate. All combinations are treated as independent and equally probable. All fine particles are assumed to have equivalent health effects, but the benefit per ton estimates vary because each ton of precursor reduced has a different propensity to become $PM_{2.5}$. The monetized co-benefits incorporate the conversion from precursor emissions to ambient fine particles.

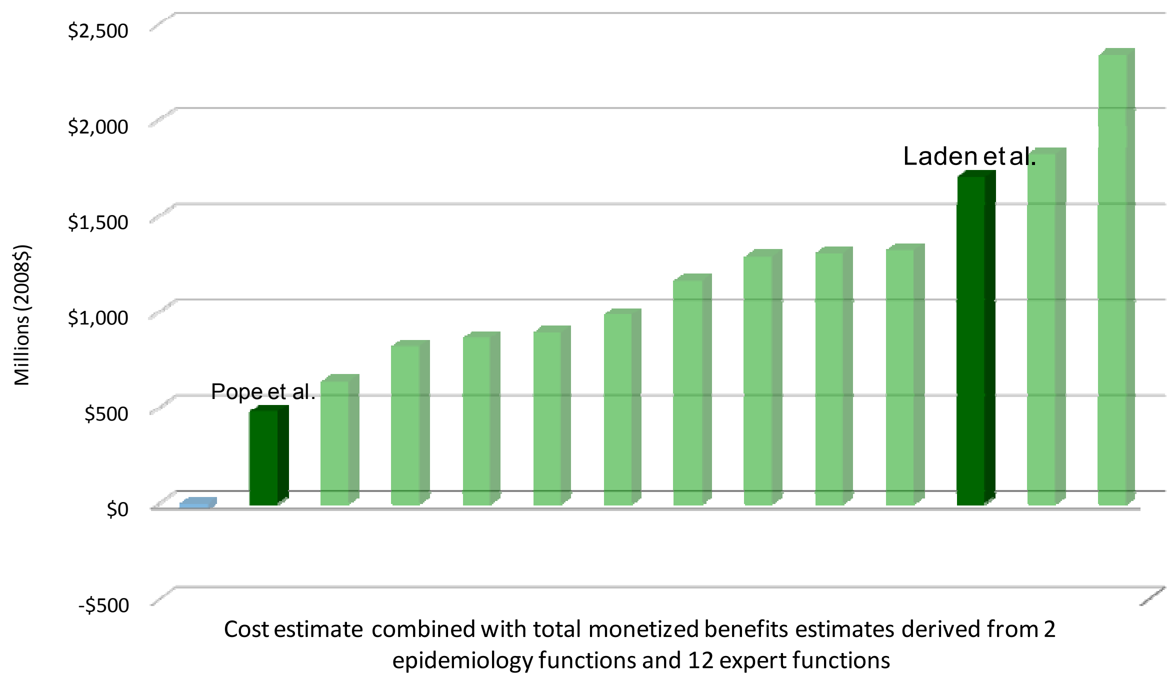



**Figure 7-5. Net Benefits for RICE NESHAP at 7% Discount Rate[a]**

[a] Net benefits are quantified in terms of $PM_{2.5}$ co-benefits for the year of implementation.. This graph shows 14 co-benefits estimates combined with the cost estimate. All combinations are treated as independent and equally probable. All fine particles are assumed to have equivalent health effects, but the benefit per ton estimates vary because each ton of precursor reduced has a different propensity to become $PM_{2.5}$. The monetized co-benefits incorporate the conversion from precursor emissions to ambient fine particles.

# SECTION 8
# REFERENCES


American Hospital Association. 2007. "AHA Hospital Statistics: 2008 Edition." Health Forum.

Fann, N., C.M. Fulcher, and B.J. Hubbell. 2009. The influence of location, source, and emission type in estimates of the human health benefits of reducing a ton of air pollution. Air Qual Atmos Health, 2:169-176.

Fullerton, D., and G. Metcalf. 2002. "Tax Incidence." In A. Auerbach and M. Feldstein, eds., *Handbook of Public Economics*, Vol.4, Amsterdam: Elsevier.

Industrial Economics, Inc., 2006. Expanded Expert Judgment Assessment of the Concentration-Response Relationship Between $PM_{2.5}$ Exposure and Mortality. Prepared for the U.S. EPA, Office of Air Quality Planning and Standards, September. Available on the Internet at <http://www.epa.gov/ttn/ecas/regdata/Uncertainty/pm_ee_report.pdf>.

Interstate Oil & Gas Compact Commission. 2007. "Marginal Wells: Fuel for Economic Growth." Table 3.B. <http://iogcc.myshopify.com/collections/frontpage/products/2007-marginal-well-report-2007>.

Kochi, I., B. Hubbell, and R. Kramer. 2006. An Empirical Bayes Approach to Combining Estimates of the Value of Statistical Life for Environmental Policy Analysis. Environmental and Resource Economics, 34:385-406.

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.

Lincoln Electric Holdings. 2006. Form 10-K. Filed February 24, 2006.

Mrozek, J.R., and L.O. Taylor. 2002. "What Determines the Value of Life? A Meta-Analysis." Journal of Policy Analysis and Management, 21(2):253-270.

National Research Council (NRC). 2002. Estimating the Public Health Benefits of Proposed Air Pollution Regulations. Washington, DC: The National Academies Press.

Nelson, B., EC/R Inc. February 7, 2010. Memorandum to Melanie King, U.S. Environmental Protection Agency. Impacts Associated with NESHAP for Existing Stationary CI RICE.

Nicholson, Walter. 1998. *Microeconomic Theory*. Orlando: The Dryden Press.

Office of Management and Budget (OMB), 2003. Circular A-4: Regulatory Analysis. Washington, DC. Available on the internet at <http://www.whitehouse.gov/omb/circulars/a004/a-4.html>.

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.

Roman, Henry A., Katherine D. Walker, Tyra L. Walsh, Lisa Conner, Harvey M. Richmond, Bryan J. Hubbell, and Patrick L. Kinney. 2008. Expert Judgment Assessment of the Mortality Impact of Changes in Ambient Fine Particulate Matter in the U.S. Environ. Sci. Technol., 42(7):2268-2274.

The Federal Reserve Board. “Industrial Production and Capacity Utilization: Industrial Production” Series ID: G17/IP_MINING_AND_UTILITY_DETAIL/IP.G2211.S <http://www.federalreserve.gov/datadownload/>. (December 15, 2008)

Troy, Leo. 2008. “Almanac of Business and Industrial Financial Ratios: 2009 Edition.” CCH.

U.S. Bureau of Economic Analysis (BEA). 2002. 2002 and 1997 Benchmark Input-Output Accounts: Detailed Make Table, Use Table and Direct Requirements Table. Tables 4 and 5. <http://www.bea.gov/industry/index.htm#benchmark_io>.

U.S. Bureau of Economic Analysis (BEA). 2009. Table 1.1.9. Implicit Price Deflators for Gross Domestic Product. Last revised December 22, 2009.

U.S. Bureau of the Census. 2002; generated by RTI International; using American FactFinder; “Sector 21: Mining: Industry Series: 2002 and 1997.” <http://factfinder.census.gov>; (November 10, 2008).

U.S. Bureau of the Census. 2002; generated by RTI International; using American FactFinder; “Sector 22: Utilities: 2002.” <http://factfinder.census.gov>; (November 10, 2008).

U.S. Bureau of the Census. 2002; generated by RTI International; using American FactFinder; “Sector 62: Health Care and Social Assistance: Geographic Area Series: 2002.” <http://factfinder.census.gov>; (November 10, 2008).

U.S. Census Bureau. 2002a. “Industry Series.” *Crude Petroleum & Natural Gas: 2002. EC02-21I-211111 (RV)*. Washington, DC: U.S. Bureau of the Census. Table 1.

U.S. Census Bureau. 2002b. “Industry Series.” *Electric Power Generation, Transmission, and Distribution: 2002. EC02-22I-03*. Washington, DC: U.S. Bureau of the Census. Table 1.

U.S. Census Bureau. 2002c. “Industry Series.” *Hospitals: 2002. EC02-62I-02*. Washington, DC: U.S. Bureau of the Census. Table 1.

U.S. Census Bureau. 2002d. “Industry Series.” *Natural Gas Liquid Extraction: 2002. EC02-21I-211112*. Washington, DC: U.S. Bureau of the Census. Table 1.

U.S. Census Bureau. 2002e. “Industry Series.” *Pipeline Transportation: 2002. EC02-48I-02*. Washington, DC: U.S. Bureau of the Census. Table 1.

U.S. Census Bureau. 2005a. *2002 Census of Governments, Volume 4, Number 3, Finances of County Governments: 2002 GC02(4)-3*. U.S. Government Printing Office, Washington, DC. Table 12.

U.S. Census Bureau. 2005b. *2002 Census of Governments, Volume 4, Number 4, Finances of Municipal and Township Governments: 2002 GC02(4)-4*. U.S. Government Printing Office, Washington, DC. Table 13.

U.S. Census Bureau. 2006a. Firm Size Data from the Statistics of U.S. Businesses: U.S. Detail Employment Sizes: 2002. < http://www.census.gov/csd/susb/download_susb02.htm>.

U.S. Census Bureau. 2006b. Firm Size Data from the Statistics of U.S. Businesses, U.S. All Industries Tabulated by Receipt Size: 2002. < http://www.census.gov/csd/susb/download_susb02.htm>.

U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 21: Mining: Industry Series: Historical Statistics for the Industry: 2002 and 1997." <http://factfinder.census.gov>; (November 26, 2008).

U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 22: Utilities: Subject Series—Estab & Firm Size: Concentration by Largest Firms for the United States: 2002." <http://factfinder.census.gov>; (November 21, 2008).

U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 22: Utilities: Geographic Area Series: Summary Statistics: 2002 and 1997." <http://factfinder.census.gov>; (November 26, 2008).

U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 62: Health Care and Social Assistance: Subject Series—Estab & Firm Size: Legal Form of Organization for the United States: 2002" <http://factfinder.census.gov>; (November 21, 2008).

U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 31: Manufacturing: Industry Series: Historical Statistics for the Industry: 2002 and Earlier Years" <http://factfinder.census.gov>; (November 25, 2008).

U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 48: Transportation and Warehousing: Industry Series: Comparative Statistics for the United States (1997 NAICS Basis): 2002 and 1997" <http://factfinder.census.gov>; (December 12, 2008).

U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 48: Transportation and Warehousing: Subject Series—Estab & Firm Size: Concentration by Largest Firms for the United States: 2002" <http://factfinder.census.gov>; (December 12, 2008).

U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 48-49: Geographic Distribution—Pipeline transportation of natural gas: 2002." <http://factfinder.census.gov>; (November 10, 2008).

U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 48-49: Transportation and Warehousing: Subject Series—Estab & Firm Size: Legal Form of Organization for the United States: 2002" <http://factfinder.census.gov>; (December 12, 2008).

U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 00: All sectors: Geographic Area Series: Economy-Wide Key Statistics: 2002" <http://factfinder.census.gov>; (January 4, 2010).

U.S. Department of Agriculture (USDA), National Agricultural Statistics Service (NASS). 2004. "2003 Farm and Ranch Irrigation Survey." Washington, DC: USDA-NASS.

U.S. Department of Agriculture (USDA), National Agricultural Statistics Service (NASS). 2009. "2008 Farm and Ranch Irrigation Survey." Washington, DC: USDA-NASS.

U.S. Department of Agriculture (USDA). 2008. "Agricultural Projections to 2017." <http://www.ers.usda.gov/Publications/OCE081/OCE20081c.pdf>.

U.S. Department of Agriculture (USDA). 2008. "Agricultural Projections to 2017." <http://www.ers.usda.gov/Publications/OCE081/OCE20081c.pdf>.

U.S. Department of Energy, Energy Information Administration. 2007. "2006 EIA-906/920 Monthly Time Series."

U.S. Energy Information Administration. 2008a. <http://www.eia.doe.gov/cneaf/electricity/page/restructuring/restructure_elect.html>. Last updated September 2008.

U.S. Energy Information Administration. 2009. Supplemental Tables to the Annual Energy Outlook 2010. Table 2. Available at: <http://www.eia.doe.gov/oiaf/aeo/aeoref_tab.html>.

U.S. Environmental Protection Agency (U.S. EPA). 2000. Guidelines for Preparing Economic Analyses. EPA 240-R-00-003. National Center for Environmental Economics, Office of Policy Economics and Innovation. Washington, DC. September. Available on the Internet at <http://yosemite.epa.gov/ee/epa/eed.nsf/webpages/Guidelines.html/$file/cover.pdf>.

U.S. Environmental Protection Agency (EPA). May 2004. *Final Regulatory Analysis: Control of Emissions from Nonroad Diesel Engines.* EPA420-R-04-007. Washington, DC: EPA. < http://www.epa.gov/nonroad-diesel/2004fr/420r04007.pdf>.

U.S. Environmental Protection Agency. 2006. Regulatory Impact Analysis, 2006 National Ambient Air Quality Standards for Particulate Matter, Chapter 5. Available at <http://www.epa.gov/ttn/ecas/regdata/RIAs/Chapter%205--Benefits.pdf >.

U.S. Environmental Protection Agency (U.S. EPA). 2008. Guidelines for Preparing Economic Analyses: External Review Draft. National Center for Environmental Economics, Office of Policy Economics and Innovation. Washington, DC. September. Available on the Internet at <http://yosemite.epa.gov/ee/epa/eermfile.nsf/vwAN/EE-0516-01.pdf/$File/EE-0516-01.pdf>.

U.S. Environmental Protection Agency. 2008. Regulatory Impact Analysis, 2008 National Ambient Air Quality Standards for Ground-level Ozone, Chapter 6. Available at <http://www.epa.gov/ttn/ecas/regdata/RIAs/6-ozoneriachapter6.pdf>.

U.S. Environmental Protection Agency. 2008. Technical Support Document: Calculating Benefit Per-Ton estimates, Ozone NAAQS Docket #EPA-HQ-OAR-2007-0225-0284.

U.S. Environmental Protection Agency. 2008. Integrated Science Assessment for Particulate Matter (External Review Draft). Washington, DC, EPA/600/R-08/139. Available on the Internet at <http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=201805>.

U.S. Environmental Protection Agency (U.S. EPA). 2009a. Regulatory Impact Analysis: National Emission Standards for Hazardous Air Pollutants from the Portland Cement Manufacturing Industry. Office of Air Quality Planning and Standards, Research Triangle Park, NC. April. Available on the Internet at <http://www.epa.gov/ttn/ecas/regdata/RIAs/portlandcementria_4-20-09.pdf >.

U.S. Environmental Protection Agency (U.S. EPA). 2009b. Proposed $SO_2$ NAAQS Regulatory Impact Analysis (RIA). Office of Air Quality Planning and Standards, Research Triangle Park, NC. November. Available on the Internet at <http://www.epa.gov/ttn/ecas/regdata/RIAs/pso2full11-16-09.pdf >.

U.S. Environmental Protection Agency (U.S. EPA). 2009c. Integrated Science Assessment for Particulate Matter (Final Report). EPA-600-R-08-139F. National Center for Environmental Assessment – RTP Division. December. Available on the Internet at <http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=216546>.

U.S. Environmental Protection Agency - Science Advisory Board (U.S. EPA-SAB). 2007. SAB Advisory on EPA's Issues in Valuing Mortality Risk Reduction. EPA-SAB-08-001. October. Available on the Internet at <http://yosemite.epa.gov/sab/sabproduct.nsf/4128007E7876B8F0852573760058A978/$File/sab-08-001.pdf >.

U.S. Environmental Protection Agency - Science Advisory Board (U.S. EPA-SAB). 2009a. Review of EPA's Integrated Science Assessment for Particulate Matter (First External Review Draft, December 2008). EPA-COUNCIL-09-008. May. Available on the Internet at <http://yosemite.epa.gov/sab/SABPRODUCT.NSF/81e39f4c09954fcb85256ead006be86e/73ACCA834AB44A10852575BD0064346B/$File/EPA-CASAC-09-008-unsigned.pdf>.

U.S. Environmental Protection Agency - Science Advisory Board (U.S. EPA-SAB). 2009b. Consultation on EPA's Particulate Matter National Ambient Air Quality Standards: Scope and Methods Plan for Health Risk and Exposure Assessment. EPA-COUNCIL-09-009. May. Available on the Internet at <http://yosemite.epa.gov/sab/SABPRODUCT.NSF/81e39f4c09954fcb85256ead006be86e/723FE644C5D758DF852575BD00763A32/$File/EPA-CASAC-09-009-unsigned.pdf>.

U.S. Small Business Administration (SBA). 2008. "Table of Small Business Size Standards Matched to North American Industry Classification System Codes." Effective August 22, 2008. <http://www.sba.gov/idc/groups/public/documents/sba_homepage/serv_sstd_tablepdf.pdf>.

Viscusi, V.K., and J.E. Aldy. 2003. "The Value of a Statistical Life: A Critical Review of Market Estimates throughout the World." Journal of Risk and Uncertainty, 27(1):5-76.

Wade, S.H. 2003. "Price Responsiveness in the AEO2003 NEMS Residential and Commercial Buildings Sector Models." <http://www.eia.doe.gov/oiaf/analysispaper/elasticity/pdf/buildings.pdf>.

| | | |
|---|---|---|
| United States Environmental Protection Agency | Office of Air Quality Planning and Standards<br>Health and Environmental Impacts Division<br>Research Triangle Park, NC | Publication No. EPA-452/R-10-002<br>February 2010 |