April 2010

Regulatory Impact Analysis: Standards of Performance for New Stationary Sources and Emission Guidelines for Existing Sources: Commercial and Industrial Solid Waste Incineration Units

Draft Report

Prepared for
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(MD-C439-02)
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RTI International is a trade name of Research Triangle Institute.

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SECTION 1
INTRODUCTION

The U.S. Environmental Protection Agency (EPA) is proposing new standards of performance and emission guidelines based on a review of the standards and guidelines as part of the Clean Air Act Section 129(a)(5) requirement to review the new source performance standards and emission guidelines every 5 years. Additionally, when revising the standards of performance and emission guidelines we considered the District of Columbia Circuit Court rulings on maximum achievable control technology standards that were issued after promulgation of the new source performance standards and emission guidelines for commercial and industrial solid waste incineration units in 2000 and a concurrently proposed definition of nonhazardous secondary materials as solid waste under the Resource Conservation and Recovery Act. EPA also proposes other amendments that EPA believes are necessary to adequately address air emissions from commercial and industrial solid waste incineration units and to clarify certain portions of the rules. As part of the regulatory process, EPA is required to develop a regulatory impact analysis (RIA). The RIA includes an economic impact analysis (EIA) and a small entity impacts analysis and documents the RIA methods and results.

1.1 Executive Summary

The key results of the RIA are as follows:

- **Engineering Cost Analysis:** EPA estimates the proposed rule's total annualized costs will be $216 million (2008$). However, the estimates in this RIA reflect a previous annualized engineering cost estimate of $224 million (2008$), which results in a slight overestimate of the economic impacts.

- **Market Analysis:** Under the proposed rule, the Agency's economic model suggests the average national market-level variables (prices, production-levels, consumption, international trade) will not change significantly (e.g., are less than 0.1%).

- **Social Cost Analysis:** The estimated social cost is just under $224 million (2008$). In the near term, the Agency's economic model suggests that industries are able to pass approximately $62 million of the rule's costs to consumers (e.g., marginally higher market prices). Domestic industries' surplus falls by $166 million, while other countries on net benefit from higher prices (a net increase in rest-of-the world [ROW] surplus of $4 million). Additional costs and savings that are not included in the economic model represent a net benefit of less than $1 million.

- **Employment Changes:** Near-term employment changes associated with the proposed rule are estimated to be less than 500 job losses; over a longer time period, net employment effects range between 400 job losses to 800 job gains.

- **Small Entity Analyses:** EPA performed a screening analysis for impacts on small entities by comparing compliance costs to sales/revenues (e.g., sales and revenue tests). EPA's analysis found the tests were below 1% for small entities included in the screening analysis.

- **Benefits Analysis:** In the year of full implementation (2015), EPA estimates the monetized $PM_{2.5}$ benefits of the proposed NSPS and Emission Guidelines are \$240 million to \$580 million and \$210 million to \$520 million, at 3% and 7% discount rates respectively. All estimates are in 2008\$ for the year 2015. Using alternate relationships between $PM_{2.5}$ and premature mortality supplied by experts, higher and lower benefits estimates are plausible, but most of the expert-based estimates fall between these estimates. The benefits from reducing other air pollutants have not been monetized in this analysis, including reducing 24,000 tons of carbon monoxide, 560 tons of HCl, 6.0 tons of lead, 5.4 tons of cadmium, 280 pounds of mercury, and 230 grams of total dioxins/furans each year. In addition, ecosystem benefits and visibility benefits have not been monetized in this analysis

- **Net Benefits:** The net benefits for the NSPS and Emission Guidelines are \$19 million to \$360 million and \$-2.4 million to \$310 million, at 3% and 7% discount rates respectively (Table 1-1). All estimates are in 2008\$ for the year 2015.

1.2 Organization of this Report

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

- Section 2 presents the affected industry profiles.
- Section 3 describes the engineering cost analysis.
- Section 4 describes the economic impact analysis.
- Section 5 describes the small entity analyses.
- Section 6 presents the benefits estimates.
- Section 7 presents supplemental economic analyses for the alternate approach
- Appendix A describes the multimarket model used in the economic analysis.

Table 1-1. Summary of the Monetized Benefits, Social Costs, and Net Benefits for the CISWI NSPS and Emissions Guidelines in 2015 (millions of 2008$)[1]

	3% Discount Rate	7% Discount Rate
Proposed Option		
Total Monetized Benefits[2]	$240 to $580	$210 to $520
Total Social Costs[3]	$220	$220
Net Benefits	$19 to $360	$-2.4 to $310
Proposed Option with Alternate Approach		
	3% Discount Rate	7% Discount Rate
Total Monetized Benefits[4]	$2,700 to $6,700	$2,500 to $6,000
Total Social Costs[3]	$480	$480
Net Benefits	$2,300 to $6,200	$2,000 to $5,600

[1] All estimates are for the implementation year (2015), and are rounded to two significant figures.

[2] The total monetized benefits reflect the human health benefits associated with reducing exposure to $PM_{2.5}$ through reductions of 660 tons of directly emitted $PM_{2.5}$ and $PM_{2.5}$ precursors such as 1,400 tons of NO_x and 2,700 tons of SO_2. The benefits from reducing 24,000 tons of carbon monoxide, 560 tons of hydrochloric acid, 5.4 tons of cadmium, 6.0 tons of lead, and 280 pounds of mercury, and 230 grams of total dioxins/furans each year are not included in these estimates. In addition, the benefits from reducing ecosystem effects and visibility impairment are not included.

[3] The methodology used to estimate social costs for one year in the multimarket model using surplus changes results in the same social costs for both discount rates.

[4] The total monetized benefits reflect the human health benefits associated with reducing exposure to $PM_{2.5}$ through reductions of 12,000 tons of directly emitted $PM_{2.5}$ and $PM_{2.5}$ precursors such as 520 tons of NO_x and 205 tons of SO_2. The benefits from reducing 128,000 tons of carbon monoxide, 430 tons of hydrochloric acid, 4.3 tons of cadmium, 3.4 tons of lead, 1.2 tons of mercury, and 85 grams of total dioxins/furans each year are not included in these estimates. In addition, the benefits from reducing ecosystem effects and visibility impairment are not included.

SECTION 2
INDUSTRY PROFILES

In this section, we provide an introduction selected industries that are affected by the proposed rule. The industries were selected based on high facility population counts within 3-digit NAICs industries reported in the combustion facility survey. The purpose is to give the reader a general understanding of economic aspects and industry trends to provide additional context for the economic impact analysis.

2.1 Wood Product Manufacturing

2.1.1 Introduction

The wood product industry does not have the potential for high returns in the near future. According to a report by Standard & Poor's (2008), a number of factors are shaping the current economic environment for wood products, including, but not limited to, the housing slump, high input costs, low prices for lumber and other building materials, and a weak dollar. Table 2-1 shows that revenues in this industry are not entirely predictable, exhibiting a drop in shipment revenue between 1997 and 2002 but a rise back to within $5 billion of the 1997 value in 2006 and a decline to within $14 billion of the 2006 value in 2007. Upon closer review, one also notices a rise in the cost of labor (shipment revenue per dollar of payroll—$5.54 in 2002, $6.20 in 2006, and $5.84 in 2007) and material inputs during this same time period, making high profit margins difficult to predict.

While total payroll dropped 3% over this time, annual payroll per employee rose 6.5% from 1997 to 2007 because of the decline in the number of employees (Table 2-2). Shipments per employee grew 10.6% from 1997 to 2006 and dropped 8.9% from 2006 to 2007 (Table 2-2).

The U.S. Census Bureau categorizes this industry's facilities into three categories: "sawmills and wood preservation"; "veneer, plywood, and engineered wood product manufacturing"; and "other wood product manufacturing." These are further divided into the following types of facilities as defined by the Census Bureau:

- Sawmills and Wood Preservation
  - Sawmills and Wood Preservation (NAICS 32111): This industry comprises establishments primarily engaged in one or more of the following manufacturing activities: (a) sawing dimension lumber, boards, beams, timber, poles, ties, shingles, shakes, siding, and wood chips from logs or bolts; (b) sawing round wood poles, pilings, and posts and treating them with preservatives; and

Table 2-1. Key Statistics: Wood Product Manufacturing (NAICS 321)

	1997	2002	2006	2007
Shipments ($2007, 10^6)	$110,956	$102,721	$115,390	$101,879
Payroll ($2007, 10^6)	$17,959	$18,528	$18,623	$17,439
Employees	570,034	543,459	536,094	519,651
Establishments	17,367	17,255	NA	14,862

NA = Not available.

Sources: U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 31: Annual Survey of Manufactures: General Statistics: Statistics for Industry Groups and Industries: 2006 and 2005." <http://factfinder.census.gov>; (July 8, 2008).

U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 00: All Sectors: Core Business Statistics Series: Comparative Statistics for the United States and the States (1997 NAICS Basis): 2002 and 1997." <http://factfinder.census.gov>; (July 8, 2008).

U.S. Census Bureau; generated by Kapur Energy and Environment; using American FactFinder; "Sector 00: EC0700A1: All Sectors: Geographic Area Series: Economy-Wide Key Statistics: 2007." Accessed on December 27, 2009.

Table 2-2. Industry Ratios: Wood Product Manufacturing (NAICS 321)

Industry Ratios	1997	2002	2006	2007
Total shipments ($2007, 10^6)	$110,956	$102,721	$115,390	$101,879
Shipments per establishment ($$10^3$)	$25,613	$5,953	NA	$6,855
Shipments per employee ($2007)	$194,648	$189,014	$215,243	$196,053
Shipments per $ of payroll ($2007)	$6.18	$5.54	$6.20	$5.84
Annual payroll per employee ($2007)	$31,504	$34,093	$34,738	$33,558
Employees per establishment	33	31	NA	35

NA = Not available.

Sources: U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 31: Annual Survey of Manufactures: General Statistics: Statistics for Industry Groups and Industries: 2006 and 2005." <http://factfinder.census.gov>; (July 8, 2008).

U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 00: All Sectors: Core Business Statistics Series: Comparative Statistics for the United States and the States (1997 NAICS Basis): 2002 and 1997." <http://factfinder.census.gov>; (July 8, 2008).

U.S. Census Bureau; generated by Kapur Energy and Environment; using American FactFinder; "Sector 00: EC0700A1: All Sectors: Geographic Area Series: Economy-Wide Key Statistics: 2007." Accessed on December 27, 2009.

(c) treating wood sawed, planed, or shaped in other establishments with creosote or other preservatives to prevent decay and to protect against fire and insects. Sawmills may plane the rough lumber that they make with a planing machine to achieve smoothness and uniformity of size.

- Veneer, Plywood, and Engineered Wood Product Manufacturing
  - Veneer, Plywood, and Engineered Wood Product Manufacturing (NAICS 32121): This industry comprises establishments primarily engaged in one or more of the following manufacturing activities: (a) veneer and/or plywood, (b) engineered wood members, and (c) reconstituted wood products. This industry includes manufacturing plywood from veneer made in the same establishment or from veneer made in other establishments, and manufacturing plywood faced with non-wood materials, such as plastics or metal.
- Other Wood Product Manufacturing
  - Millwork (NAICS 32191): This industry comprises establishments primarily engaged in manufacturing hardwood and softwood cut stock and dimension stock (i.e., shapes); wood windows and wood doors; and other millwork including wood flooring. Dimension stock or cut stock is defined as lumber and worked wood products cut or shaped to specialized sizes. These establishments generally use woodworking machinery, such as jointers, planers, lathes, and routers to shape wood.
  - Wood Container and Pallet Manufacturing (NAICS 32192): This industry comprises establishments primarily engaged in manufacturing wood pallets, wood box shook, wood boxes, other wood containers, and wood parts for pallets and containers.
  - All Other Wood Product Manufacturing (NAICS 32199): This industry comprises establishments primarily engaged in manufacturing wood products (except establishments operating sawmills and wood preservation facilities; and establishments manufacturing veneer, plywood, engineered wood products, millwork, wood containers, or pallets).

Figure 2-1 shows that the industry proportion of the value of shipments for other wood product manufacturing (51%) was greater than the value of shipments for sawmills and wood preservation (27%) and veneer, plywood, and engineered wood products (22%). Figure 2-2 indicates that the majority of employees in this industry fell under other wood products (60%). Veneer, plywood, and engineered wood products had the same percentage (20%) of employees as sawmills and wood preservation (20%), even though it contributed to a lesser portion of the value of shipments.

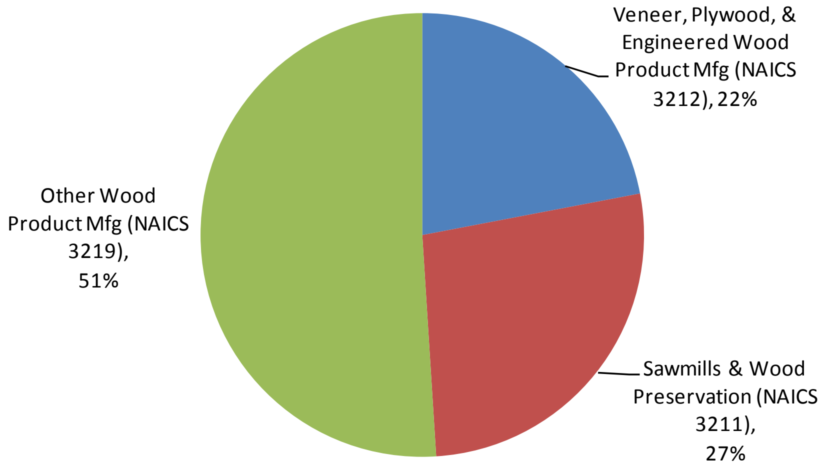

Figure 2-1. Distribution of Value of Shipments within Wood Product Manufacturing (NAICS 322): 2007

Source: U.S. Census Bureau; generated by Kapur Energy and Environment; "Sector 00: EC0700A1: All Sectors: Geographic Area Series: Economy-Wide Key Statistics: 2007." <http://factfinder.census.gov>. Accessed on December 27, 2009. [Source for 2007 numbers]

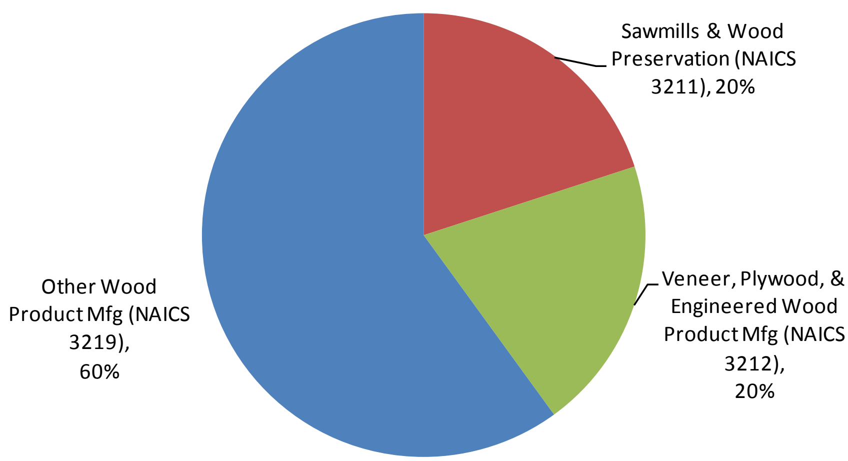

Figure 2-2. Distribution of Employment within Wood Product Manufacturing (NAICS 322): 2007

Source: U.S. Census Bureau; generated by Kapur Energy and Environment; "Sector 00: EC0700A1: All Sectors: Geographic Area Series: Economy-Wide Key Statistics: 2007" Release Date: 12/22/09. <http://factfinder.census.gov>. Accessed on December 27, 2009. [Source for 2007 numbers]

2.1.2 Supply and Demand Characteristics

Next, we provide a broad overview of the supply and demand sides of the wood product manufacturing industry. We emphasize the economic interactions this industry has with other industries and people and identify the key goods and services used by the industry and the major uses and consumers wood products.

2.1.2.1 Goods and Services Used in Wood Product Manufacturing

In 2007, the cost of materials made up 59% of the total shipment value of goods in the wood product manufacturing industry (Table 2-3). Total compensation of employees represented 22% of the total value in 2007. Both the number of total shipments and the number of employees in this industry decreased between 2005 and 2007—the former by 14% and the latter by 3%.

Table 2-3. Costs of Goods and Services in Wood Product Manufacturing (NAICS 321)

Industry Ratios	2005	Share	2006	Share	2007	Share
Total shipments ($2007, 10^6)	$118,705	100%	$115,390	100%	$102,002	100%
Total compensation ($2007, 10^6)	$23,327	20%	$23,306	20%	$22,513	22%
Annual payroll ($2007)	$18,884	16%	$18,623	16%	$17,444	17%
Fringe benefits	$4,442	4%	$4,683	4%	$5,069	5%
Total employees	538,890		536,094		524,212	
Average compensation per employee ($2007)	$43,286		$43,473		$42,947	
Total production workers' wages ($2007, 10^6)	$13,363	11%	$13,132	11%	$12,086	12%
Total production workers	431,569		432,315		417,471	
Total production hours (10^3)	911,332		887,613		837,074	
Average production wages per hour ($2007)	$15		$15		$14	
Total cost of materials ($2007, 10^3)	$71,808	60%	$69,892	61%	$60,682	59%
Materials, parts, packaging	$65,319	55%	$63,499	55%	$54,462	53%
Purchased electricity	$1,530	1%	$1,625	1%	$1,446	1%
Purchased fuel ($2007)	$810	1%	$835	1%	$843	1%
Other	$4,149	3%	$3,933	3%	$3,931	4%

Sources: U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 31: Annual Survey of Manufactures: General Statistics: Statistics for Industry Groups and Industries: 2006 and 2005." <http://factfinder.census.gov>; (July 8, 2008).

U.S. Census Bureau; generated by Kapur Energy and Environment: using American FactFinder; "Sector 31: EC0731I1: Manufacturing: Industry Series: Detailed Statistics by Industry for the United States: 2007." Accessed on December 27, 2009. [Source for 2007 numbers]

The top 10 industry groups supplying inputs to the wood product industry accounted for 80% of the total intermediate inputs according to 2008 Bureau of Economic Analysis data (Table 2-4). The largest comes from the wood product industry itself. This is quite understandable, since the descriptions of the various industries within wood product manufacturing imply that they supply each other with products in order to add value and distribute their products to the broader market. The top five inputs are rounded out by forestry and logging products, wholesale trade, management of companies and enterprises, and truck transportation, which together make up 70% of the total cost of input.

Table 2-4. Key Goods and Services Used in Wood Product Manufacturing (NAICS 321) ($2007, 10^6)

Description	BEA Commodity Code	Wood Products
Wood products	3210	$20,989
Forestry and logging products	1130	$18,914
Wholesale trade	4200	$5,417
Management of companies and enterprises	5500	$2,853
Truck transportation	4840	$2,542
Electric power generation, transmission, and distribution	2211	$1,388
Other fabricated metal products	332B	$1,310
Nonmetallic mineral products	3270	$1,110
Real estate	5310	$799
All other administrative and support services	561A	$748
Architectural and structural metal products	3323	$725
Rail transportation	4820	$723
Other inputs		$14,650
Total intermediate inputs	T005	$72,169

Source: U.S. Bureau of Economic Analysis (BEA). 2008. "2002 Benchmark Input-Output Accounts: 2002 Standard Make and Use Tables at the Summary Level." Table 2. Washington, DC: BEA.

2.1.2.1.1 Energy. The Department of Energy (DOE) categorizes wood product manufacturing (NAICS 321) as a non-energy-intensive industry. The 2008 Annual Energy Outlook predicts that the wood product industry will be one of five (out of eight) non-energy-intensive industries experiencing positive average growth of delivered energy consumption between 2006 and 2030 (DOE, 2008).

Table 2-5 shows that total energy use decreased between 1998 and 2002 by 26 and then between 2002 and 2006, total energy use rose by 19%. However, Figure 2-3 shows that electrical power use decreased rapidly during this period, including a steady decline in the latter part of 2000. Following a rapid decrease at the end of 2002, electric power use has been increasing steadily since then.

Table 2-5. Energy Used in Wood Product Manufacturing (NAICS 321)

Fuel Type	1998	2002	2006
Total (trillion BTU)	504	375	445
Net electricity[a] (million kWh)	21,170	20,985	26,723
Residual fuel oil (million bbl)	*	*	1
Distillate fuel oil[b] (million bbl)	2	2	3
Natural gas[c] (billion cu ft)	71	56	84
LPG and NGL[d] (million bbl)	1	1	1
Coal (million short tons)	*	*	Q
Coke and breeze (million short tons)	—	—	*
Other[e] (trillion BTU)	341	229	228

[a] Net electricity is obtained by summing purchases, transfers in, and generation from noncombustible renewable resources, minus quantities sold and transferred out. It does not include electricity inputs from on-site cogeneration or generation from combustible fuels because that energy has already been included as generating fuel (for example, coal).

[b] Distillate fuel oil includes Nos. 1, 2, and 4 fuel oils and Nos. 1, 2, and 4 diesel fuels.

[c] Natural gas includes natural gas obtained from utilities, local distribution companies, and any other supplier(s), such as independent gas producers, gas brokers, marketers, and any marketing subsidiaries of utilities.

[d] Examples of liquefied petroleum gases (LPGs) are ethane, ethylene, propane, propylene, normal butane, butylene, ethane-propane mixtures, propane-butane mixtures, and isobutene produced at refineries or natural gas processing plants, including plants that fractionate raw natural gas liquids (NGLs).

[e] Other includes net steam (the sum of purchases, generation from renewables, and net transfers), and other energy that respondents indicated was used to produce heat and power.

* Estimate less than 0.5.
Q = Withheld because relative standard error is greater than 50%.

Sources: U.S. Department of Energy, Energy Information Administration. 2007. "2002 Energy Consumption by Manufacturers—Data Tables." Tables 3.2 and N3.2. <http://www.eia.doe.gov/emeu/mecs/mecs2002/data02/shelltables.html>. Washington, DC: DOE.

U.S. Department of Energy, Energy Information Administration. 2007b. "2006 Energy Consumption by Manufacturers—Data Tables." Tables 3.1. <http://www.eia.doe.gov/emeu/mecs/mecs2006/2006tables.html>. [Source for 2006 numbers]

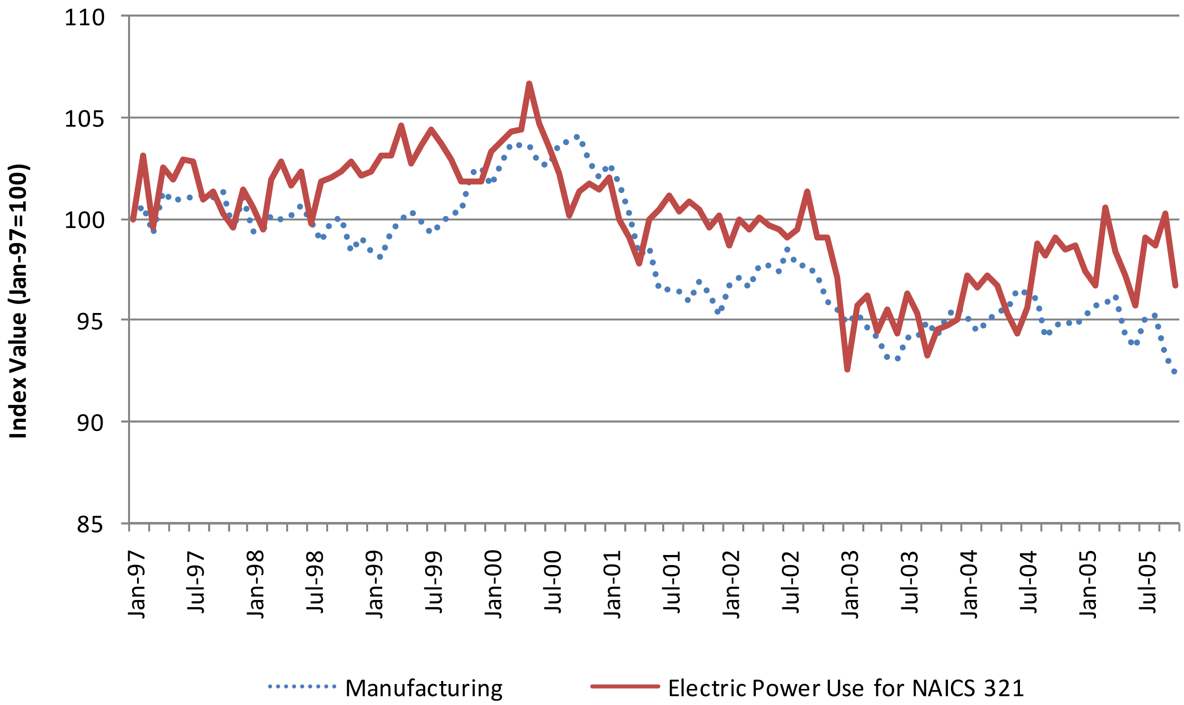

Figure 2-3. Electrical Power Use Trends in the Wood Product Manufacturing Industry (NAICS 321): 1997–2005

Source: Federal Reserve Board. 2009. "Industrial Production and Capacity Utilization: Electric Power Use: Manufacturing and Mining." Series ID: G17/KW/KW.GMF.S & G17/KW/KW.G321.S. <http://www.federalreserve.gov/datadownload/>. Accessed on December 15, 2009.

2.1.2.2 Uses and Consumers

Table 2-6 shows that three of the top four consumers of wood products are represented by the construction sector of the economy (NAICS 23). New residential construction, new nonresidential construction, and maintenance and repair construction consume 35% of the total commodity output in this industry. The top 10 consumers of wood products make up 54% of the demand for wood products. Although many of the top consumers deal with construction, repair, or real estate services, other types of consumers, such as food services and drinking places, rail transportation, plastics and rubber products manufacturing, and other, use these products.

2.1.3 Firm and Market Characteristics

This section describes geographic, production, and market data. These data provide the basis for further analysis, including regulatory flexibility analyses, as well as a complete picture of the recent historical trends of production and pricing.

Table 2-6. Demand by Sector: Wood Product Manufacturing (NAICS 321) ($2007, 10^6)

Sector	BEA Code	3210 Wood Products
New residential construction	2302	$19,997
New nonresidential construction	2301	$11,854
Furniture and related product manufacturing	3370	$8,197
Maintenance and repair construction	2303	$4,048
Motor vehicle body, trailer and parts manufacturing	336A	$2,516
Real estate	5310	$2,335
Food services and drinking places	7220	$2,307
Other miscellaneous manufacturing	3399	$1,311
Wholesale trade	4200	$1,284
Rail transportation	4820	$1,138
Retail trade	4A00	$1,047
Plastics and rubber products manufacturing	3260	$877
General state and local government use	S007	$3,116
Owner occupied dwelling	S008	$11,209
Private fixed investment	F020	$7,933
Exports of goods and services	F040	$3,978
Total final uses (gross domestic product [GDP])	T004	$3,719
Total commodity output	T007	$101,753

Source: U.S. Bureau of Economic Analysis (BEA). 2008. "2002 Benchmark Input-Output Accounts: 2002 Standard Make and Use Tables at the Summary Level." Table 2. Washington, DC: BEA.

2.1.3.1 Location

As Figure 2-4 illustrates, the states with the largest number of wood product manufacturing establishments are dispersed throughout the country, with a significant concentration of establishments in the northeastern states. Other states with many establishments include California, Texas, and North Carolina.

2.1.3.2 Production Capacity and Utilization

Capacity utilization of the wood product manufacturing industry has been experiencing capacity utilization increases and declines with more extreme fluctuations than those of all manufacturing industries combined. The decline in wood product manufacturing is similar to total manufacturing between 1997 and 2002. However, capacity utilization in total manufacturing, which peaked in 2006, started increasing at a faster rate than wood product manufacturing, but decreased sharply after its peak. Wood product manufacturing experienced its own rapid decrease in capacity utilization between 2007 and 2009, though not at the same rate as total manufacturing (Figure 2-5).

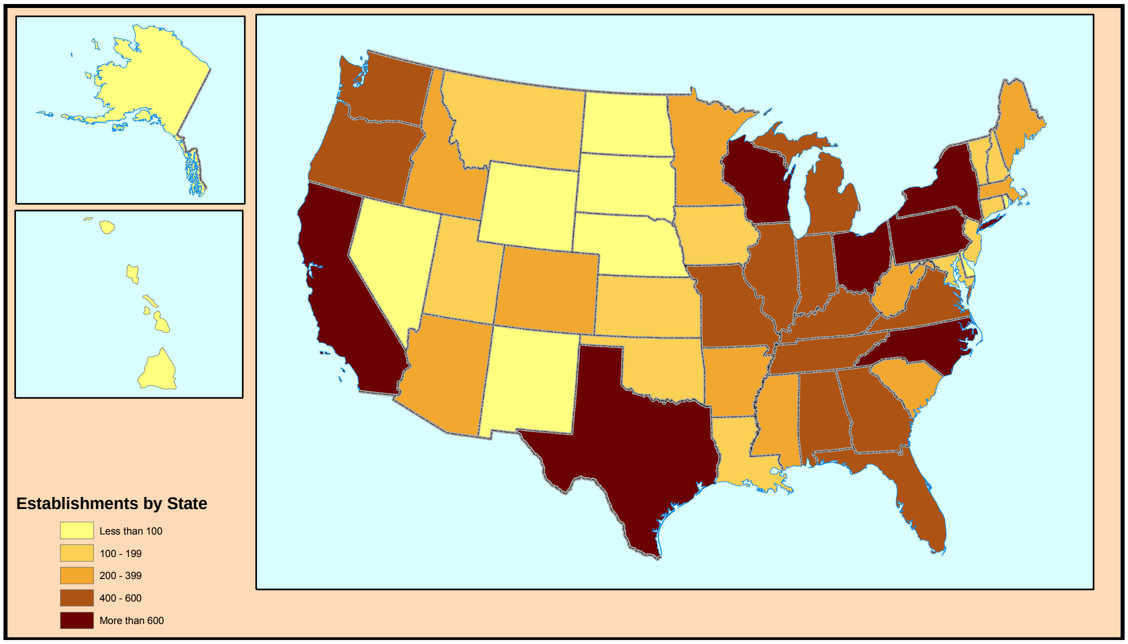

Figure 2-4. Establishment Concentration in the Wood Product Manufacturing Industry (NAICS 321): 2002

Source: U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 31: Manufacturing: Geographic Area Series: Industry Statistics for the States, Metropolitan and Micropolitan Statistical Areas, Counties, and Places: 2002." <http://factfinder.census.gov>; (July 23, 2008).

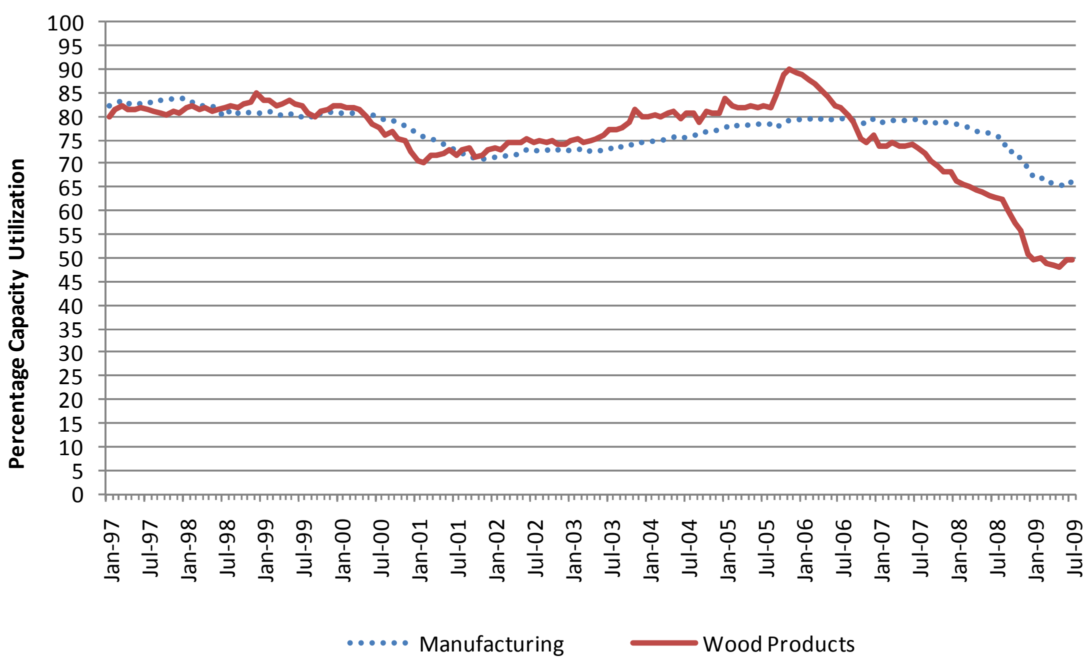

Figure 2-5. Capacity Utilization Trends in the Wood Product Manufacturing Industry (NAICS 321)

Source: Federal Reserve Board. 2009. "Industrial Production and Capacity Utilization: Capacity Utilization." Series ID: G17/CAPUTL/CAPUTL.GMF.S & G17/CAPUTL/CAPUTL.G321.S. <http://www.federalreserve.gov/datadownload/>. Accessed on December 15, 2009.

2.1.3.3 Employment

California has the largest number of employees in the wood product manufacturing industry with over 39,000 reported in the 2002 census followed by over 32,000 in Oregon (Figure 2-6). The states with the highest number of employees do not directly correlate with the states with the highest number of establishments. States such as Indiana, Georgia, Arkansas, and Oregon had fewer than 600 establishments, as shown in Figure 2-6, but had more than 20,000 employees, whereas states such as Ohio and New York had fewer than 20,000 employees but more than 600 establishments.

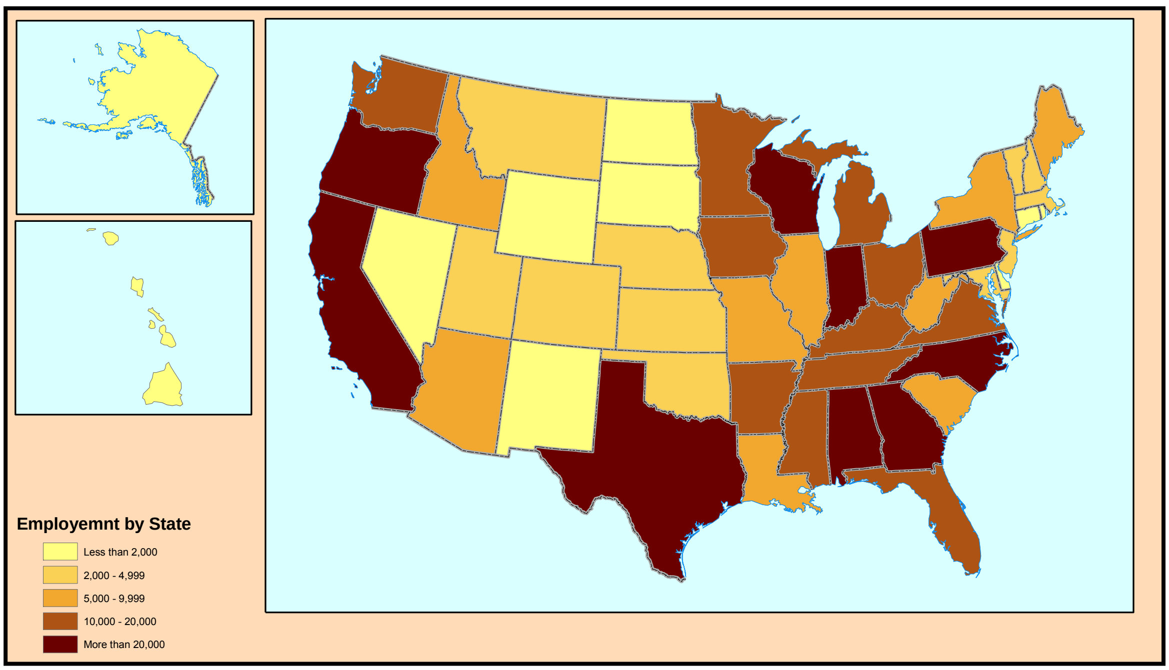

Figure 2-6. Employment Concentration in the Wood Product Manufacturing Industry (NAICS 321): 2002

Source: U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 31: Manufacturing: Geographic Area Series: Industry Statistics for the States, Metropolitan and Micropolitan Statistical Areas, Counties, and Places: 2002." <http://factfinder.census.gov>; (July 23, 2008).

2.1.3.4 Plants and Capacity

While the capacity of the manufacturing sector has been growing consistently since 1997, the wood product manufacturing industry has experienced inconsistent growth. After a small amount of growth in capacity between 1997 and 2001, the wood product manufacturing industry's capacity dipped between 2002 and 2005 but has been growing at a slow rate since then though it started to dip again in 2008 and 2009 (Figure 2-7).

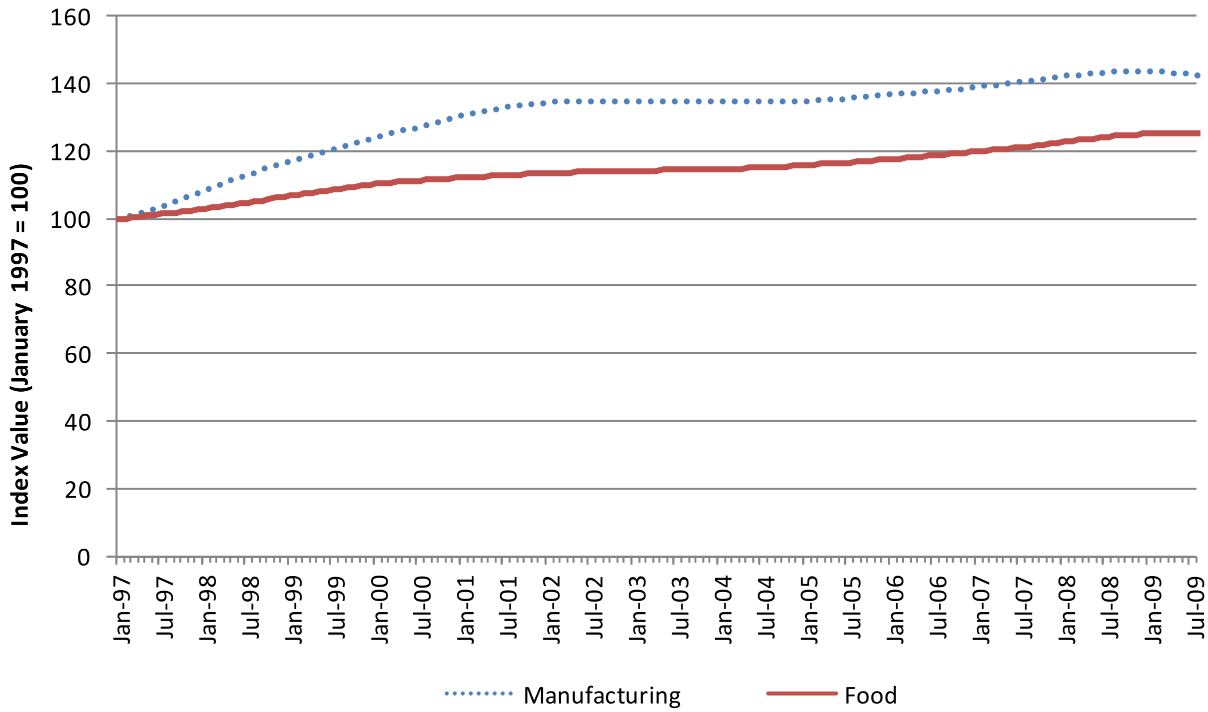

Figure 2-7. Capacity Trends in the Wood Product Manufacturing Industry (NAICS 321)

Source: Federal Reserve Board. "Industrial Production and Capacity Utilization: Industrial Capacity." Series ID: G17/CAP/CAP.GMF.S & G17/CAP/CAP.G321.S. <http://www.federalreserve.gov/datadownload/>. Accessed on December 15, 2009.

2.1.3.5 Firm Characteristics

In 2006, the top 10 paper and forest product companies produced over $75 billion in sales, with the top two companies—International Paper and Weyerhaeuser—generating nearly $22 billion each (Table 2-7). The top two companies' revenue consists of 58% of the revenue of the top 10 companies in Standard & Poor's (S&P's) list (Benwart, 2006). Although these numbers do not exclusively reflect wood products, they do convey the market environment in which firms in this sector compete.

2.1.3.6 Size Distribution

The primary criterion for categorizing a business as small is the number of employees, using definitions by the SBA for regulatory flexibility analyses. According to SUSB reports for 2002, small companies were the recipients of the majority of receipts in 2002; 53% of receipts were generated by companies with fewer than 500 employees (Table 2-8). The number of employees in the small business cutoff is 500 employees for all sub-industries in the wood product manufacturing industry (Table 2-9).

Table 2-7. Largest U.S. Paper and Forest Products Companies: 2006

Company	Revenues ($$10^6$)[a]
International Paper	21,995
Weyerhaeuser	21,896
Smurfit-Stone	7,157
MeadWestvaco	6,530
Temple-Inland	5,558
Bowater	3,530
Grief Inc.	2,628
Louisiana-Pacific	2,235
Packaging Corp.	2,187
Plum Creek	1,627

[a] Includes revenues from operations other than paper and forest products in certain cases.

Source: Benwart, S.J. 2006. "Paper & Forest Products." *Standard and Poor's Industry Surveys*. 176(28).

2.1.3.7 Domestic Production

Similar to industry capacity rates, industry production rates for wood product manufacturing have decreased since 2006 compared to the steady increase in production for the manufacturing sector since 1997 (Figure 2-8). Similar to capacity utilization trends (Figure 2-8), the index shows a faster rate of decline for wood products than the entire manufacturing sector.

2.1.3.8 International Trade

Since 1997, the wood product manufacturing industry has contributed to an increasing trade deficit (Figure 2-9). The value of imports has fluctuated greatly since 1997; however, exports have remained fairly constant, with seasonal changes, since 1997.

2.1.3.9 Market Prices

Prices of goods in the wood product manufacturing industry have remained roughly the same since 2005. The prices for the entire manufacturing sector increased between 2003 and 2008 but have decreased since August 2008. Producer price indices (PPIs) show that producer prices for wood products increased by 6% from 2004 to 2007, while producer prices for all manufacturing goods increased by roughly 34% at its peak and was at 23% in November 2008 and 24% in November 2009 (Figure 2-10).

Table 2-8. Distribution of Economic Data by Enterprise Size: Wood Product Manufacturing (NAICS 321)

		Enterprises with					
Variable	Total	1 to 20 Employees[a]	20 to 99 Employees	100 to 499 Employees	500 to 749 Employees	750 to 999 Employees	1,000 to 1,499 Employees
Firms	15,198	9,740	3,280	791	63	27	30
Establishments	17,052	9,758	3,482	1,271	166	91	133
Employment	534,011	65,423	132,612	118,910	19,784	11,944	18,533
Receipts ($\$10^3$)	$88,649	$8,204	$18,276	$19,717	$3,192	$1,902	$3,118
Receipts/firm ($\$10^3$)	$5,833	$842	$5,572	$24,927	$50,673	$70,453	$103,927
Receipts/establishment ($\$10^3$)	$5,199	$841	$5,249	$15,513	$19,231	$20,904	$23,442
Receipts/employment ($)	$166,006	$125,393	$137,818	$165,814	$161,363	$159,262	$168,231

[a] Excludes *Statistics of U.S. Businesses* (SUSB) employment category for zero employees. These entities only operated for a fraction of the year.

Source: U.S. Census Bureau. 2008. "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>.

Table 2-9. Small Business Size Standards: Wood Product Manufacturing (NAICS 321)

NAICS	NAICS Description	Employees
321113	Sawmills	500
321114	Wood Preservation	500
321211	Hardwood Veneer and Plywood Manufacturing	500
321212	Softwood Veneer and Plywood Manufacturing	500
321213	Engineered Wood Member (except Truss) Manufacturing	500
321214	Truss Manufacturing	500
321219	Reconstituted Wood Product Manufacturing	500
321911	Wood Window and Door Manufacturing	500
321912	Cut Stock, Resawing Lumber, and Planing	500
321918	Other Millwork (including Flooring)	500
321920	Wood Container and Pallet Manufacturing	500
321991	Manufactured Home (Mobile Home) Manufacturing	500
321992	Prefabricated Wood Building Manufacturing	500
321999	All Other Miscellaneous Wood Product Manufacturing	500

Source: 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/services/contractingopportunities/sizestandardstopics/size/index.html>.

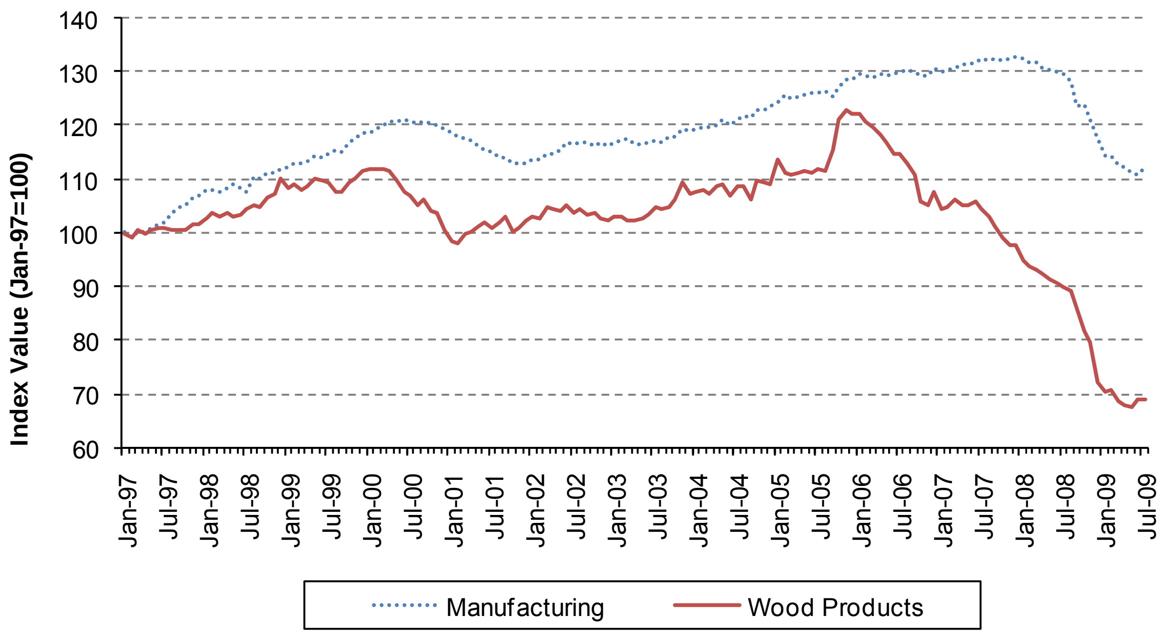

Figure 2-8. Industrial Production Trends in the Wood Product Manufacturing Industry (NAICS 321): 1997–2009

Source: Federal Reserve Board. "Industrial Production and Capacity Utilization: Industrial Production." Series ID: G17/IP_MAJOR_INDUSTRY_GROUPS/IP.GMF.S & G17/IP_MAJOR_INDUSTRY_GROUPS/ IP.G321.S. <http://www.federalreserve.gov/datadownload/>. Accessed on December 15, 2009.

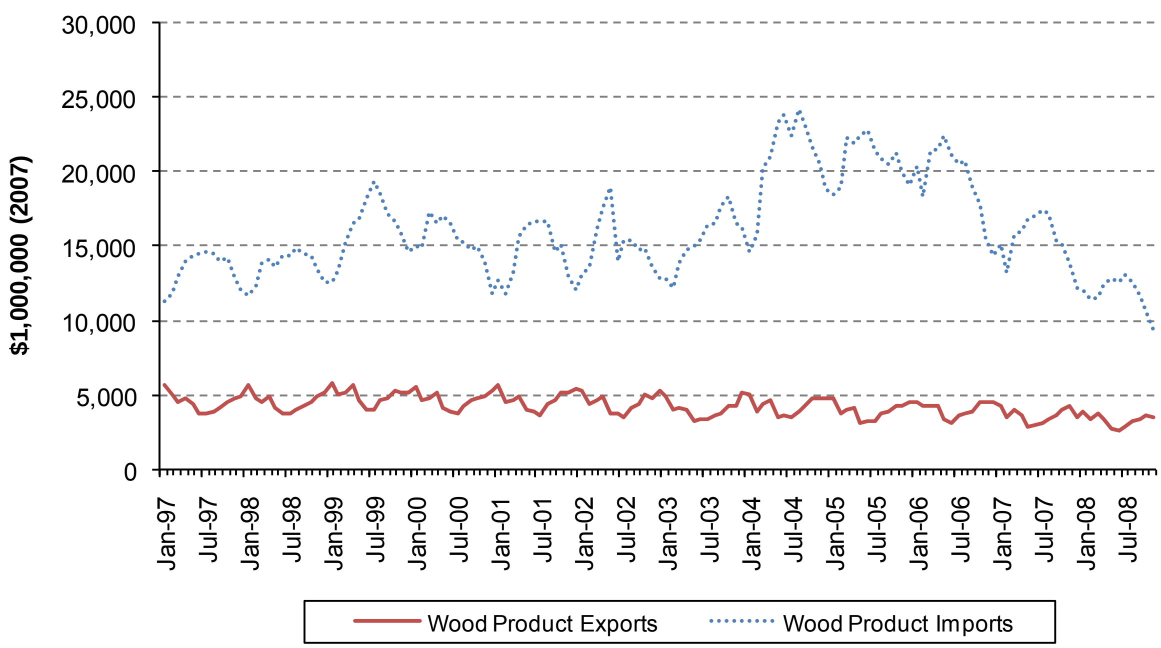

Figure 2-9. International Trade Trends in the Wood Product Manufacturing Industry (NAICS 321)]

Source: U.S. International Trade Commission. 2008a. "U.S. Domestic Exports" & "U.S. Imports for Consumption." <http://dataweb.usitc.gov/scripts/user_set.asp>; (July 17, 2008).

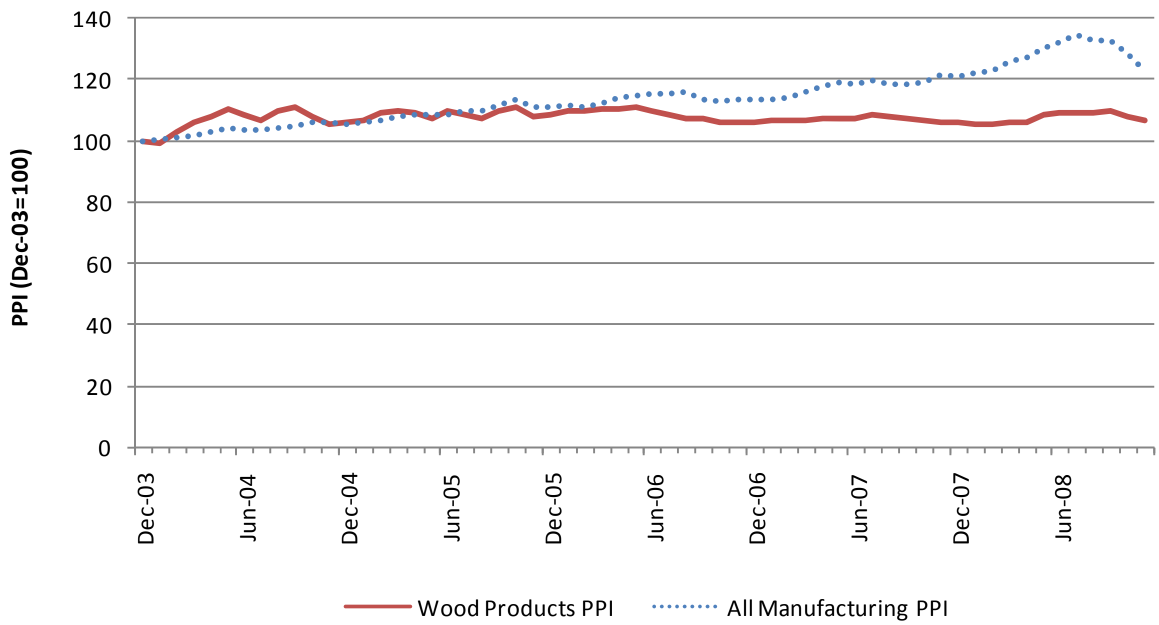

Figure 2-10. Producer Price Trends in the Wood Product Manufacturing Industry (NAICS 321)

Source: U.S. Bureau of Labor Statistics (BLS). 2009. "Producer Price Index." Series ID: PCU321—321—& PCUOMFG—OMFG—. <http://www.bls.gov/ppi/home.htm>. Accessed on January 8, 2010.

2.2 Paper Manufacturing

2.2.1 Introduction

The paper manufacturing subsector is an essential component of all business operations worldwide. Broadly speaking, paper and paperboard are manufactured by converting timber or other recycled material into products such as printing and writing papers, newsprint, tissue, and containerboard (Benwart, 2006). The subsector has been experiencing a decline in shipments as of late. From 1997 to 2007, shipments in the industry declined 7%, and employment declined by 27% (Table 2-10). While total payroll dropped 26% over this time, annual payroll per employee rose 2% from 1997 to 2007 because of the decline in the number of employees). Shipments per employee grew 28% from 1997 to 2007, with much of that growth taking place between 2002 and 2006 (Table 2-11).

Table 2-10. Key Statistics: Paper Manufacturing (NAICS 322)

	1997	2002	2006	2007
Shipments ($2007, 10^6)	$188,496	$175,983	$174,887	$175,806
Payroll ($2007, 10^6)	$27,983	$24,561	$21,188	$20,804
Employees	574,274	489,367	414,049	416,886
Establishments	5,868	5,495	NA	4,803

NA = Not available.

Sources: U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 31: Annual Survey of Manufactures: General Statistics: Statistics for Industry Groups and Industries: 2006 and 2005." <http://factfinder.census.gov>; (July 8, 2008).

U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 00: All Sectors: Core Business Statistics Series: Comparative Statistics for the United States and the States (1997 NAICS Basis): 2002 and 1997." <http://factfinder.census.gov>; (July 8, 2008).

U.S. Census Bureau; generated by Kapur Energy and Environment; using American FactFinder; "Sector 00: EC0700A1: All Sectors: Geographic Area Series: Economy-Wide Key Statistics: 2007." Accessed on December 28, 2009. [Source for 2007 numbers]

Table 2-11. Industry Ratios: Paper Manufacturing (NAICS 322)

Industry Ratios	1997	2002	2006	2007
Total shipments ($2007, 10^6)	$188,496	$175,983	$174,887	$175,806
Shipments per establishment ($2007, 10^3)	$32,123	$32,026	NA	$36,603
Shipments per employee ($2007)	$328,233	$359,614	$422,381	$421,712
Shipments per $ of payroll ($2007)	$6.74	$7.17	$8.25	$8.45
Annual payroll per employee ($2007)	$48,727	$50,189	$51,174	$49,904
Employees per establishment	98	89	NA	87

NA = Not available.

Sources: U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 31: Annual Survey of Manufactures: General Statistics: Statistics for Industry Groups and Industries: 2006 and 2005." <http://factfinder.census.gov>; (July 8, 2008).

U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 00: All Sectors: Core Business Statistics Series: Comparative Statistics for the United States and the States (1997 NAICS Basis): 2002 and 1997." <http://factfinder.census.gov>; (July 8, 2008).

U.S. Census Bureau; generated by Kapur Energy and Environment; using American FactFinder; "Sector 00: EC0700A1: All Sectors: Geographic Area Series: Economy-Wide Key Statistics: 2007." <http://factfinder.census.gov>. Accessed on December 28, 2009. [Source for 2007 numbers]

The U.S. Census Bureau categorizes this industry's facilities into two categories: pulp, paper, and paperboard manufacturing and converted paper product manufacturing. These are further divided into the following types of facilities as defined by the Census Bureau (2001):

- Pulp, Paper, and Paperboard:
  - Pulp Mills (NAICS 32211): This industry comprises establishments primarily engaged in manufacturing pulp without manufacturing paper or paperboard. The pulp is made by separating the cellulose fibers from the other impurities in wood or other materials, such as used or recycled rags, linters, scrap paper, and straw.
  - Paper Mills (NAICS 32212): This industry comprises establishments primarily engaged in manufacturing paper from pulp. These establishments may manufacture or purchase pulp. In addition, the establishments may convert the paper they make. The activity of making paper classifies an establishment into this industry regardless of the output.
  - Paperboard Mills (NAICS 32213): This industry comprises establishments primarily engaged in manufacturing paperboard from pulp. These establishments may manufacture or purchase pulp. In addition, the establishments may also convert the paperboard they make.
- Converted Paper Products:
  - Paperboard Containers Manufacturing (NAICS 32221): This industry comprises establishments primarily engaged in converting paperboard into containers without manufacturing paperboard. These establishments use corrugating, cutting, and shaping machinery to form paperboard into containers. Products made by these establishments include boxes; corrugated sheets, pads, and pallets; paper dishes; and fiber drums and reels.
  - Paper Bag and Coated and Treated Paper Manufacturing (NAICS 32222): This industry comprises establishments primarily engaged in one or more of the following manufacturing activities: cutting and coating paper and paperboard; cutting and laminating paper and paperboard and other flexible materials (except plastics film to plastics film); bags or multiwall bags or sacks of paper, metal foil, coated paper, or laminates or coated combinations of paper and foil with plastics film; laminated aluminum and other converted metal foils from purchased foils; and surface coating paper or paperboard.
  - Stationary Product Manufacturing (NAICS 32223): This industry comprises establishments primarily engaged in converting paper or paperboard into products used for writing, filing, art work, and similar applications.
  - Other Converted Paper Products (NAICS 32229): This industry comprises establishments primarily engaged in one of the following manufacturing activities:
    - converting paper and paperboard into products (except containers, bags, coated and treated paper and paperboard, and stationery products), or

- converting pulp into pulp products, such as disposable diapers, or molded pulp egg cartons, food trays, and dishes.

Figure 2-11 shows that the value of shipments for converted paper products was slightly higher in 2007, 54%, than the value of shipments for pulp, paper, and paperboard products in that year, 46%. However, Figure 2-12 indicates that significantly more employees worked in the converted paper product category of the industry, 70%, thus making converted paper products more labor intensive.

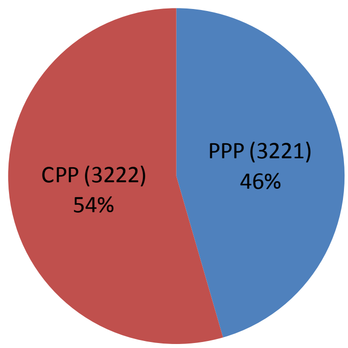

Figure 2-11. Distribution of Value of Shipments within Paper Manufacturing (NAICS 322): 2007

Source: U.S. Census Bureau; generated by Kapur Energy and Environment; using American FactFinder: "Sector 31: EC0731I1: Manufacturing: Industry Series: Detailed Statistics by Industry for the United States: 2007." Accessed on December 28, 2009.

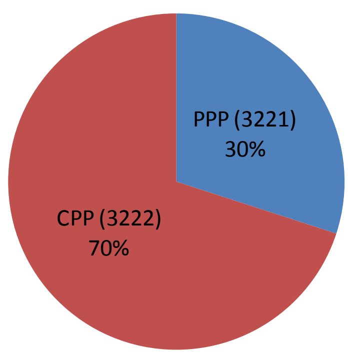

Figure 2-12. Distribution of Employment within Paper Manufacturing (NAICS 322): 2007

Source: U.S. Census Bureau; generated by Kapur Energy and Environment; using American FactFinder; "Sector 31: EC0731I1: Manufacturing: Industry Series: Detailed Statistics by Industry for the United States: 2007." <http://factfinder.census.gov>. Accessed on December 28, 2009.

2.2.2 Supply and Demand Characteristics

Next, we provide a broad overview of the supply and demand sides of the paper manufacturing industry. We emphasize the economic interactions this industry has with other industries and people and identify the key goods and services used by the industry and the major uses and consumers of paper manufacturing products.

2.2.2.1 Goods and Services Used in Paper Manufacturing

In 2007, the cost of materials made up 53% of the total shipment value of goods in the paper manufacturing industry (Table 2-12). Total compensation of employees represented 15% of the total value in 2007, down from 17% in 2005. The total number of employees dropped by 2%, between 2005 and 2007, while shipments increased by 3% in the same period.

Table 2-12. Costs of Goods and Services Used in the Paper Manufacturing Industry (NAICS 322)

Variable	2005	Share	2006	Share	2007	Share
Total shipments ($2007, 10^6)	$171,477	100%	$174,887	100%	$176,018	100%
Total compensation ($2007, 10^6)	$28,846	17%	$27,791	16%	$27,150	15%
Annual payroll	$21,792	13%	$21,188	12%	$20,804	12%
Fringe benefits	$7,054	4%	$6,603	4%	$6,346	4%
Total employees	426,748		414,049		417,367	
Average compensation per employee	$67,596		$67,121		$65,051	
Total production workers wages ($2007, 10^6)	$14,965	9%	$14,689	8%	$14,190	8%
Total production workers	331,228		321,684		321,937	
Total production hours (10^3)	716,963		691,134		680,732	
Average production wages per hour	$21		$21		$21	
Total cost of materials ($2007, 10^3)	$91,897	54%	$92,452	53%	$94,029	53%
Materials, parts, packaging	$77,494	45%	$78,202	45%	$79,984	45%
Purchase electricity	$3,788	2%	$3,841	2%	$3,780	2%
Purchased fuel ($2007)	$5,537	3%	$5,509	3%	$5,511	3%
Other	$5,078	3%	$4,901	3%	$4,755	3%

Sources: U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 31: Annual Survey of Manufactures: General Statistics: Statistics for Industry Groups and Industries: 2006 and 2005." <http://factfinder.census.gov>; (July 8, 2008).

U.S. Census Bureau; generated by Kapur Energy and Environment; using American FactFinder; "Sector 31: EC0731I1: Manufacturing: Industry Series: Detailed Statistics by Industry for the United States: 2007." <http://factfinder.census.gov>. Accessed on December 28, 2009. [Source for 2007 numbers]

The top 10 industry groups supplying inputs to the paper manufacturing subsector accounted for 70% of the total intermediate inputs according to 2008 Bureau of Economic Analysis (BEA) data (Table 2-13). Inputs for pulp, paper, and paperboard products are notably different from inputs for converted paper products because the NAICS 3221 group represents the initial step in the paper manufacturing process; thus, its inputs include more raw resources such as wood products, forestry and logging products, natural gas, and electricity. This becomes evident when observing inputs for converted paper products: 49% of the cost of inputs comes from pulp, paper, and paperboard products.

Table 2-13. Key Goods and Services Used in the Paper Manufacturing Industry (NAICS 322) ($\$10^6$, \$2007)

Description	BEA Code	NAICS 3221 Pulp, Paper, and Paperboard	NAICS 3222 Converted Paper Products	Total
Pulp, paper, and paperboard	3221	$4,155	$30,448	$34,603
Wholesale trade	4200	$3,916	$6,356	$10,273
Management of companies and enterprises	5500	$3,154	$3,838	$6,993
Forestry and logging products	1130	$5,389	$0	$5,389
Basic chemicals	3251	$3,734	$263	$3,997
Electric power generation, transmission, and distribution	2211	$2,690	$913	$3,603
Wood products	3210	$3,450	$33	$3,484
Converted paper products	3222	$1,415	$1,745	$3,159
Natural gas distribution	2212	$2,680	$345	$3,026
Truck transportation	4840	$1,428	$1,571	$2,999
Total intermediate inputs	T005	$47,835	$62,690	$110,525

Source: U.S. Bureau of Economic Analysis (BEA). 2008. "2002 Benchmark Input-Output Accounts: 2002 Standard Make and Use Tables at the Summary Level." Table 2. Washington, DC: BEA.

2.2.2.1.1 Energy. The Department of Energy (DOE) categorizes paper manufacturing (NAICS 322) as an energy-intensive subsector. The 2008 Annual Energy Outlook predicts that the paper-producing subsector will be one of four subsectors experiencing positive average growth of delivered energy consumption between 2006 and 2030 (DOE, 2008).

Energy generation from the recovery boiler is often insufficient for total plant needs, so facilities augment recovery boilers with fossil fuel–fired and wood waste–fired boilers (hogged fuel) to generate steam and often electricity. Industry-wide, the use of pulp wastes, bark, and other papermaking residues supplies 58% of the energy requirements of pulp and paper companies (EPA, 2002).

Likewise, Table 2-14 shows that total energy use decreased between 1998 and 2006 by 14%. Figure 2-13 indicates that total electrical power use changed sporadically between 2002 and 2004 but decreased consistently and rapidly after 2004.

Table 2-14. Energy Used in Paper Manufacturing (NAICS 322)

Fuel Type	1998	2002	2006
Total (trillion BTU)	2,744	2,361	2,354
Net electricity[a] (million kWh)	70,364	65,503	72,518
Residual fuel oil (million bbl)	24	16	15
Distillate fuel oil[b] (million bbl)	2	2	2
Natural gas[c] (billion cu ft)	570	490	461
LPG and NGL[d] (million bbl)	1	2	1
Coal (million short tons)	12	11	10
Coke and breeze (million short tons)	—	*	—
Other[e] (trillion BTU)	1,476	1,276	1,303

[a] Net electricity is obtained by summing purchases, transfers in, and generation from noncombustible renewable resources, minus quantities sold and transferred out. It does not include electricity inputs from on-site cogeneration or generation from combustible fuels because that energy has already been included as generating fuel (for example, coal).

[b] Distillate fuel oil includes Nos. 1, 2, and 4 fuel oils and Nos. 1, 2, and 4 diesel fuels.

[c] Natural gas includes natural gas obtained from utilities, local distribution companies, and any other supplier(s), such as independent gas producers, gas brokers, marketers, and any marketing subsidiaries of utilities.

[d] Examples of liquefied petroleum gases (LPG) are ethane, ethylene, propane, propylene, normal butane, butylene, ethane-propane mixtures, propane-butane mixtures, and isobutene produced at refineries or natural gas processing plants, including plants that fractionate raw natural gas liquids (NGLs).

[e] Other includes net steam (the sum of purchases, generation from renewables, and net transfers), and other energy that respondents indicated was used to produce heat and power.

* Estimate less than 0.5.

Sources: U.S. Department of Energy, Energy Information Administration. 2007. “2002 Energy Consumption by Manufacturers—Data Tables.” Tables 3.2 and N3.2. <http://www.eia.doe.gov/emeu/mecs/mecs2002/data02/shelltables.html>. Washington, DC: DOE.

U.S. Department of Energy, Energy Information Administration. 2007b. “2006 Energy Consumption by Manufacturers—Data Tables.” Table 3.1. <http://www.eia.doe.gov/emeu/mecs/mecs2006/2006tables.html>. Accessed on December 27, 2009. [Source for 2006 numbers]

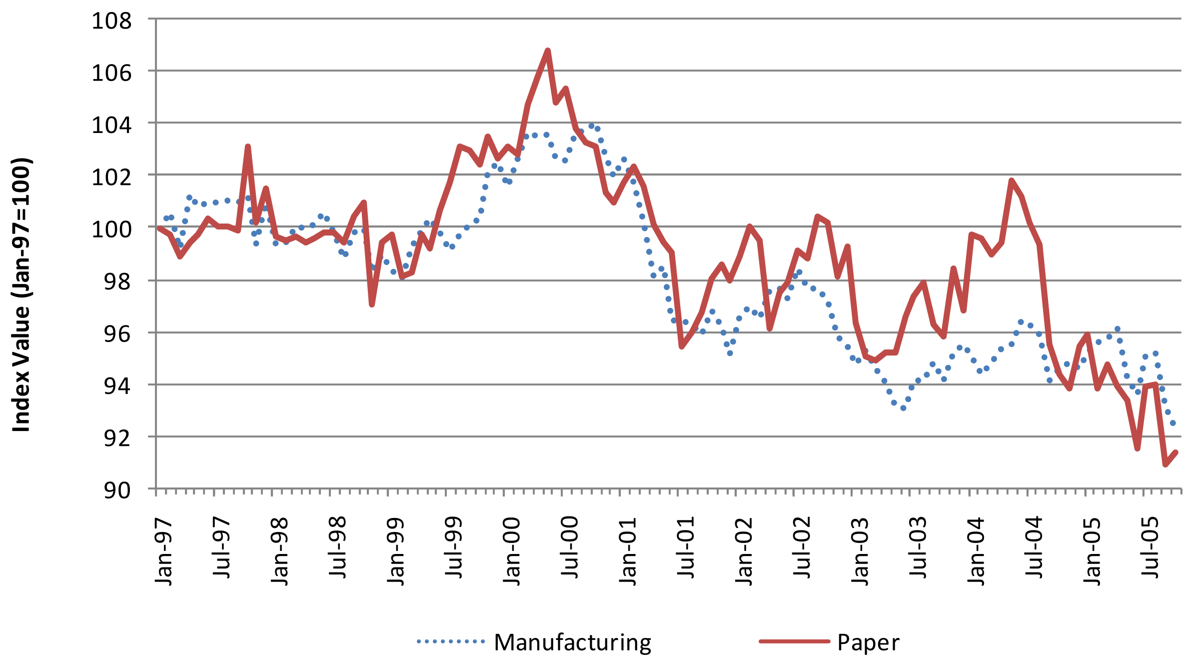

Figure 2-13. Electrical Power Use Trends in the Paper Manufacturing Industry: 1997–2005

Source: Federal Reserve Board. 2009. "Industrial Production and Capacity Utilization: Electric Power Use: Manufacturing and Mining." Series ID: G17/KW/KW.GMF.S & G17/KW/KW.G322.S. <http://www.federalreserve.gov/datadownload/>.

Over the last 25 years, the pulp and paper subsector has changed its energy generation methods from fossil fuels to a greater use of processes such as increases in the use of wood wastes in place of fuel (Table 2-15). During the 1972–1999 period, the proportion of total industry power generated from the combination of woodroom wastes, spent liquor solids, and other self-generated methods increased from about 41% to about 56%, while coal, fuel oil, and natural gas use decreased from about 54% to about 36% (EPA, 2002).

2.2.2.2 Uses and Consumers

Products manufactured in the NAICS groups 3221 and 3222 have different, but complementary, consumer profiles. NAICS 3221 supplies a significant portion of NAICS 3222 demand (37% of total commodity output). Both industries specialize in products with intermediate uses, with an average of 92% of sales between the two going toward this purpose. NAICS 3222 has a very diverse assortment of subsector groups from which it receives demand. Food manufacturing makes up 21% of the demand, making members of this industry the largest consumer of converted paper products (Table 2-16). Pulp, paper, and paperboard products have a large trade deficit, while converted paper products have a very small trade surplus.

Table 2-15. Estimated Energy Sources for the U.S. Pulp and Paper Industry

Energy Source	1972	1979	1990	1999
Purchased steam	5.4%	6.7%	7.3%	1.5%
Coal	9.8%	9.1%	13.7%	12.5%
Fuel oil	22.3%	19.1%	6.4%	6.3%
Natural gas	21.5%	17.8%	16.4%	17.6%
Other purchased energy	—	—	—	6.7%
Waste wood and wood chips (hogged fuel) and bark	6.6%	9.2%	15.4%	13.5%
Spent liquor solids	33.7%	37.3%	39.4%	40.3%
Other self-generated power	0.6%	0.8%	1.2%	1.6%

Source: U.S. Environmental Protection Agency. 2002. "Profile of the Pulp and Paper Industry." Sector Notebook Project. <http://www.epa.gov/Compliance/resources/publications/assistance/sectors/notebooks/index.html>.

Table 2-16. Demand by Sector: Paper Manufacturing Industry (NAICS 322) ($$10^6$, $2007)

Sector	BEA Code	3221 Pulp, Paper, and Paperboard	3222 Converted Paper Products	Total
Converted paper product manufacturing	3222	$30,448	$1,745	$32,193
Food manufacturing	3110	$638	$18,782	$19,421
Printing and related support activities	3230	$13,320	$3,874	$17,194
General state and local government services	S007	$6,065	$7,792	$13,857
Pulp, paper, and paperboard mills	3221	$4,155	$1,415	$5,569
Newspaper, periodical, book, and directory publishers	5111	$4,851	$168	$5,018
Plastics and rubber products manufacturing	3260	$1,249	$3,403	$4,651
Wholesale trade	4200	$990	$2,619	$3,609
Food services and drinking places	7220	$1,510	$2,597	$4,107
Total intermediate use	T001	$76,729	$80,862	$157,591
Personal consumption expenditures	F010	$11,882	$9,295	$21,177
Exports of goods and services	F040	$7,724	$5,799	$13,523
Imports of goods and services	F050	−$15,284	−$5,720	−$21,005
Total final uses (GDP)	T004	$4,996	$9,607	$14,604
Total commodity output	T007	$81,725	$90,469	$172,195

Source: U.S. Bureau of Economic Analysis (BEA). 2008. "2002 Benchmark Input-Output Accounts: 2002 Standard Make and Use Tables at the Summary Level." Table 2. Washington, DC: BEA.

2.2.3 *Firm and Market Characteristics*

This section describes geographic, production, and market data. These data provide the basis for further analysis, including regulatory flexibility analyses, and give a complete picture of the recent historical trends of production and pricing.

2.2.3.1 Location

As Figure 2-14 illustrates, California is home to the most paper manufacturing establishments in the United States, followed by Illinois and some bordering northeastern states. The location of establishments in the paper manufacturing industry varies a great deal by subsector. Wisconsin and New York have the most pulp, paper, and paperboard establishments, while California dominates with over 500 converted paper product establishments. Overall, the United States has 561 pulp, paper, and paperboard establishments and 4,956 converted paper product establishments.

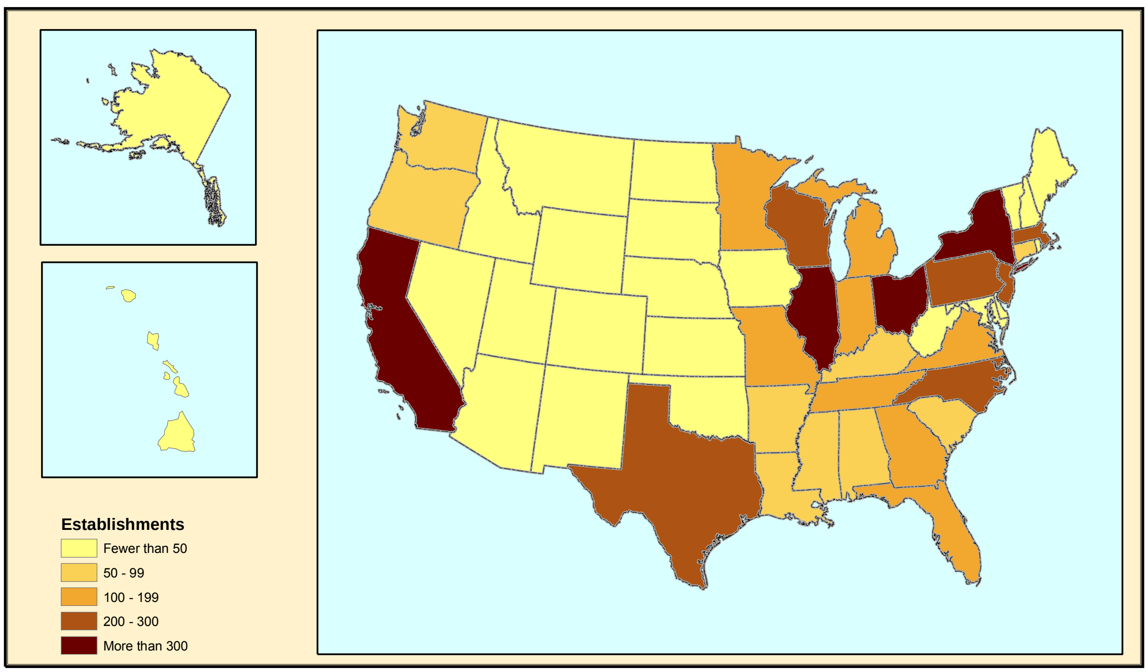

Figure 2-14. Establishment Concentration in Paper Manufacturing Industry (NAICS 322): 2002

Source: U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 31: Manufacturing: Geographic Area Series: Industry Statistics for the States, Metropolitan and Micropolitan Statistical Areas, Counties, and Places: 2002." <http://factfinder.census.gov>; (July 23, 2008).

2.2.3.2 Production Capacity and Utilization

Capacity utilization of the paper manufacturing subsector has been experiencing a steady decline, similar to the decline of the total manufacturing sector. However, paper manufacturing has managed to use its capacity at a consistently higher rate than the average for manufacturing industries (Figure 2-15).

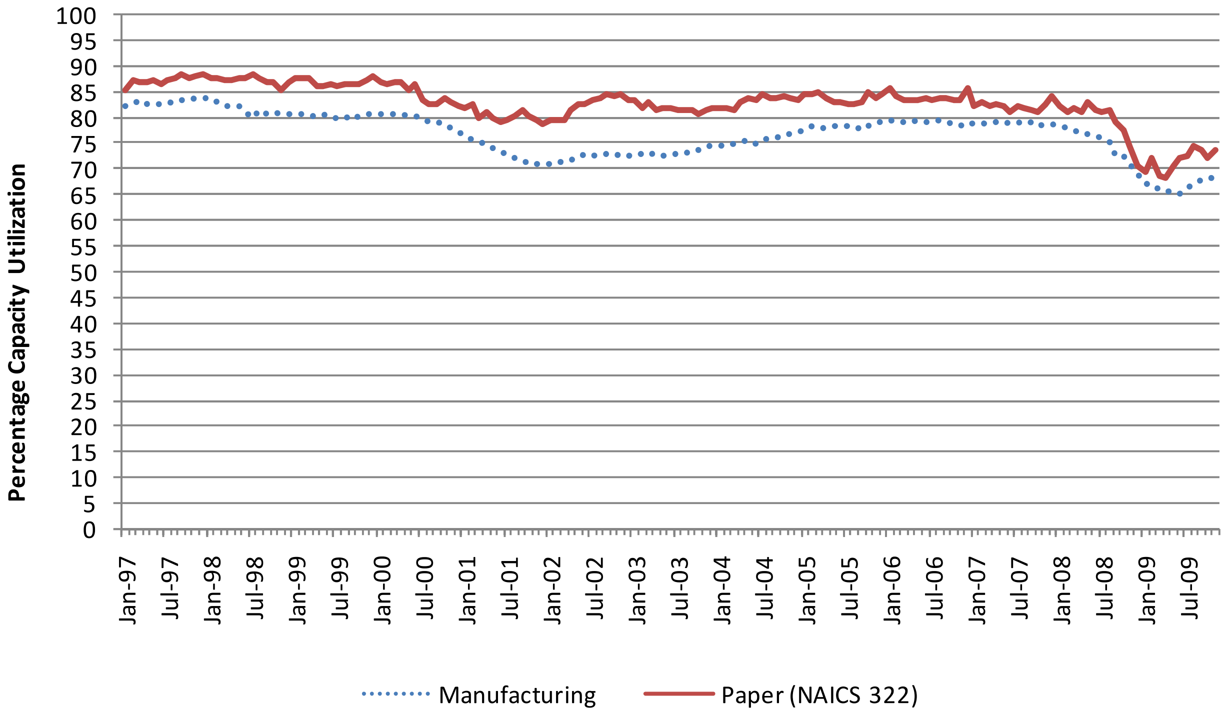

Figure 2-15. Capacity Utilization Trends in the Paper Manufacturing Industry (NAICS 322)

Source: Federal Reserve Board. 2009. "Industrial Production and Capacity Utilization: Capacity Utilization." Series ID: G17/CAPUTL/CAPUTL.GMF.S & G17/CAPUTL/CAPUTL.G322.S. <http://www.federalreserve.gov/datadownload/>.

2.2.3.3 Employment

Wisconsin has the largest number of employees in the paper manufacturing subsector with over 38,008 reported in the 2002 census followed by 29,379 in California (Figure 2-16). The converted paper products group has more employees per establishment, 283, than the pulp, paper, and paperboard group, 67.

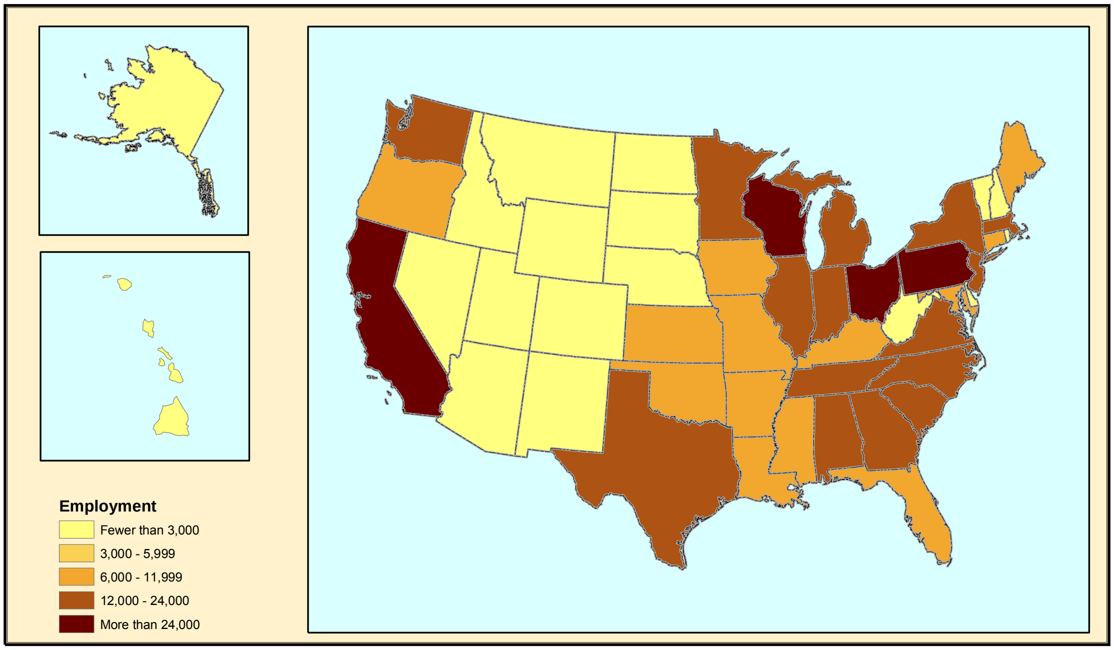

Figure 2-16. Employment Concentration in the Paper Manufacturing Industry (NAICS 322): 2002

Source: U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 31: Manufacturing: Geographic Area Series: Industry Statistics for the States, Metropolitan and Micropolitan Statistical Areas, Counties, and Places: 2002." <http://factfinder.census.gov>; (July 23, 2008).

2.2.3.4 Plants and Capacity

While the manufacturing sector has been growing consistently since 1997, the paper manufacturing sector has not experienced the same amount of success in the same period. Despite a small amount of growth in capacity between 1997 and 2001, the paper manufacturing subsector's capacity has declined to as much as 7% below 1997 capacity levels (Figure 2-17).

2.2.3.5 Firm Characteristics

In 2006, the top 10 paper and forest product companies produced over $1.6 billion in sales, with the top two companies—International Paper and Weyerhaeuser—generating nearly $22 billion each (Table 2-17). The top two companies' revenue consists of 58% of the revenue of the top 10 companies in Standard & Poor's (S&P's) list (Benwart, 2006). Although these numbers do not exclusively reflect paper products, they do convey the market environment in which firms in this sector compete.

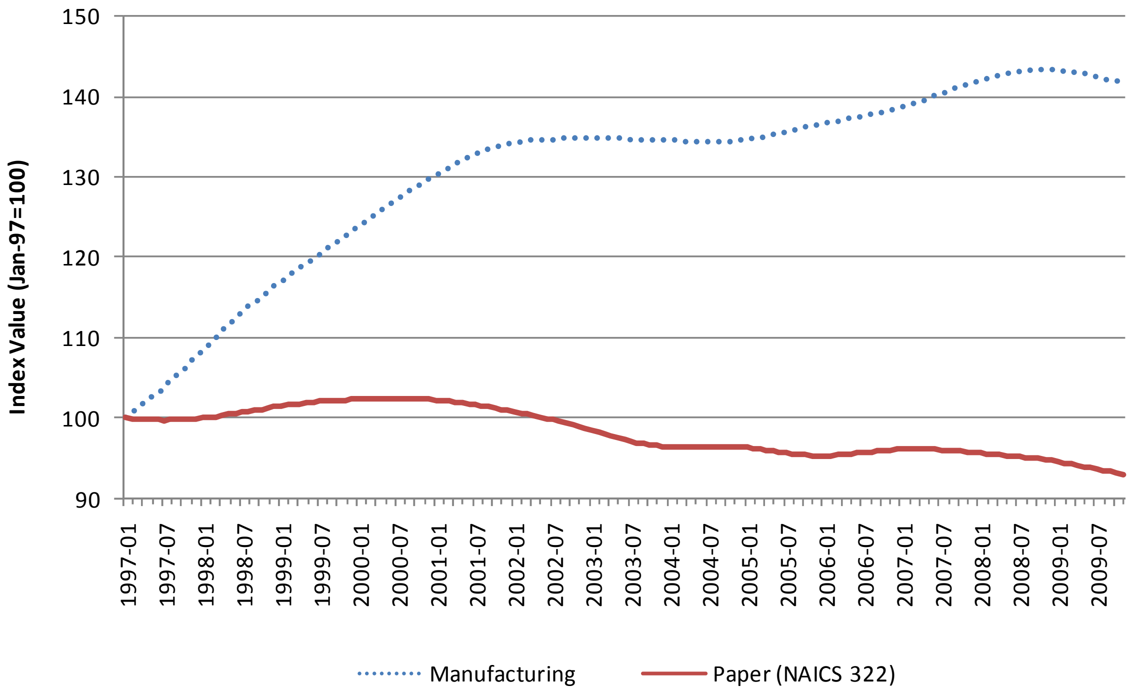

Figure 2-17. Capacity Trends in the Paper Manufacturing Industry (NAICS 322)

Source: Federal Reserve Board. 2009. "Industrial Production and Capacity Utilization: Industrial Capacity." Series ID: G17/CAP/CAP.GMF.S & G17/CAP/CAP.G322.S. <http://www.federalreserve.gov/datadownload/>.

Table 2-17. Largest U.S. Paper and Forest Products Companies: 2006

Company	Revenues ($\$10^6$)[a]
International Paper	21,995
Weyerhaeuser	21,896
Smurfit-Stone	7,157
MeadWestvaco	6,530
Temple-Inland	5,558
Bowater	3,530
Grief Inc.	2,628
Louisiana-Pacific	2,235
Packaging Corp.	2,187
Plum Creek	1,627

[a] Includes revenues from operations other than paper and forest products in certain cases.

Sources: Benwart, S.J. 2006. "Paper & Forest Products. Standard and Poor's Industry Surveys." 176(28). U.S. and international sales data from company reports.

2.2.3.6 Size Distribution

The primary criterion for categorizing a business as small is the number of employees, using definitions by the SBA for regulatory flexibility analyses. According to SUSB reports for 2002, large companies dominated revenue-generating transactions in the paper manufacturing subsector; 80% of receipts were generated by companies with 500 employees or more (Table 2-18). This was especially true in the pulp, paper, and paperboard group, in which large companies generated 92% of receipts. The number of employees in the small business cutoff varies according to six-digit NAICS codes (Table 2-19). The cutoff for all subsectors in the pulp, paper, and paperboard group is 750 employees, while the cutoff for most converted paper product groups is 500 employees.

2.2.3.7 Domestic Production

Similar to industry capacity rates, subsector production rates for paper manufacturing have witnessed a decreasing rate of production compared to the steady increase in production for the manufacturing sector since 1997 (Figure 2-18). It seems that the paper manufacturing sector was not able to return to its former levels of growth following the 2001 recession; it has experienced a downward production trend since then.

Table 2-18. Distribution of Economic Data by Enterprise Size: Paper Manufacturing (NAICS 322)

		Enterprises with					
Variable	**Total**	**1 to 20 Employees[a]**	**20 to 99 Employees**	**100 to 499 Employees**	**500 to 749 Employees**	**750 to 999 Employees**	**1,000 to 1,499 Employees**
Firms	3,538	1,482	1,200	476	43	22	33
Establishments	5,546	1,488	1,271	755	83	69	138
Employment	495,990	11,325	52,334	78,402	13,293	12,496	23,283
Receipts ($\$10^6$)	$154,746	$2,218	$9,483	$17,620	$3,034	$3,951	$6,798
Receipts/firm ($\$10^3$)	$43,738	$1,497	$7,903	$37,017	$70,561	$179,577	$206,001
Receipts/establishment ($\$10^3$)	$27,902	$1,491	$7,461	$23,338	$36,556	$57,256	$49,261
Receipts/employment ($)	$311,994	$195,850	$181,203	$224,742	$228,250	$316,157	$291,974

[a] Excludes SUSB employment category for zero employees. These entities only operated for a fraction of the year.

Source: U.S. Census Bureau. 2008. “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>.

Table 2-19. Small Business Size Standards: Paper Manufacturing (NAICS 322)

NAICS	NAICS Description	Employees
322110	Pulp Mills	750
322121	Paper (except Newsprint) Mills	750
322122	Newsprint Mills	750
322130	Paperboard Mills	750
322211	Corrugated and Solid Fiber Box Manufacturing	500
322212	Folding Paperboard Box Manufacturing	750
322213	Setup Paperboard Box Manufacturing	500
322214	Fiber Can, Tube, Drum, and Similar Products Manufacturing	500
322215	Non-Folding Sanitary Food Container Manufacturing	750
322221	Coated and Laminated Packaging Paper Manufacturing	500
322222	Coated and Laminated Paper Manufacturing	500
322223	Coated Paper Bag and Pouch Manufacturing	500
322224	Uncoated Paper and Multiwall Bag Manufacturing	500
322225	Laminated Aluminum Foil Manufacturing for Flexible, Packaging Uses	500
322226	Surface-Coated Paperboard Manufacturing	500
322231	Die-Cut Paper and Paperboard Office Supplies, Manufacturing	500
322232	Envelope Manufacturing	500
322233	Stationery, Tablet, and Related Product Manufacturing	500
322291	Sanitary Paper Product Manufacturing	500
322299	All Other Converted Paper Product Manufacturing	500

Source: 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/services/contractingopportunities/sizestandardstopics/size/index.html>.

2.2.3.8 International Trade

Since 1997, paper manufacturing products, both pulp, paper, and paperboard products and converted paper products, have contributed to an increasing trade surplus in this sector (Figure 2-19). Imports and exports have been changing at similar rates since 1999.

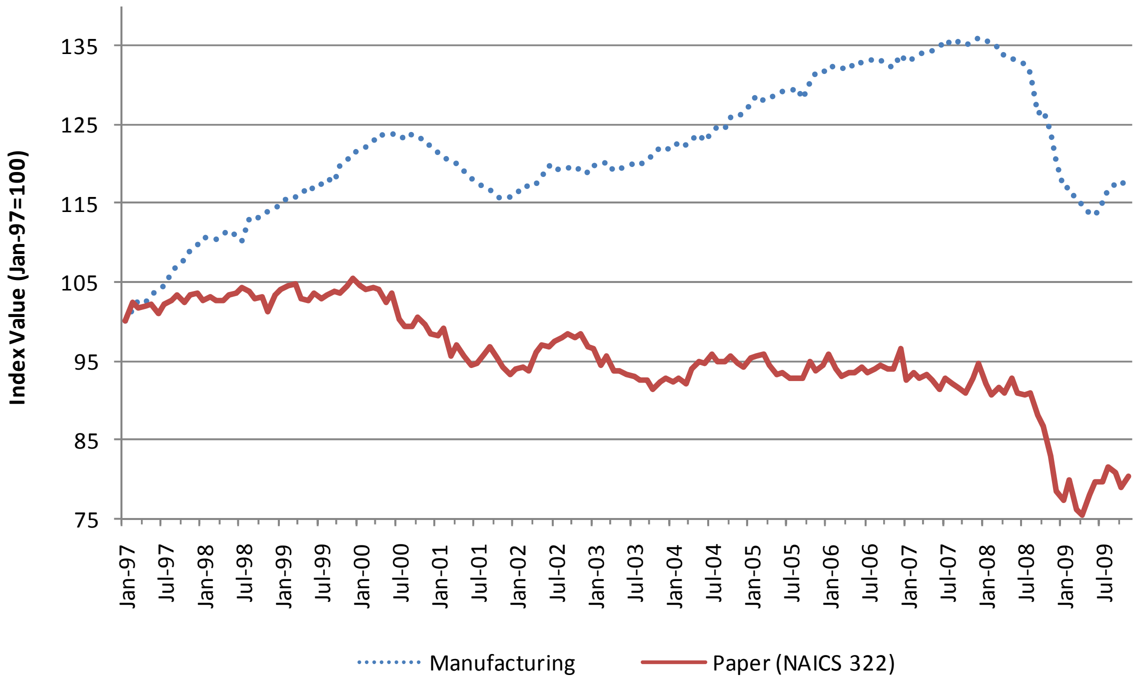

Figure 2-18. Industrial Production Trends in the Paper Manufacturing Industry (NAICS 322): 1997–2009

Source: Federal Reserve Board. 2009. "Industrial Production and Capacity Utilization: Industrial Production." Series ID: G17/IP_MAJOR_INDUSTRY_GROUPS/IP.GMF.S & G17/IP_MAJOR_INDUSTRY_GROUPS/IP.G322.S. <http://www.federalreserve.gov/datadownload/>.

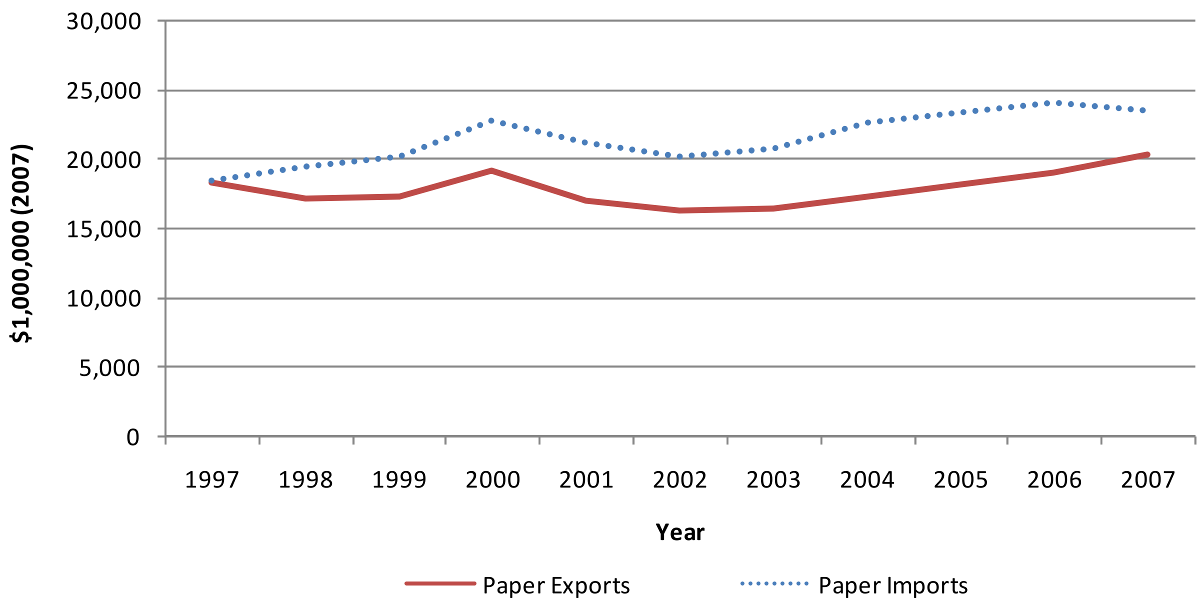

Figure 2-19. International Trade Trends in the Paper Manufacturing Industry (NAICS 322)

Source: U.S. International Trade Commission. 2008b. "U.S. Total Exports" & "U.S. Imports for Consumption." <http://dataweb.usitc.gov/scripts/user_set.asp>.

2.2.3.9 Market Prices

Prices of goods in paper manufacturing have been increasing at a rate consistent with all manufacturing products (Figure 2-20). Producer price indices (PPIs) show that producer prices for paper in 2007 increased by 20% since 1997, while producer prices for all manufacturing goods increased by roughly 27%.

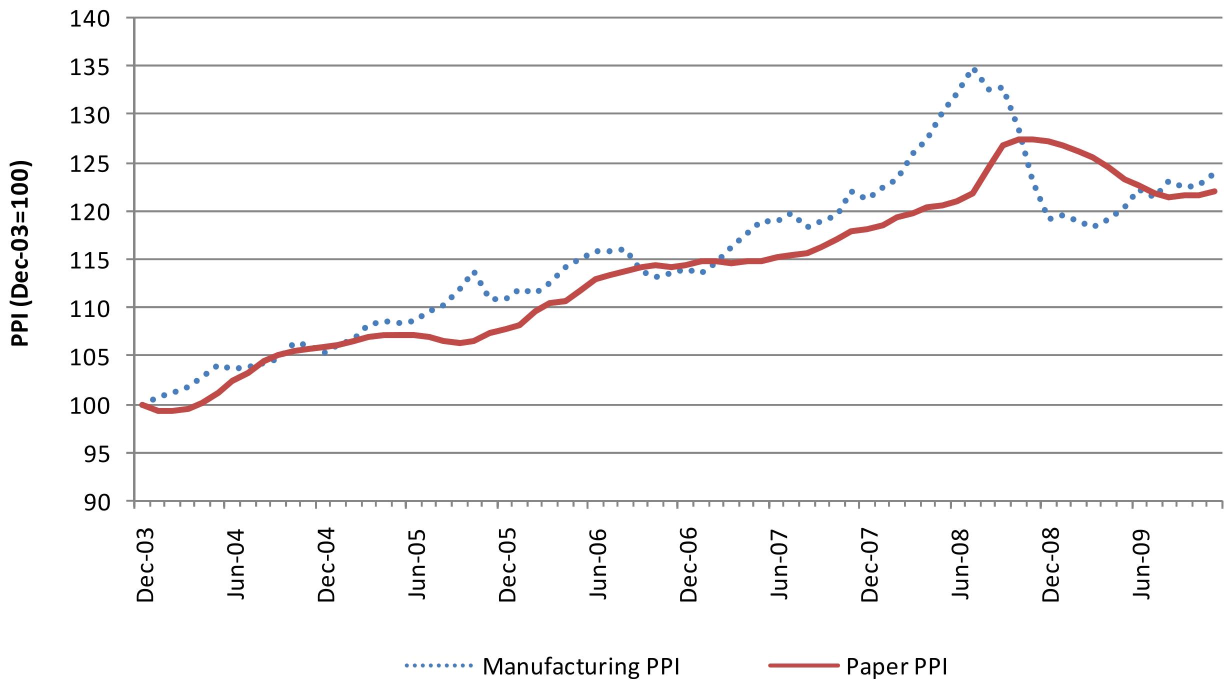

Figure 2-20. Producer Price Trends in the Paper Manufacturing Industry (NAICS 222)

Source: U.S. Bureau of Labor Statistics (BLS). 2009. "Producer Price Index." Series ID: PCU322–322– & PCUOMFG–OMFG–. <http://www.bls.gov/ppi/home.htm>.

2.3 Chemical Manufacturing

2.3.1 Introduction

The chemical manufacturing industry produces over 70,000 chemical substances, many of which are ubiquitous in American life. Broadly speaking, chemical manufacturing operates by converting feedstocks into chemical products that can serve as intermediate goods or final products such as medicine, soap, and printer ink. From 1997 to2007, shipments in the industry grew 42%, while employment declined by 8% (Table 2-20). While total payroll dropped 0.6% over this time, annual payroll per employee rose 7.8% from 1997 to 2007 because of the decline in the number of employees (Table 2-21). Shipments per employee grew 54% from 1997 to 2007, with much of that growth taking place between 2002 and 2006 (Table 2-21).

Table 2-20. Key Statistics: Chemical Manufacturing (NAICS 325)

	1997	2002	2006	2007
Shipments ($2007, 10^6)	$521,251	$531,173	$675,223	$738,303
Payroll ($2007, 10^6)	$49,961	$51,317	$46,981	$49,648
Employees	882,645	853,224	747,134	814,024
Establishments	13474	13,475	NA	12,937

NA = Not available.

Sources: U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 31: Annual Survey of Manufactures: General Statistics: Statistics for Industry Groups and Industries: 2006 and 2005." <http://factfinder.census.gov>; (July 8, 2008).

U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 00: All Sectors: Core Business Statistics Series: Comparative Statistics for the United States and the States (1997 NAICS Basis): 2002 and 1997." <http://factfinder.census.gov>; (July 8, 2008).

U.S. Census Bureau; generated by Kapur Energy and Environment; using American FactFinder; "Sector 00: EC0700A1: All Sectors: Geographic Area Series: Economy-Wide Key Statistics: 2007." <http://factfinder.census.gov>. Accessed on December 27, 2009. [Source for 2007 numbers]

Table 2-21. Industry Ratios: Chemical Manufacturing (NAICS 325)

Industry Ratios	1997	2002	2006	2007
Total shipments ($2007, 10^6)	$521,251	$531,173	$675,223	$738,303
Shipments per establishment ($\$10^3$)	$38,686	$39,419	NA	$57,069
Shipments per employee ($2007)	$590,556	$622,548	$903,750	$906,979
Shipments per $ of payroll ($2007)	$10.43	$10.35	$14.37	$14.87
Annual payroll per employee ($2007)	$56,603	$60,145	$62,882	$60,991
Employees per establishment	66	63	NA	63

NA = Not available.

Sources: U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 31: Annual Survey of Manufactures: General Statistics: Statistics for Industry Groups and Industries: 2006 and 2005." <http://factfinder.census.gov>; (July 8, 2008).

U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 00: All Sectors: Core Business Statistics Series: Comparative Statistics for the United States and the States (1997 NAICS Basis): 2002 and 1997." <http://factfinder.census.gov>; (July 8, 2008).

U.S. Census Bureau; generated by Kapur Energy and Environment; using American FactFinder; "Sector 00: EC0700A1: All Sectors: Geographic Area Series: Economy-Wide Key Statistics: 2007." <http://factfinder.census.gov>. Accessed on December, 27, 2009. [Source for 2007 numbers]

Chemical manufacturing (NAICS 325) covers a diverse set of industry groups, which we have aggregated into the following three groups:

- Bulk Chemicals—Includes the most energy-intensive industry groups as aggregated by the Department of Energy (DOE) (DOE/EIA-0554, 2008): Basic Chemical Manufacturing (NAICS 3251); Resin, Rubber, and Artificial Fibers Manufacturing (NAICS 3252); and Agricultural Chemical Manufacturing (NAICS 3253).
- Pharmaceutical and Medicine Manufacturing (NAICS 3254)—Consists primarily of pharmaceutical preparation manufacturing. This industry group is the largest importer of goods within chemical manufacturing.
- Other Chemical Manufacturing: Consists of Paint, Coating, and Adhesive Manufacturing (NAICS 3255); Soap, Cleaning Compound, and Toiletry Manufacturing (NAICS 3256); and Other Chemical Product and Preparation Manufacturing (NAICS 3259).

In 2007, each of these groups generated approximately one-third of the total employment in chemical manufacturing (Figure 2-21). The bulk chemicals group accounted for the biggest share of chemical manufacturing's total value of shipments (Figure 2-22).

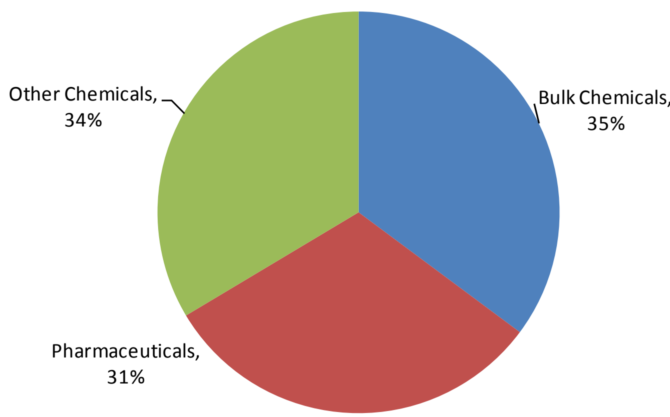

Figure 2-21. Distribution of Employment within Chemical Manufacturing (NAICS 325): 2007

Source: U.S. Census Bureau; generated by Kapur Energy and Environment; using American FactFinder; "Sector 31: EC0731I1: Manufacturing: Industry Series: Detailed Statistics by Industry for the U.S.: 2007." Release date: October 30, 2009. Accessed on December 27, 2009.

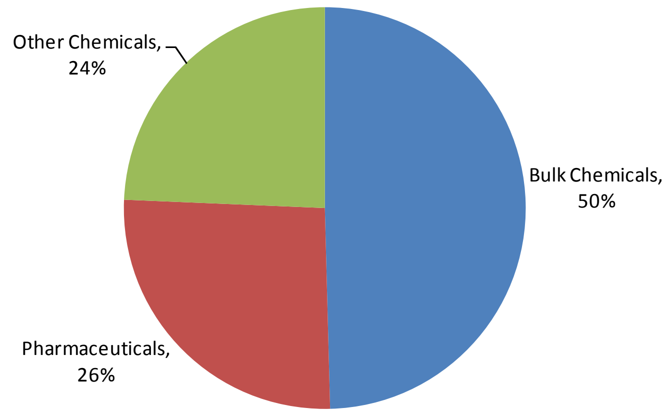

Figure 2-22. Distribution of Total Value of Shipments within Chemical Manufacturing (NAICS 325): 2007

Source: U.S. Census Bureau; generated by Kapur Energy and Environment; using American FactFinder; "Sector 31:EC0731I1: Manufacturing Industry Series: Detailed Statistics by Industry for U.S.: 2007." <http://factfinder.census.gov>. Accessed on December 27, 2009.

2.3.2 Supply and Demand Characteristics

Next, we provide a broad overview of the supply and demand side of the chemical manufacturing industry. We emphasize the economic interactions this industry has with other industries and people, including identifying the key goods and services used by the industry and the major uses and consumers of chemical manufacturing products.

The top 10 industry groups supplying inputs to the chemical manufacturing industry in 2002 accounted for 71% of the total intermediate inputs (Table 2-22). Bulk chemicals' production was the most energy intensive, using 79% of the chemical manufacturing inputs from petroleum and coal products, electric power generation, transmission and distribution, and natural gas distribution.

2.3.2.1 Goods and Services Used in Chemical Manufacturing

In2007, the cost of materials made up 49% of chemical manufacturing's total shipment value (Table 2-22). Total compensation to employees represented 9% of total shipment value, down from 10% in 2005.

2.3.2.1.1 Energy. The Department of Energy (DOE) classifies bulk chemical manufacturing as an energy-intensive industry. Pharmaceuticals and other chemical manufacturing are categorized as non-energy-intensive industries, grouped together with other industry groups under the "Balance of Manufacturing" category (DOE, 2008).

Table 2-22. Key Goods and Services Used in Chemical Manufacturing (NAICS 325) ($2007, 10^6)

Good or Service	BEA Code	Bulk Chemicals	Pharmaceuticals	Other Chemicals	Total
Basic chemicals	3251	$59,495	$4,772	$14,021	$78,288
Management of companies and enterprises	5500	$15,071	$19,380	$16,396	$50,846
Pharmaceuticals and medicines	3254	$0	$25,125	$0	$25,125
Wholesale trade	4200	$9,428	$8,367	$6,077	$23,872
Scientific research and development services	5417	$6,172	$6,139	$5,554	$17,865
Petroleum and coal products	3240	$10,066	$398	$3,432	$13,896
Plastics and rubber products	3260	$2,675	$1,132	$5,556	$9,363
Resins, rubber, and artificial fibers	3252	$4,048	$0	$4,949	$8,996
Electric power generation, transmission, and distribution	2211	$6,025	$716	$807	$7,548
Natural gas distribution	2212	$6,390	$154	$390	$6,934
Total intermediate use	T005	$167,699	$82,403	$91,833	$341,935

Source: U.S. Bureau of Economic Analysis (BEA). 2008. "2002 Benchmark Input-Output Accounts: 2002 Standard Make and Use Tables at the Summary Level." Table 2. Washington, DC: BEA.

Fuel used in chemical production can either facilitate chemical processes or provide the feedstock to derive value-added chemicals. In 2007, 70% of chemical manufacturing's energy bill was spent on fuel used as feedstocks (O'Reilly, 2008). These fuel costs represented 2% of chemical manufacturing's total value of shipments (Table 2-23).

As a whole, chemical manufacturing has become less energy intensive over the last 10 years. According to DOE, natural gas use by the chemical manufacturing industry dropped 30% from 1998 to 2006, and electricity use fell 10% (Table 2-24). From 1997 to 2005, when data ceased to be available, chemical manufacturing became less electricity intensive faster than the manufacturing sector as a whole (Figure 2-23).

Table 2-23. Costs of Goods and Services Used in Chemical Manufacturing (NAICS 325)

Variable	2005	Share	2006	Share	2007	Share
Total shipments ($2007)	$646,895	100%	$675,223	100%	$722,494	100%
Total compensation ($2007, 10^6)	$62,669	10%	$61,683	9%	$63,591	9%
Annual payroll	$48,159	7%	$46,981	7%	$48,780	7%
Fringe benefits	$14,510	2%	$14,702	2%	$14,811	2%
Total employees	756,078		747,134		801,567	
Average compensation per employee ($2007)	$82,887		$82,559		$79,333	
Total production workers' wages ($2007, 10^6)	$22,643	4%	$22,231	3%	$23,157	3%
Total production workers	431,502		430,880		463,802	
Total production hours (10^3)	899,499		885,993		948,244	
Average production wages per hour	$25		$25		$24	
Total cost of materials ($$10^3$)	$299,859	46%	$318,945	47%	$357,055	49%
Materials, parts, packaging	$247,851	38%	$260,934	39%	$291,656	40%
Purchase electricity	$8,291	1%	$8,490	1%	$8,936	1%
Purchased fuel	$14,568	2%	$13,667	2%	$14,227	2%
Other	$29,148	5%	$35,855	5%	$42,236	6%

Sources: U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 31: Annual Survey of Manufactures: General Statistics: Statistics for Industry Groups and Industries: 2006 and 2005." <http://factfinder.census.gov>; (July 8, 2008).

U.S. Census Bureau; generated by Kapur Energy and Environment; using American FactFinder; "Sector 31: EC0731I1: Manufacturing: Industry Series: Detailed Statistics by Industry for the United States: 2007." Accessed on December, 27, 2009.

2.3.2.2 Uses and Consumers

Products manufactured in the groups bulk chemicals, pharmaceuticals, and other chemicals have very different consumer profiles. Bulk chemicals is dominated by intermediate use, representing 93% of its total commodity output and 56% of the total intermediate use of chemical manufacturing products. Pharmaceuticals has both a high level of demand from personal consumption, accounting for 67% of the total personal consumption of chemical manufacturing products, and a large trade deficit (Table 2-25).

Table 2-24. Energy Used in Chemical Manufacturing (NAICS 325)

Fuel Type	1998	2002	2006
Total (trillion BTU)	3,704	3,769	3,159
Net electricity[a] (million kWh)	169,233	153,104	151,646
Residual fuel oil (million bbl)	8	7	4
Distillate fuel oil[b] (million bbl)	2	2	2
Natural gas[c] (billion cu ft)	1,931	1,634	1,349
LPG and NGL[d] (million bbl)	15	9	2
Coal (million short tons)	13	14	8
Coke and breeze (million short tons)	*	*	*
Other[e] (trillion BTU)	748	1,158	1,045

[a] Net electricity is obtained by summing purchases, transfers in, and generation from noncombustible renewable resources, minus quantities sold and transferred out. It does not include electricity inputs from on-site cogeneration or generation from combustible fuels because that energy has already been included as generating fuel (for example, coal).

[b] Distillate fuel oil includes Nos. 1, 2, and 4 fuel oils and Nos. 1, 2, and 4 diesel fuels.

[c] Natural gas includes natural gas obtained from utilities, local distribution companies, and any other supplier(s), such as independent gas producers, gas brokers, marketers, and any marketing subsidiaries of utilities.

[d] Examples of liquefied petroleum gases (LPGs) are ethane, ethylene, propane, propylene, normal butane, butylene, ethane-propane mixtures, propane-butane mixtures, and isobutene produced at refineries or natural gas processing plants, including plants that fractionate raw natural gas liquids (NGLs).

[e] Other includes net steam (the sum of purchases, generation from renewables, and net transfers), and other energy that respondents indicated was used to produce heat and power.

* Estimate less than 0.5.

Sources: U.S. Department of Energy, Energy Information Administration. 2007b. “2006 Energy Consumption by Manufacturers—Data Tables.” Table 3.1. Washington, DC: DOE. <http://www.eia.doe.gov/emeu/mecs/mecs2006/2006tables.html>. [Source for 2006 numbers]

U.S. Department of Energy, Energy Information Administration. 2007. “2002 Energy Consumption by Manufacturers—Data Tables.” Tables 3.2 and N3.2. Washington, DC: DOE. <http://www.eia.doe.gov/emeu/mecs/mecs2002/data02/shelltables.html>.

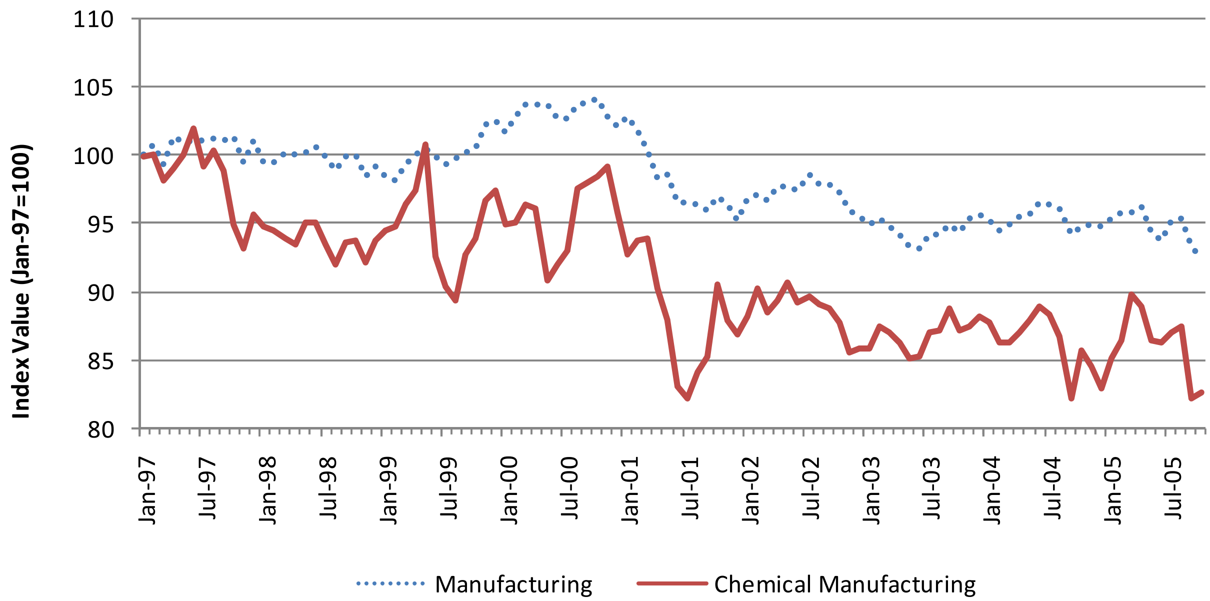

Figure 2-23. Electric Power Use Trends in Chemical Manufacturing (NAICS 325): 1997–2005

Source: Federal Reserve Board. 2009. "Industrial Production and Capacity Utilization: Electric Power Use: Manufacturing and Mining." Series ID: G17/KW/KW.GMF.S & G17/KW/KW.G325.S. <http://www.federalreserve.gov/datadownload/>; (November 17, 2009).

2.3.3 Firm and Market Characteristics

This remaining subsection describes geographic, production, and market data. These data provide the basis for further analysis, including regulatory flexibility analyses, and give a complete picture of the recent historical trends of production and pricing.

2.3.3.1 Location

In 2002, California had the most chemical manufacturing establishments in the United States, followed by Texas and New Jersey (Figure 2-24). The composition of establishments in these states differs among the different industry groups. Despite the fact that each group employed an approximately equal share of people in 2002, 54% of the total establishments were other chemicals establishments, and only 13% were pharmaceutical establishments.

2.3.3.2 Production Capacity and Utilization

Capacity utilization of the chemical manufacturing industry has been broadly in line with the manufacturing sector (Figure 2-25). In the second half of 2005, the chemical manufacturing industry's capacity utilization fell dramatically because of the multiple hurricanes affecting the Gulf Coast states. The impact of the economic downturn in 2001 can be seen in the capacity utilization of both manufacturing and chemical manufacturing.

Table 2-25. Demand by Sector: Chemical Manufacturing (NAICS 325) ($2007 10^6)

Sector	BEA Code	Bulk Chemicals	Pharmaceuticals	Other Chemicals	Total
Plastics and rubber products manufacturing	3260	$39,353	$0	$3,057	$42,410
Basic chemical manufacturing	3251	$33,972	$0	$1,675	$35,647
Pharmaceutical and medicine manufacturing	3254	$4,778	$25,125	$462	$30,365
Resin, rubber, and artificial fibers manufacturing	3252	$28,249	$0	$1,076	$29,325
Ambulatory health care services	6210	$2,716	$22,900	$934	$26,550
General state and local government services	S007	$7,150	$10,586	$8,807	$26,543
Hospitals	6220	$2,936	$15,390	$394	$18,720
Other chemical product and preparation manufacturing	3259	$8,021	$0	$2,680	$10,701
Textile mills	3130	$9,568	$0	$930	$10,498
Soap, cleaning compound, and toiletry manufacturing	3256	$3,886	$0	$6,289	$10,176
Total intermediate use	T001	$212,996	$83,279	$82,107	$378,382
Personal consumption expenditures	F010	$4,449	$123,746	$55,882	$184,077
Exports of goods and services	F040	$47,121	$15,683	$13,136	$75,940
Imports of goods and services	F050	−$38,732	−$67,950	−$10,906	−$117,588
Total final uses (GDP)	T004	$15,733	$73,485	$58,023	$147,241
Total commodity output	T007	$228,729	$156,765	$140,129	$525,623

Source: U.S. Bureau of Economic Analysis (BEA). 2008. "2002 Benchmark Input-Output Accounts: 2002 Standard Make and Use Tables at the Summary Level." Table 2. Washington, DC: BEA.

2.3.3.3 Employment

The geographic distribution of employment in chemical manufacturing differs largely among the different groups. In California, 52% of the chemical manufacturing employment comes from the pharmaceutical industry, while 60% of the chemical manufacturing employment in the Gulf Coast states comes from bulk chemicals manufacturing (Figure 2-26).

2.3.3.4 Plants and Capacity

Production capacity in chemical manufacturing has grown 33% since 1997. This growth, however, is 9% less than the growth rate for the manufacturing industry as a whole (Figure 2-27).

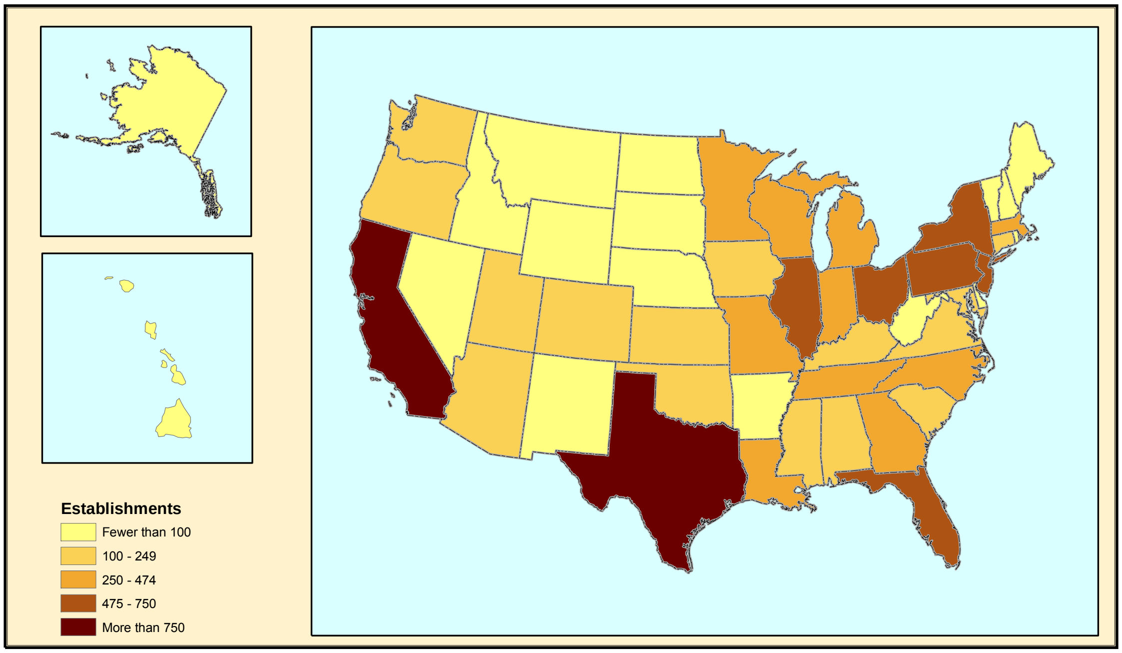

Figure 2-24. Establishment Concentration in Chemical Manufacturing (NAICS 325): 2002

Source: U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 31: Manufacturing: Geographic Area Series: Industry Statistics for the States, Metropolitan and Micropolitan Statistical Areas, Counties, and Places: 2002." <http://factfinder.census.gov>; (July 23, 2008).

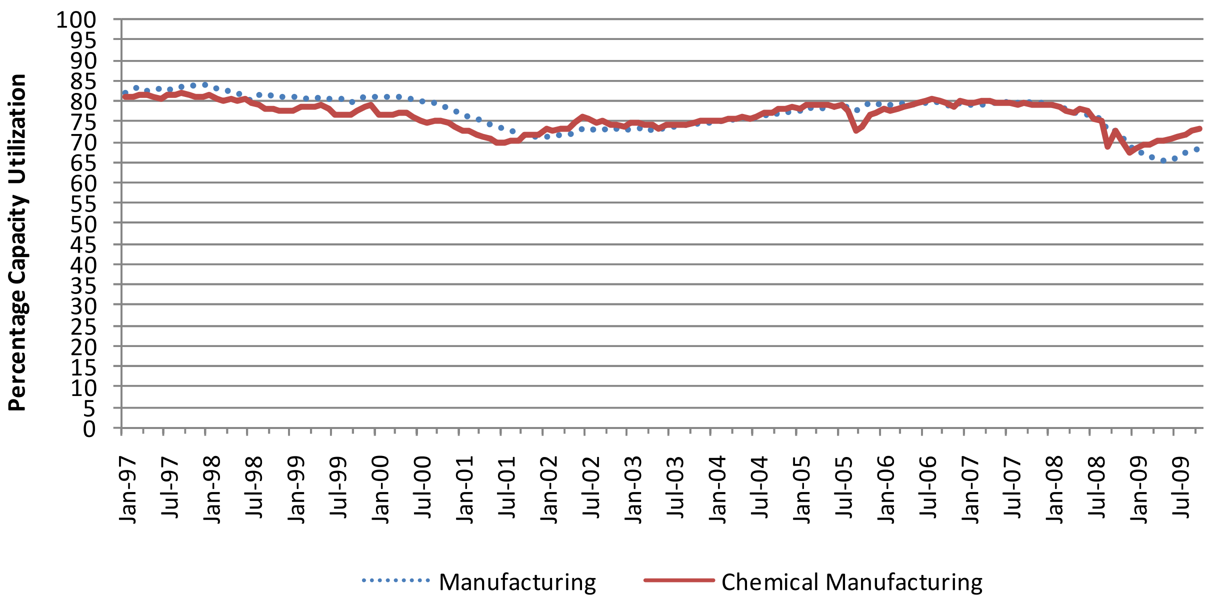

Figure 2-25. Capacity Utilization Trends in Chemical Manufacturing (NAICS 325)

Source: Federal Reserve Board. 2009. "Industrial Production and Capacity Utilization: Capacity Utilization." Series ID: G17/CAPUTL/CAPUTL.GMF.S & G17/CAPUTL/CAPUTL.G325.S. <http://www.federalreserve.gov/datadownload/>.

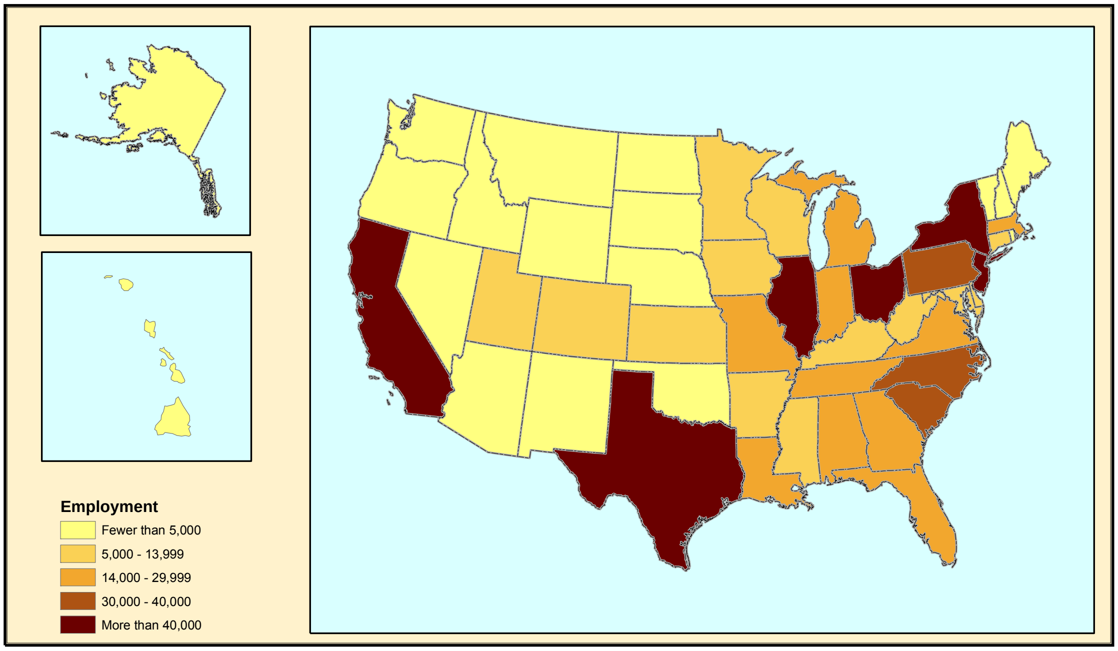

Figure 2-26. Employment Concentration in Chemical Manufacturing (NAICS 325): 2002

Source: U.S. Census Bureau; generated by RTI International; using American FactFinder; "Sector 31: Manufacturing: Geographic Area Series: Industry Statistics for the States, Metropolitan and Micropolitan Statistical Areas, Counties, and Places: 2002." <http://factfinder.census.gov>; (July 23, 2008).

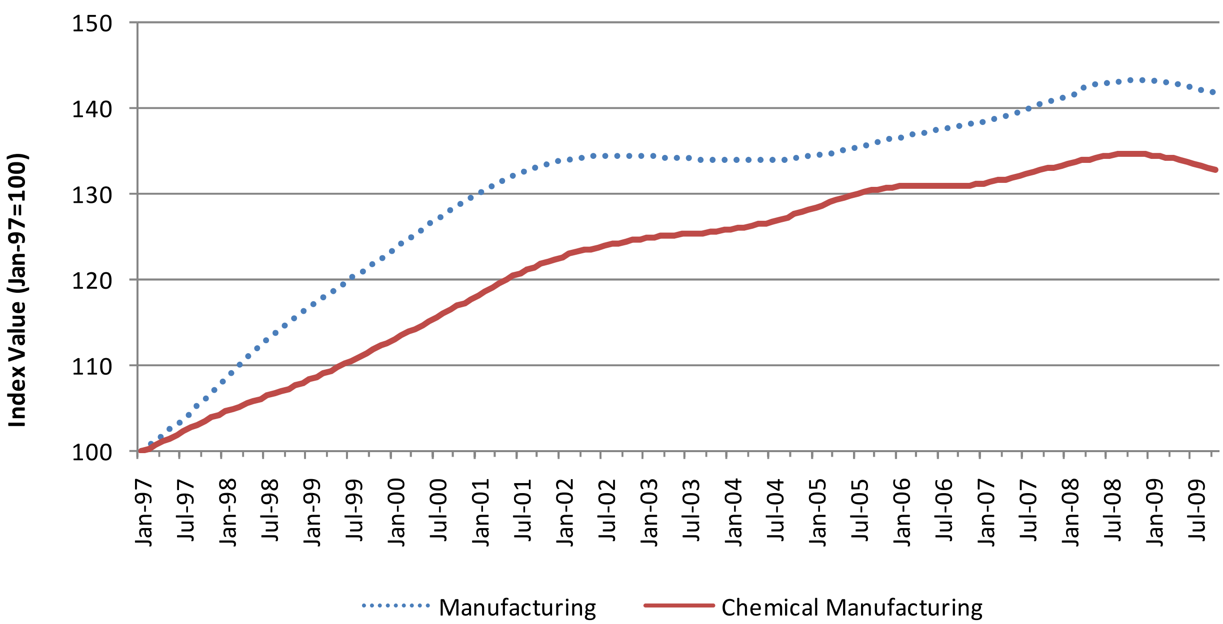

Figure 2-27. Capacity Trends in Chemical Manufacturing (NAICS 325)

Source: Federal Reserve Board. 2009. "Industrial Production and Capacity Utilization: Industrial Capacity." Series ID: G17/CAP/CAP.GMF.S & G17/CAP/CAP.G325.S. <http://www.federalreserve.gov/datadownload/>.

2.3.3.5 Firm Characteristics

In 2007, the top six companies by chemical sales had greater than $10 billion in sales. Together, their sales are greater than the next 44 highest chemical companies combined. These, however, are global companies, with a large portion of both sales and production coming from operations outside of the United States (Table 2-26). The largest chemical manufacturing company, Dow Chemicals, has 108 out of 150 manufacturing sites located outside of the United States (Dow Chemical Company, 2008).

Table 2-26. Top Chemical Producers: 2007

	Chemical Sales ($\$10^6$)	% of Total Sales	% of Sales in United States
Dow Chemical	53,513	100%	35%
ExxonMobil	36,826	9%	38%
DuPont	29,218	100%	38%
Lyondell[a]	16,165	57%	80%
Chevron Phillips	12,534	100%	86%
PPG Industries[a]	10,025	90%	56%
Huntsman Chemical	9,651	100%	50%
Praxair	9,402	100%	43.5%
Air Products[a]	8,820	88%	51%
Rohm & Haas[b]	7,837	88%	49%

[a] Percentage of sales in the United States calculated from total sales, not chemical sales.
[b] Percentage of sales in the United States is actually percentage of sales in North America.

Sources: O'Reilly, R. 2008. "Chemicals." *Standard and Poor's Industry Surveys*. 176(28).

In 2007, 58%of U.S. chemical manufacturing corporations generated net income. Including those with and without net income, chemical manufacturers had an average before-tax profit margin of 10.24%. Profitability is highest for pharmaceutical and medicine corporations (Table 2-27).

2.3.3.6 Size Distribution

The primary criterion for categorizing a business as small is number of employees, using definitions by the SBA for regulatory flexibility analyses. The data describing size standards are provided in Table 2-28. In 2002, enterprises with fewer than 500 employees accounted for 27% of employment and 15% of receipts within the chemical manufacturing industry (Table 2-29).

Table 2-27. 2007 Corporate Income and Profitability (NAICS 325)

Industry	Number of Corporations	Number of Corporations with Net Income	Total Receipts ($$10^3$)	Business Receipts ($$10^3$)	Before-Tax Profit Margin	After-Tax Profit Margin
Chemical manufacturing	9,564	5,512	$912,353,710	$808,897,810	10.24%	7.89%
Basic chemical	1,244	757	$195,022,700	$178,019,490	5.07%	4.10%
Resin, synthetic rubber, and artificial synthetic fibers and filaments	1,067	648	$44,692,366	$40,078,009	8.06%	6.33%
Pharmaceutical and medicine	1,034	611	$381,339,258	$317,414,432	15.63%	11.66%
Paint, coating, and adhesive	1,411	1,260	$51,778,868	$49,486,744	5.39%	4.02%
Soap, cleaning compound, and toilet preparation	1,862	463	$150,506,485	$139,836,602	9.07%	7.51%
Other chemical product and preparation	2,946	1,773	$89,014,032	$84,062,534	6.71%	5.27%

Source: Internal Revenue Service, U.S. Department of Treasury. 2008. "Corporation Source Book: Data File 2007." <http://www.irs.gov/taxstats/article/0,,id=167415,00.html>; (January, 15, 2010).

2.3.3.7 Domestic Production

In the late 1990s, overall manufacturing production was growing much faster than the chemical manufacturing component (Figure 2-28). Following the recession of 2001, however, the components have moved broadly in line with one another, except for the drop in chemical manufacturing production caused by the hurricane season of 2005.

2.3.3.8 International Trade

In the year 2000, the United States moved from having a trade surplus to a trade deficit in chemical manufacturing products (Figure 2-29). This change occurred because the trade deficit in pharmaceutical manufacturing, currently at $35 billion, overwhelmed the trade surplus of bulk chemicals and other chemical manufacturing combined, currently at $22 billion.

2.3.3.9 Market Prices

Prices of goods in chemical manufacturing have accelerated rapidly in the last 2 years, having outpaced overall manufacturing since 2002 (Figure 2-30). Much of this recent acceleration seen in the industry PPI is due to the bulk chemicals segment, largely reflecting the rapid increase in fertilizer prices.

Table 2-28. Small Business Size Standards: Chemical Manufacturing (NAICS 325)

NAICS	Description	Employees
325110	Petrochemical Manufacturing	1,000
325120	Industrial Gas Manufacturing	1,000
325131	Inorganic Dye and Pigment Manufacturing	1,000
325132	Synthetic Organic Dye and Pigment Manufacturing	750
325181	Alkalies and Chlorine Manufacturing	1,000
325182	Carbon Black Manufacturing	500
325188	All Other Basic Inorganic Chemical Manufacturing	1,000
325191	Gum and Wood Chemical Manufacturing	500
325192	Cyclic Crude and Intermediate Manufacturing	750
325193	Ethyl Alcohol Manufacturing	1,000
325199	All Other Basic Organic Chemical Manufacturing	1,000
325211	Plastics Material and Resin Manufacturing	750
325212	Synthetic Rubber Manufacturing	1,000
325221	Cellulosic Organic Fiber Manufacturing	1,000
325222	Noncellulosic Organic Fiber Manufacturing	1,000
325311	Nitrogenous Fertilizer Manufacturing	1,000
325312	Phosphatic Fertilizer Manufacturing	500
325314	Fertilizer (Mixing Only) Manufacturing	500
325320	Pesticide and Other Agricultural Chemical Manufacturing	500
325411	Medicinal and Botanical Manufacturing	750
325412	Pharmaceutical Preparation Manufacturing	750
325413	In-Vitro Diagnostic Substance Manufacturing	500
325414	Biological Product (except Diagnostic) Manufacturing	500
325510	Paint and Coating Manufacturing	500
325520	Adhesive Manufacturing	500
325611	Soap and Other Detergent Manufacturing	750
325612	Polish and Other Sanitation Good Manufacturing	500
325613	Surface Active Agent Manufacturing	500
325620	Toilet Preparation Manufacturing	500
325910	Printing Ink Manufacturing	500
325920	Explosives Manufacturing	750
325991	Custom Compounding of Purchased Resins	500
325992	Photographic Film, Paper, Plate and Chemical Manufacturing	500
325998	All Other Miscellaneous Chemical Product and Preparation Manufacturing	500

Source: 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/services/contractingopportunities/sizestandardstopics/size/index.html>.

Table 2-29. Distribution of Economic Data by Enterprise Size: Chemical Manufacturing (NAICS 325)

		Enterprises with					
Variable	**Total**	**1 to 20 Employees[a]**	**20 to 99 Employees**	**100 to 499 Employees**	**500 to 749 Employees**	**750 to 999 Employees**	**1,000 to 1,499 Employees**
Firms	9,341	5,413	1,974	790	95	56	71
Establishments	13,096	5,433	2,208	1,352	250	185	276
Employment	827,430	34,838	78,090	113,326	28,025	18,119	28,338
Receipts ($\$10^6$)	\$468,211	\$9,631	\$21,394	\$39,111	\$12,217	\$7,324	\$14,762
Receipts/firm ($\$10^3$)	\$50,124	\$1,779	\$10,838	\$49,507	\$128,603	\$130,779	\$207,913
Receipts/establishment ($\$10^3$)	\$35,752	\$1,773	\$9,689	\$28,928	\$48,869	\$39,587	\$53,485
Receipts/employment (\$)	\$565,862	\$276,464	\$273,971	\$345,117	\$435,942	\$404,195	\$520,920

[a] Excludes SUSB employment category for zero employees. These entities only operated for a fraction of the year.

Source: U.S. Census Bureau. 2008. "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>.

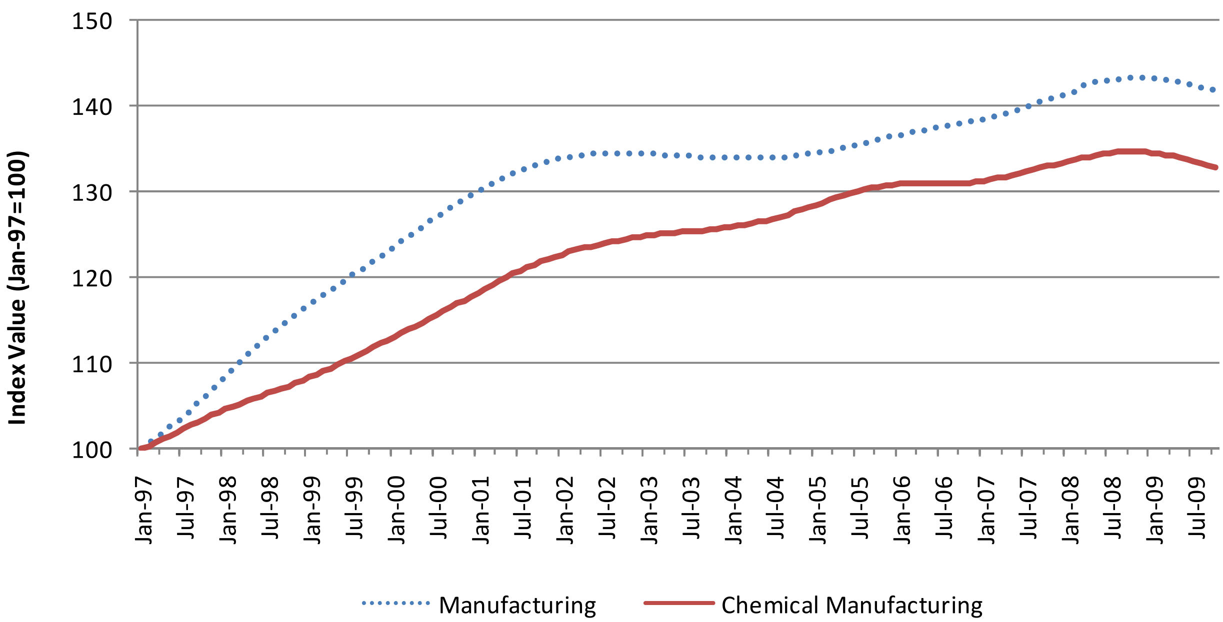

Figure 2-28. Industrial Production Trends in Chemical Manufacturing (NAICS 325)

Source: Federal Reserve Board. 2009. "Industrial Production and Capacity Utilization: Industrial Production." Series ID: G17/IP_MAJOR_INDUSTRY_GROUPS/IP.GMF.S & G17/IP_MAJOR_INDUSTRY_GROUPS/IP.G325.S. <http://www.federalreserve.gov/datadownload/>.

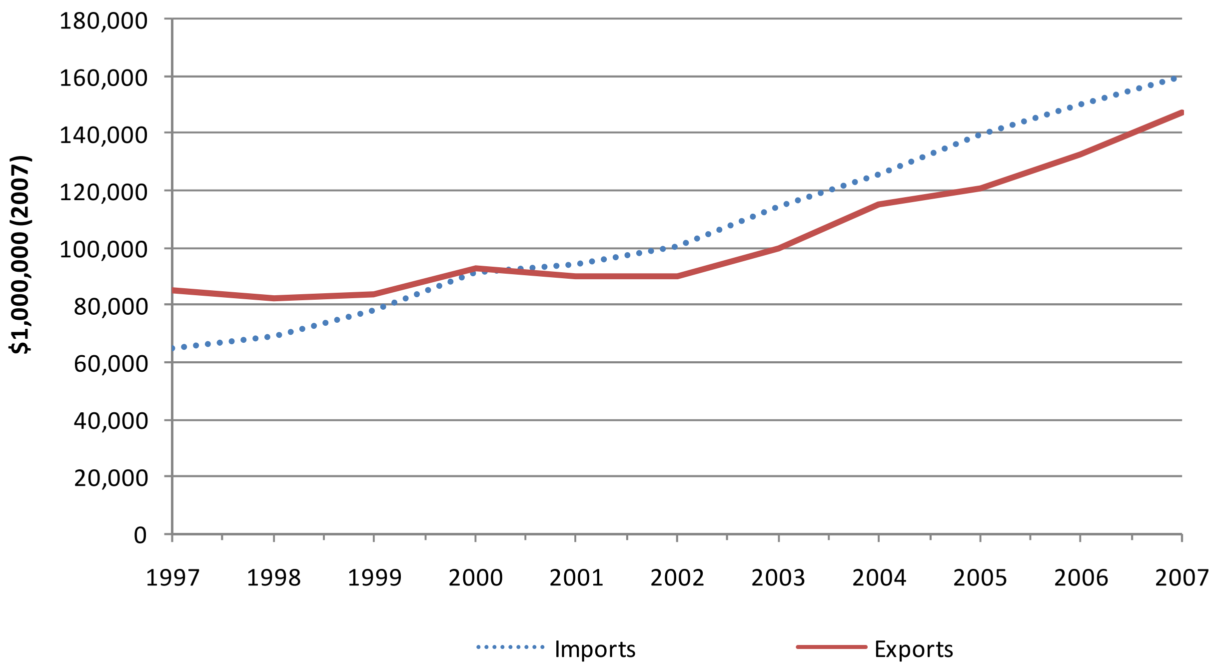

Figure 2-29. International Trade Trends in Chemical Manufacturing (NAICS 325)

Source: U.S. International Trade Commission. 2008a. "U.S. Domestic Exports" & "U.S. Imports for Consumption." <http://dataweb.usitc.gov/scripts/user_set.asp>.

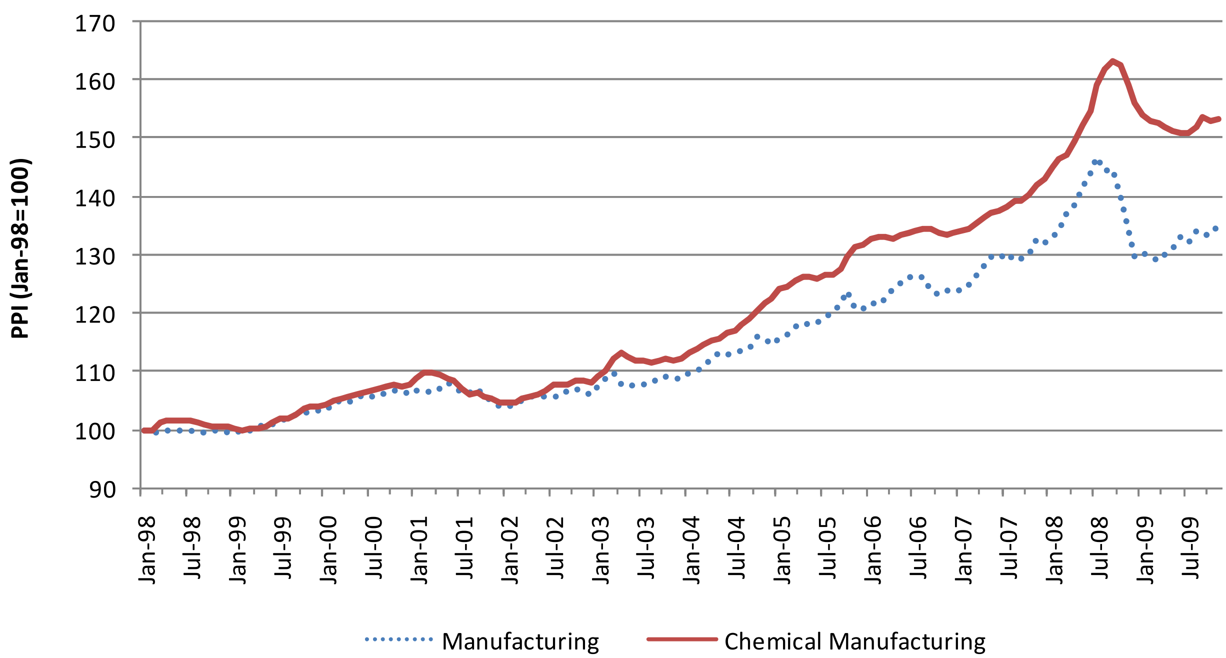

Figure 2-30. Producer Price Trends in Chemical Manufacturing (NAICS 325)

Source: U.S. Bureau of Labor Statistics (BLS). 2009. Producer Price Index. Series ID: PCU325—325—&PCUOMFG—OMFG—. <http://www.bls.gov/ppi/home.htm>.

SECTION 3
ENGINEERING COST ANALYSIS

This section provides an overview of the engineering cost analysis used to estimate the additional private expenditures industry may make in order to comply with the rule. A detailed discussion of the methodology used to estimate cost impacts is presented in "Compliance Cost Analysis for Existing CISWI Units" in Appendix B.

To estimate the national cost impacts of the proposed rule for existing sources, EPA developed average baseline emission factors for each pollutant and each subcategory of CISWI unit based on the emissions data obtained and contained in the CISWI emissions and inventory database. If a unit reported emissions data, we assigned its unit-specific emissions data as its baseline emissions. If identical units were operated at the facility but no data were available, the emissions data from the unit with data were applied to the identical units. For units that did not report emissions data, we assigned the appropriate emission factor for the units in that subcategory. We then compared each unit's baseline emission factors for each pollutant to the proposed MACT floor emission limit to determine if control devices were needed to meet the emission limits. The control analysis considered fabric filters to be the primary control device for particulate matter, cadmium, and lead control; packed bed scrubbers for hydrogen chloride and sulfur dioxide control; activated carbon injection for mercury and dioxins/furans control; selective non-catalytic reduction for oxides of nitrogen; and afterburner retrofits, tune-ups, advanced combustion controls, and oxidation catalysts for carbon monoxide controls. We also considered whether existing control devices could be improved to achieve the proposed limits, such as adding more lime to duct sorbent injection systems to meet the proposed sulfur dioxide limits. We included costs for testing and monitoring requirements contained in the proposed rule. Finally, we analyzed the costs of alternative disposal options, such as diverting waste to a landfill or abrasive blasting to remove paint to see if less expensive options to incineration were available. In certain cases, such as small remote incinerators, our data suggest that sending waste to a landfill may likely be less costly than operating and maintaining an incineration unit. The resulting total national cost impact of the proposed rule is 574 million dollars in capital expenditures and 216 million dollars per year in total annual costs. The total capital and annual costs include costs for control devices, work practices, testing and monitoring. Costs include testing and monitoring costs, but not recordkeeping and reporting costs. Based on the cost to comply with the proposed rule, availability of alternatives to incineration, and historic negative growth in this source category, we do not anticipate any new or modified units.

Table 3-1. Summary of Capital and Annual Costs for Existing CISWI Sources

Subcategory	Number of Affected Units	Capital Costs (millions of 2008$)	Annualized Costs (millions of 2008$)
Burn-off Ovens	36	5.284	3.199
Cement Kilns	53	113.5	46.70
Energy Recovery Units	40	455.4	165.1
Incinerators	28	0	1.875
Small remote incinerators	19	0.058	−0.803

Based on this analysis, EPA anticipates an overall total capital investment of $572 million with an associated total annual cost of $216 million. However, the estimates in this RIA reflect previous estimates of engineering costs with an overall total capital investment of $574 million and an annualized estimate of $224 million (2008$), which results in a slight overestimate of the economic impacts.

The requirements result in industry recordkeeping and reporting burden associated with reviewing the amendments for all CISWI and inspections of scrubbers, fabric filters, and other air pollution control devices that may be used to meet the emission limits for all CISWI. Ongoing parametric monitoring requirements for ESPs, SNCR, and activated carbon injection are also required of all CISWI units. Stack testing and development of new parameter limits would be necessary for CISWI that need to make performance improvements to meet the proposed emission limits and for CISWI that, prior to this proposed action, have not been required to demonstrate compliance with certain pollutants. Visual emissions tests would be required for all subcategories except kilns on an annual basis. Energy recovery units would be required to continuously monitor opacity, and units larger than 250 MMBtu/hr would be required to monitor PM emissions using a PM CEMS. Kilns would be required to continuously monitor Hg emissions using an Hg CEMS. Any new CISWI would also be required to continuously monitor CO emissions. Annualized capital/startup costs and operation and maintenance (O&M) costs are associated with the EG monitoring requirements, EPA Method 22 of Appendix A-7 testing, initial stack testing, storage of data and reports, and photocopying and postage.

SECTION 4
ECONOMIC IMPACT ANALYSIS

EPA prepares an EIA to provide decision makers with a measure of the social costs of using resources to comply with a program (EPA, 2000). The social costs can then be compared with estimated social benefits (as presented in Section 6). As noted in EPA's (2000) *Guidelines for Preparing Economic Analyses*, several tools are available to estimate social costs and range from simple direct compliance cost methods to the development of a more complex market analysis that estimates market changes (e.g., price and consumption) and economic welfare changes (e.g., changes in consumer and producer surplus).

The Office of Air Quality Planning and Standards (OAQPS) adopted a standard market analysis as described in the Office's resource manual (EPA, 1999). The approach uses a single-period multimarket partial equilibrium model to compare pre-policy market baselines with expected post-policy market outcomes. The analysis' time horizon is the intermediate run; some production factors are fixed and some are variable and is distinguished from the very short run where all factors are fixed and producers cannot adjust inputs or outputs (EPA, 1999, 5-6). The intermediate time horizon allows us to capture important transitory stakeholder outcomes. Key measures in this analysis include industry-level changes in price levels, production and consumption, jobs, international trade, and social costs (changes in producer and consumer surplus).

4.1 Partial Equilibrium Analysis (Multiple Markets)

The partial equilibrium analysis develops a market model that simulates how stakeholders (consumers and industries) might respond to the additional regulatory program costs. In this section, we provide an overview of the economic model. Appendix A provides additional details on the behavioral assumptions, data, parameters, and model equations.

4.1.1 Overview

Although several tools are available to estimate social costs, current EPA guidelines suggest that multimarket models "…are best used when potential economic impacts and equity effects on related markets might be considerable" and modeling using a computable general equilibrium model is not available or practical (EPA, 2000, p. 146). Other guides for environmental economists offer similar advice (Berck and Hoffmann, 2002; Just, Hueth, and Schmitz, 2004). Multimarket models focus on "short-run" time horizons and measure a policy's near-term or transition costs (EPA, 1999). Recent studies suggest short-run analyses can complement full dynamic general equilibrium analysis. For example, Morgenstern and colleagues examine carbon price policies with short- and long-term time horizons (Morgenstern and colleagues, 2004; Ho, Morgenstern, and Shih, 2008). Aldy and Pizer (2009) assess near-term competitiveness effects of a domestic cap-and-trade program to address stakeholder concerns about shifts in economic activity and jobs to other countries. The multimarket model contains the following features:

- Industry sectors and benchmark data set
  - 100 industry sectors
  - a single benchmark year (2010)[1]
  - estimates of industry employment
- Economic behavior
  - industries respond to regulatory costs by changing production rates
  - market prices rise to reflect higher energy and other non-energy material costs
  - customers respond to these price increases and consumption falls
- Model scope
  - 100 sectors are linked with each other based on their use of energy and other non-energy materials. For example, the construction industry is linked with the petroleum, cement, and steel industries and is influenced by price changes that occur in each sector. The links allow EPA to account for indirect effects the regulation has on related markets.
  - production adjustments influence employment levels
  - international trade (imports/exports) behavior considered
- Model time horizon ("short run")
  - fixed production resources (e.g., capital) lead to an upward-sloping industry supply function
  - firms cannot alter input mixes; there is no substitution among production inputs (capital, labor, energy intermediates, and other intermediate goods and services)
  - price of labor (i.e., wage) is fixed
  - investment and government expenditures are fixed

[1] For this analysis, we use the model to approximate baseline conditions for 2015.

4.1.2 Economic Impact Analysis Results

4.1.2.1 Market-Level Results

Market-level impacts include price and quantity adjustments including the changes in international trade (Table 4-1). The Agency's economic model suggests the average national market-level variables (prices, production-levels, consumption, international trade) will not significantly change (e.g., are less than 0.1%).

Table 4-1. Market-Level Price and Quantity Changes: 2015 (Selected Approach)

Industry Sector	Prices	Production	Imports	Consumption	Exports
Energy	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%
Nonmanufacturing	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%
Manufacturing					
Food, beverages, and textiles	Less than 0.01%	Less than 0.01%	less than 0.01%	Less than 0.01%	Less than 0.01%
Lumber, paper, and printing	0.02%	Less than 0.01%	0.02%	Less than 0.01%	−0.02%
Chemicals	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%
Plastics and Rubber	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%
Nonmetallic Minerals	0.03%	Less than 0.01%	0.01%	Less than 0.01%	−0.03%
Primary Metals	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%
Fabricated Metals	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%
Machinery and Equipment	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%
Electronic Equipment	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%
Transportation Equipment	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%	less than 0.01%
Other	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%
Wholesale and Retail Trade	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%
Transportation Services	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%
Other Services	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%	Less than 0.01%

4.1.2.2 Social Cost Estimates

In the near term, the Agency's economic model suggests that industries are able to pass on $62 million (2008$) the costs to U.S. households in the form of higher prices (Table 4-2). Existing U.S. industries' surplus falls by $166 million, and the net loss for U.S. stakeholders is $228 million. As U.S. prices rise, other countries are affected through international trade relationships. Households that buy goods from the United States experience losses, while industries that sell goods to the United States benefit; the model estimates a net gain of $4 million. After accounting for international trade effects, the Agency's economic model projects the net surplus loss associated with the proposed rule is $224 million. As shown in Figure 4-1, the surplus losses are concentrated in lumber, paper, and printing (27.1%) and other services (21.1%). The Agency also considered other elements of the engineering cost analysis that could not be modeled within the multimarket model (e.g., fuel savings benefits and total annualized compliance costs [unknown sources]). The net effect of the adjustments is less than $1 million.

Table 4-2. Distribution of Social Costs (million, 2008$): 2015

Method	Selected Approach
Partial Equilibrium Model (Multiple Markets)	
Change in U.S. consumer surplus	−$62
Change in U.S. producer surplus	−$166
Change in U.S. surplus	−$228
Net change in rest of world surplus	$4
Net change in total surplus	−$224
Direct Compliance Costs Method	
Total annualized costs, unknown sources (not modeled)	Less than $1 million
Fuel savings (not modeled)	$1
Change in Total Surplus	−$224

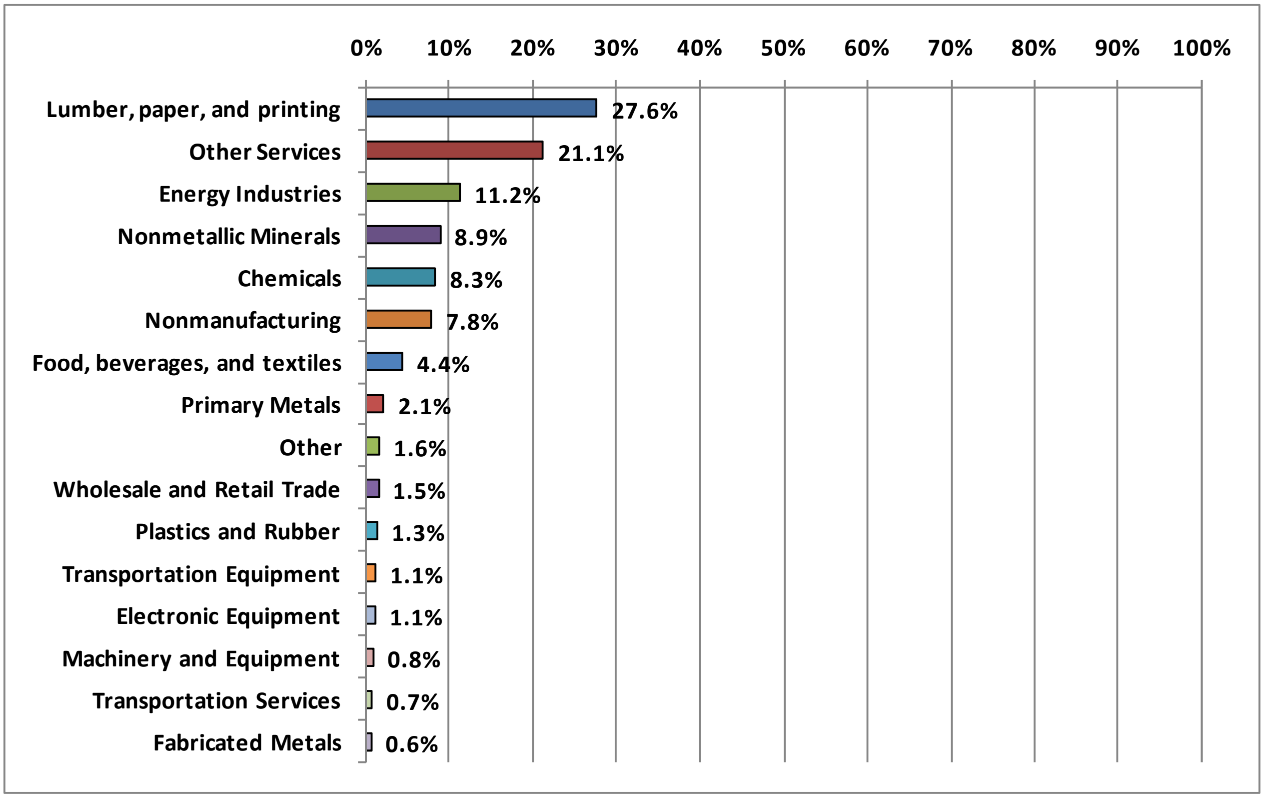

Figure 4-1. Distribution of Total Surplus Changes by Industry (Total Surplus Change = $224 million, 2008$)

4.1.2.3 Job Effects

Precise job effect estimates cannot be estimated with certainty. Morgenstern et al. (2002) identify three economic mechanisms by which pollution abatement activities can indirectly influence jobs:

- higher production costs raise market prices, higher prices reduce consumption, and employment within an industry falls ("demand effect");
- pollution abatement activities require additional labor services to produce the same level of output ("cost effect"); and
- post-regulation production technologies may be more or less labor intensive (i.e., more/less labor is required per dollar of output) ("factor-shift effect").

Several empirical studies, including Morgenstern et al. (2002), suggest the net employment decline is zero or economically small (e.g., Cole and Elliot, 2007; Berman and Bui, 2001). However, others show the question has not been resolved in the literature (Henderson, 1996; Greenstone, 2002). Morgenstern et al. use a six-year panel (U.S. Census data for plant-level prices, inputs (including labor), outputs, and environmental expenditures) to econometrically estimate the production technologies and industry-level demand elasticities. Their identification strategy leverages repeat plant-level observations over time and uses plant-level and year fixed effects (e.g., plant and time dummy variables). After estimating their model, Morgenstern show and compute the change in employment associated with an additional $1 million ($1987) in environmental spending. Their estimates covers four manufacturing industries (pulp and paper, plastics, petroleum, and steel) and Morgenstern, et al present results separately for the cost, factor shift, and demand effects, as well as the net effect. They also estimate and report an industry-wide average parameter that combines the four industry-wide estimates and weighting them by each industry's share of environmental expenditures.

EPA has most often estimated employment changes associated with plant closures due to environmental regulation or changes in output for the regulated industry (EPA, 1999; EPA, 2000). This analysis goes beyond what EPA has typically done in two ways. First, because the multimarket model provides estimates for changes in output for sectors not directly regulated, we were able to estimate a more comprehensive "demand effect." Secondly, parameters estimated in the Morgenstern paper were used to estimate all three effects ("demand," "cost," and "factor shift"). This transfer of results from the Morgenstern study is uncertain (add caveats) but avoids ignoring the "cost effect" and the "factor-shift effect."

We calculated "demand effect" employment changes by assuming that the number of jobs declines proportionally with multi-market model's simulated output changes. These results were calculated for all sectors in the EPA model that show a change in output.

We also calculated a similar "demand effect" estimate that used the Morgenstern paper. EPA selected this paper because the parameter estimates (expressed in jobs per million ($1987) of environmental compliance expenditures) provide a transparent and tractable way to transfer estimates for an employment effects analysis. Similar estimates were not available from other studies. To do this, we multiplied the point estimate for the total demand effect (−3.56 jobs per million ($1987) of environmental compliance expenditure) by the total environmental compliance expenditures used in the partial equilibrium model. For example, the jobs effect estimate for the Major Source Rule is estimated to be 500 jobs (−3.56× $224 million × 0.60).[1] Demand effect results are provided in Figure 4-2.

[1] Since Morgenstern's analysis reports environmental expenditures in $1987, we make an inflation adjustment the engineering cost analysis using GDP implicit price deflator (64.76/108.48) = 0.60)

We also present the results of using the Morgenstern paper to estimate U.S. employment "cost" and "factor-shift" effects. Although using the Morgenstern parameters to estimate these "cost" and "factor-shift" employment changes is uncertain, it is helpful to compare the potential job gains from these effects to the job losses associated with the "demand" effect. Figure 4-2 shows that using the Morgenstern point estimates of parameters to estimate the "cost" and "factor shift" employment gains may be greater than the employment losses using either of the two ways of estimating "demand" employment losses. The 95% confidence intervals are shown for all of the estimates based on the Morgenstern parameters. As shown, at the 95% confidence level, we cannot be certain if net employment changes are positive or negative.

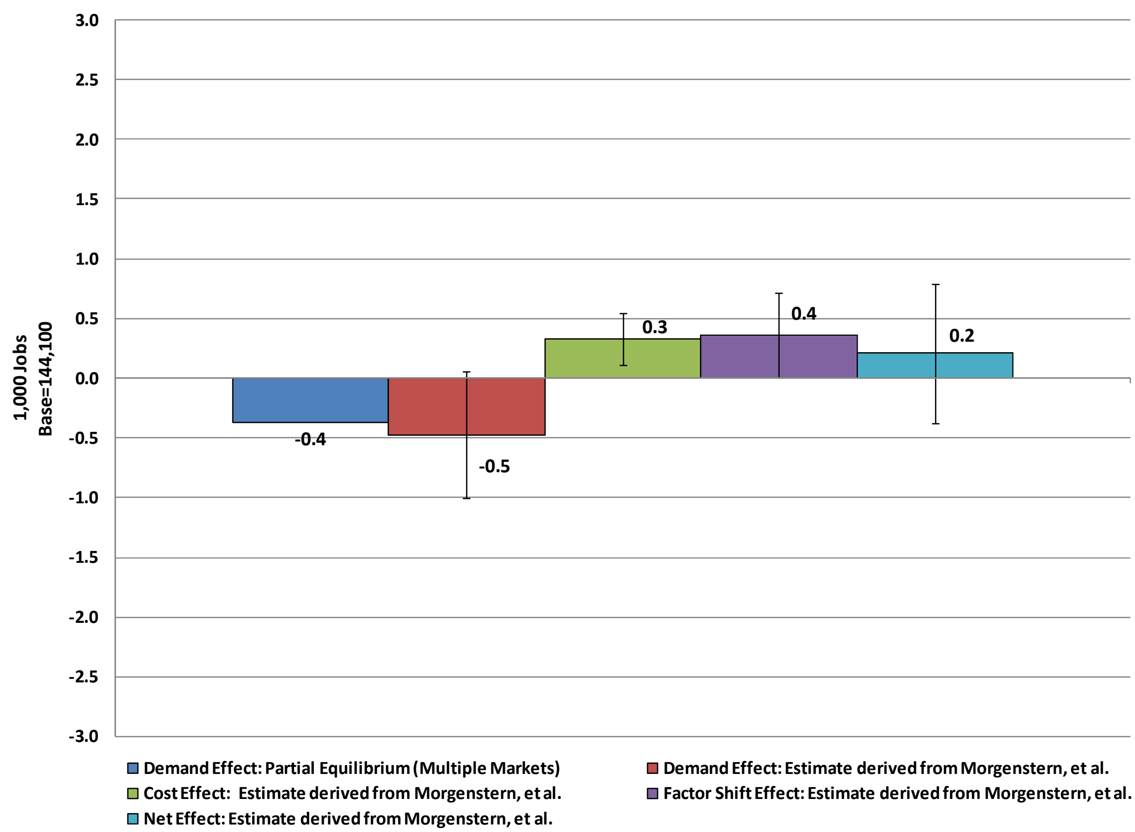

Figure 4-2. Job Losses/Gains Associated with the Proposed Rule: 2015

Although the Morgenstern paper provides additional information about the potential job effects of environmental protection programs, there are several qualifications EPA considered as part of the analysis. First, EPA has used the weighted average parameter estimates for a narrow set of manufacturing industries (pulp and paper, plastics, petroleum, and steel). Absent other data and estimates, this approach seems reasonable and the estimates come from a respected peer-reviewed source. However, EPA acknowledges the proposed rule covers a broader set of industries not considered in original empirical study. By transferring the estimates to other industrial sectors, we make the assumption that estimates are similar in size. In addition, EPA assumes also that Morgenstern et al.'s estimates derived from the 1979–1991 still applicable for policy taking place in 2013, almost 20 years later. Second, the multi-market model only considers near term employment effects in a U.S. economy where production technologies are fixed. As a result, the modeling system places more emphasis on the short term "demand effect" whereas the Morgenstern paper emphasizes other important long term responses. For example, positive job gains associated with "factor shift effects" are more plausible when production choices become more flexible over time and industries can substitute labor for other production inputs. Third, the Morgenstern paper estimates rely on sector demand elasticities that are different from the demand elasticity parameters used in the multi-market model. As a result, the demand effects are not directly comparable with the demand effects estimated by the multi-market model. Fourth, Morgenstern identifies the industry average as economically and statistically insignificant effect (i.e., the point estimates are small, measured imprecisely, and not distinguishable from zero.) EPA acknowledges this fact and has reported the 95 percent confidence intervals in Figure 4-2. Fifth, Morgenstern's methodology assumes large plants bear most of the regulatory costs. By transferring the estimates, EPA assumes a similar distribution of regulatory costs by plant size and that the regulatory burden does not disproportionately fall on smaller plants.

SECTION 5
SMALL ENTITY ANALYSES

The RFA as amended by 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 (SISNOSE). Small entities include small businesses, small governmental jurisdictions, and small not-for-profit enterprises. EPA assessed the potential small entity economic impacts using a screening analysis. After reviewing screening analysis results, EPA has determined the proposed rules will not have a SISNOSE and presumes that both proposed rules are eligible for certification under the RFA as amended by SBREFA. The remaining sections provide the factual basis for certification.

5.1 Small Entity Screening Analysis

5.1.1 Small Businesses

The sectors covered by the rule were identified through lists of small entities provided by the engineering analysis. Table 5-1 provides a list of the sectors affected (3-digit NAICS) and the range of SBA size definitions.

Table 5-1. Affected Sectors and Size Standards

2007 NAICS	Description	Size Standard (Effective August 22, 2008)
221	Utilities	[a]
311	Food Manufacturing	500 to 1,000 employees
321	Wood Product Manufacturing	500 employees
322	Paper Manufacturing	500 to 750 employees
324	Petroleum and Coal Products Manufacturing	Typically 500 to 1,500 employees
325	Chemical Manufacturing	500 to 1,000 employees
326	Plastics and Rubber Products Manufacturing	Typically 500 to 1,000 employees
337	Furniture and Related Product Manufacturing	500 employees
562	Waste Management and Remediation Services	Typically $7 to $14 million in annual receipts

[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.

5.1.1.1 Representative Small Business Analysis Using Census Statistics of U.S. Businesses

For each 3-digit NAICS code, the SUSB provides national information on the distribution of economic variables by industry and enterprise size (U.S. Census, 2008). 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.[1] Statistics include the total number of establishments and receipts for all entities within an industry; however, only a subset of entities will be covered by the proposed rule. SUSB also provides statistics by enterprise employment and receipt size.

The Census Bureau's definitions used in the SUSB 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, commissions and fees, rents, interest, dividends, and royalties. Receipts exclude all revenue collected for local, state, and federal taxes.
- *Enterprise*: An enterprise is a business organization consisting of one or more domestic establishments that were specified under common ownership or control. The enterprise and the establishment are the same for single-establishment firms. Each multi-establishment company forms one enterprise—the enterprise employment and annual payroll are summed from the associated establishments. Enterprise size designations are determined by the total 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.

The analysis generated a set of establishment sales tests (represented as cost-to-receipt ratios) for NAICS codes associated with sectors listed in Table 5-2. 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 regulatory program.

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

For each representative establishment in the SUSB data, we developed a range of facility-level cost numerators based on the engineering cost analysis. We used the maximum and minimum small entity facility-level costs observed within each 3-digit NAICS code.[1] Using these cost data and the Census estimates of average establishment receipts, several paper and utility SUSB NAICS/enterprise categories had ratios that exceeded 3%. As a result, EPA performed a more detailed analysis with a firm-specific sample of small private enterprises.

5.1.1.2 Additional Small Entity Analysis Using Sample of Small Businesses

In this approach, we identified a sample of survey facility names listed as small, traced the ultimate parent company name to verify the facility was owned by a small business, and collected the most recent parent company sales and employment figures. As Table 5-2 shows, the average cost-to-sales ratios for small companies are below 1%. The median ratios are less than 0.1%. Only one entity has a sales test that exceeds 3% and provides wood-residue, natural gas-fired cogeneration (NAICS 221).

Table 5-2. Sales Tests Using Small Companies Identified in the Combustion Survey

Sample Statistic	Selected Option
Mean	−0.8%
Median	Less than 0.1%
Maximum	4.0%
Minimum	−8.0%
Ultimate parent company observations	13
Ultimate parent company observations with sales data	5
Ultimate parent companies with Sale Tests Exceeding 3%	1

[1]Prior to computing the cost-to-receipt ratios, we adjusted the engineering compliance costs to reflect 2002 dollars using the implicit price deflators for gross domestic product (GDP). The values used are 2002 = 92.118 and 2008 = 108.483 (U.S. BEA, 2010).

SECTION 6
HUMAN HEALTH BENEFITS OF EMISSIONS REDUCTIONS

6.1 Synopsis

In this section, we provide an estimate of the monetized benefits associated with reducing particulate matter (PM) for the proposed CISWI NSPS and Emissions Guidelines. For this rule, the PM reductions are the result of emission limits on PM, emission limits on $PM_{2.5}$ precursors such as NO_x and SO_2, as well as emission limits on other pollutants. The total $PM_{2.5}$ reductions are the consequence of the technologies installed or waste diversion to meet these multiple limits. These estimates reflect the monetized human health benefits of reducing cases of morbidity and premature mortality among populations exposed to the $PM_{2.5}$ precursors reduced by this rulemaking. Using a 3% discount rate, we estimate the total monetized benefits of the proposed CISWI NSPS and Emissions Guidelines to be $240 million to $580 million in the implementation year (2015). Using a 7% discount rate, we estimate the total monetized benefits of the proposed CISWI NSPS and Emissions Guidelines to be $210 million to $520 million in the implementation year. All estimates are in 2008$.

These estimates reflect EPA's most current interpretation of the scientific literature. Higher or lower estimates of benefits are possible using other assumptions; examples of this are provided in Figure 6-2. Data, resource, and methodological limitations prevented EPA from monetizing the benefits from several important benefit categories, including benefits from reducing hazardous air pollutants, ecosystem effects, and visibility impairment. The benefits from reducing other air pollutants have not been monetized in this analysis, including reducing 24,000 tons of carbon monoxide, 560 tons of HCl, 6.0 tons of lead, 5.4 tons of cadmium, 280 pounds of mercury, and 230 grams of total dioxins/furans each year.

6.2 Calculation of $PM_{2.5}$ Human Health Benefits

This rulemaking would reduce emissions of $PM_{2.5}$, SO_2, and NO_2. Because SOx and NO_2 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. For this rule, the PM reductions are the result of emission limits on PM, emission limits on $PM_{2.5}$ precursors such as NO_x and SO_2, as well as emission limits on other pollutants. The total $PM_{2.5}$ reductions are the consequence of the technologies installed or waste diversion to meet these multiple limits. Due to analytical limitations, it was not possible to provide a comprehensive estimate of $PM_{2.5}$-related benefits. Instead, we used the "benefit-per-ton" approach to estimate these benefits based on the methodology described in Fann et al. (2009). The key assumptions are described in detail below.

These $PM_{2.5}$ benefit-per-ton estimates provide the total monetized human health 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 several previous RIAs, including the recent NO_2 NAAQS RIA (U.S. EPA, 2010b). Table 6-1 shows the quantified and unquantified benefits captured in those benefit-per-ton estimates.

Table 6-1. 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 Bronchitis: chronic and acute Hospital admissions: respiratory and cardiovascular Emergency room visits for asthma Nonfatal heart attacks (myocardial infarction) Lower and upper respiratory illness Minor restricted-activity days Work loss days Asthma exacerbations (asthmatic population) Infant mortality	Subchronic bronchitis cases Low birth weight Pulmonary function Chronic respiratory diseases other than chronic bronchitis Non-asthma respiratory emergency room visits Visibility Household soiling

Consistent with the Portland Cement NESHAP (U.S. EPA, 2009a), the $PM_{2.5}$ 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 benefits estimate.

- 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 $P_{M2.5}$ NAAQS, has been used as an alternative estimate in the $P_{M2.5}$ NAAQS RIA and $P_{M2.5}$ benefits estimates in RIAs completed since the $P_{M2.5}$ NAAQS.

- Twelve estimates are based on the C-R functions from EPA's expert elicitation study (Roman et al., 2008) on the $P_{M2.5}$ -mortality relationship and interpreted for PM benefits analysis in EPA's final RIA for the $P_{M2.5}$ NAAQS. For that study, twelve experts (labeled A through L) provided independent estimates of the $P_{M2.5}$ -mortality concentration-response function. EPA practice has been to develop independent estimates of $P_{M2.5}$ -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 benefits estimates. Previously, EPA had calculated benefits based on these two empirical studies, but derived the range of 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 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, benefits estimates using these functions generally fall between results using these epidemiology studies (see Figure 6-2). In general, the expert elicitation results support the conclusion that the 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., SO_2 emitted from electric generating units; NO_2 emitted from mobile sources). Our estimate of $PM_{2.5}$ control benefits is therefore based on the total $PM_{2.5}$ emissions controlled by sector and multiplied by this per-ton value.

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. 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

[1]These two studies specify multi-pollutant models that control for SO_2, among other 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.

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 benefits and the methods used in RIAs prior to Portland Cement, and we now calculate incremental 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, 2009b), 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 concentration-response relationship while recognizing potential uncertainty about the exact shape of the concentration-response function.[4] In conjunction with the underlying scientific literature, this document provided a basis for reconsidering the application of thresholds in $PM_{2.5}$ concentration-response functions used in EPA's RIAs.[5]

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

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[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.

[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]After adjusting the VSL to account for a different currency year (2008$) and to account for income growth to 2015, the $5.5 million VSL is $7.9m.

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 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 6-1 illustrates the relative breakdown of the monetized $PM_{2.5}$ health 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.

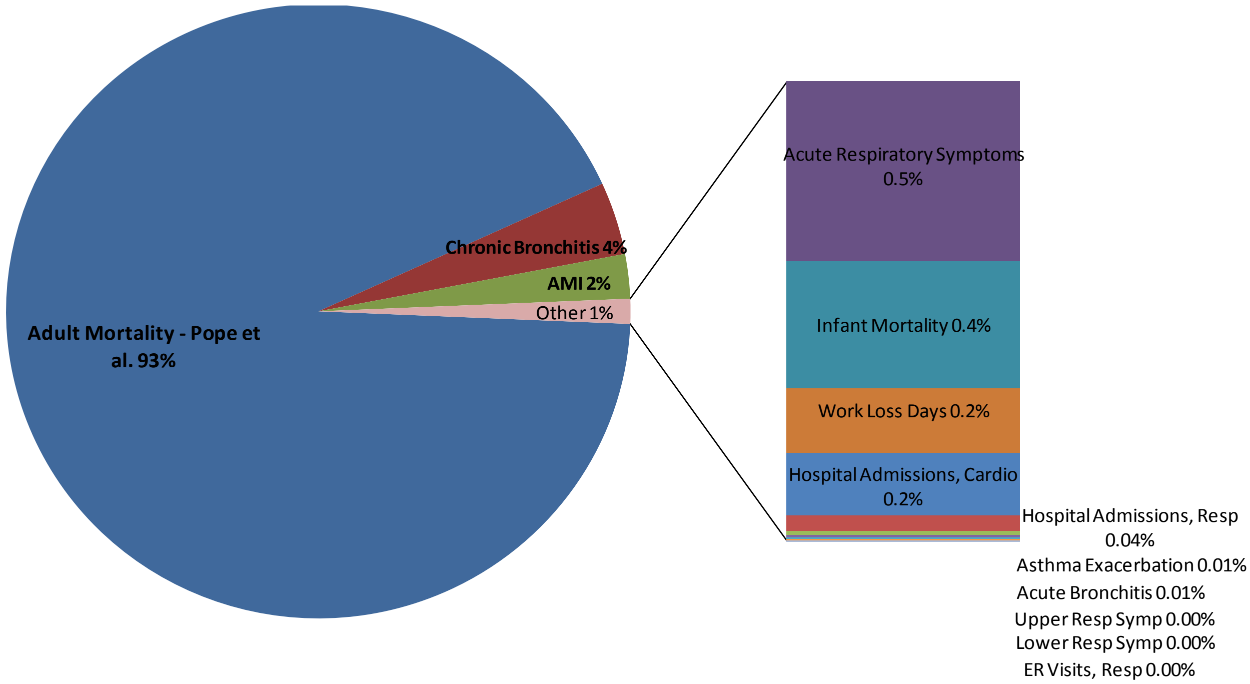

Figure 6-1. Breakdown of Monetized $PM_{2.5}$ Health Benefits using Mortality Function from Pope et al. (2002)[a]

[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 benefits due to adult 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 6-2 provides a general summary of the primary approach results by pollutant, including the emission reductions and monetized benefits-per-ton at discount rates of 3% and 7%.[9] Table 6-3 provides a summary of the reductions in health incidences as a result of the pollution reductions. In Table 6-4, we provide the benefits using our anchor points of Pope et al. and Laden et al. as well as the results from the expert elicitation on PM mortality. Figures 6-2 through 6-4 provide a visual representation of the range of benefits estimates and the pollutant breakdown of the monetized 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., 2015), and most of the PM 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 6-2. Summary of Monetized Benefits Estimates for Proposed CISWI NSPS and Emissions Guidelines in 2015 (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 Benefits (millions 2008$ at 3%)	Total Monetized Benefits (millions 2008$ at 7%)
Direct $PM_{2.5}$	660	$230,000	$560,000	$210,000	$500,000	$150 to $370	$140 to $330
$PM_{2.5}$ Precursors							
SO_2	2,659	$29,000	$72,000	$27,000	$65,000	$78.0 to $190	$71.0 to $170
NO_2	1,447	$4,900	$12,000	$4,400	$11,000	$7.0 to $17.0	$6.4 to $16.0
					Total	**$240 to $580**	**$210 to $520**

[a] All estimates are for the implementation year (2015), 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 benefits incorporate the conversion from precursor emissions to ambient fine particles.

Table 6-3. Summary of Reductions in Health Incidences from $PM_{2.5}$ Benefits for the Proposed CISWI NSPS and Emissions Guidelines in 2015[a]

Avoided Premature Mortality	
Pope et al.	26
Laden et al.	66
Avoided Morbidity	
Chronic Bronchitis	18
Acute Myocardial Infarction	41
Hospital Admissions, Respiratory	6
Hospital Admissions, Cardiovascular	13
Emergency Room Visits, Respiratory	25
Acute Bronchitis	42
Work Loss Days	3,400
Asthma Exacerbation	450
Acute Respiratory Symptoms	20,000
Lower Respiratory Symptoms	490
Upper Respiratory Symptoms	370

[a] All estimates are for the analysis year (2015) 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 6-4. All $PM_{2.5}$ Benefits Estimates for the Proposed CISWI NSPS and Emissions Guidelines at Discount Rates of 3% and 7% in 2015 (in millions of 2008$)[a]

	3%	7%
Benefit-per-ton Coefficients Derived from Epidemiology Literature		
Pope et al.	$240	$210
Laden et al.	$580	$520
Benefit-per-ton Coefficients Derived from Expert Elicitation		
Expert A	$610	$550
Expert B	$470	$420
Expert C	$470	$420
Expert D	$330	$300
Expert E	$760	$680
Expert F	$420	$380
Expert G	$280	$250
Expert H	$350	$320
Expert I	$460	$420
Expert J	$380	$340
Expert K	$92	$84
Expert L	$340	$310

[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 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.

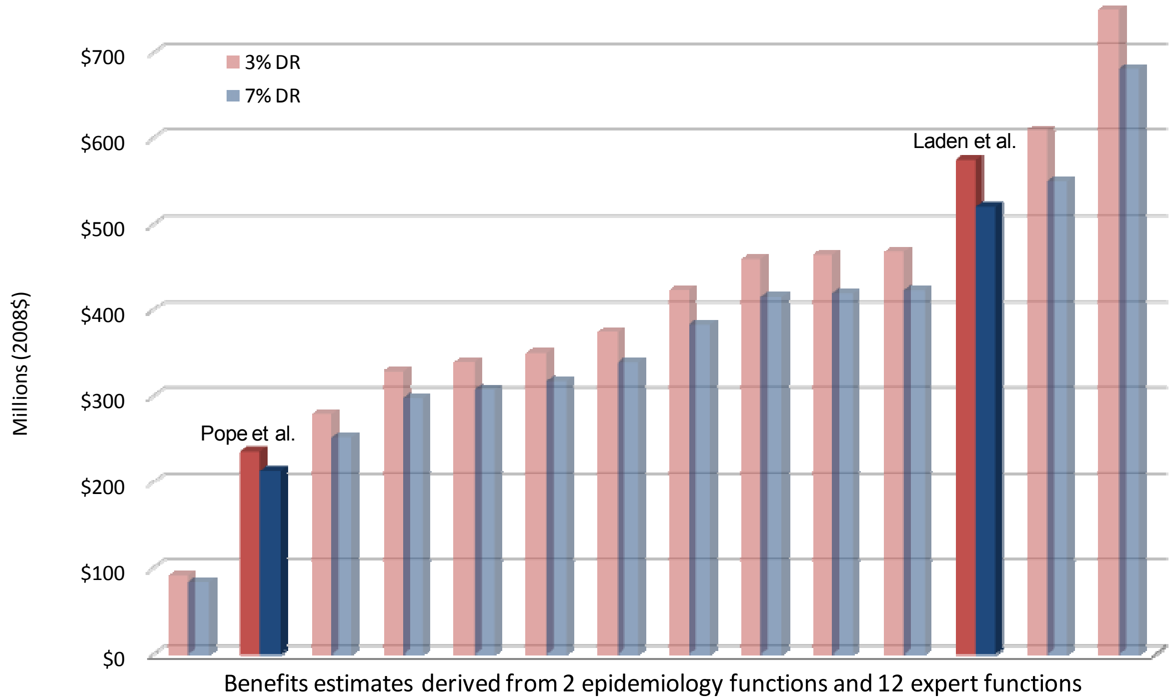

Figure 6-2. Total Monetized $PM_{2.5}$ Benefits for the Proposed CISWI NSPS and Emissions Guidelines in 2015

[a] This graph shows the estimated 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.

6.3 Unquantified Benefits

The monetized 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 toxic emissions, ecosystem effects, and visibility impairment. The health benefits from reducing hazardous air pollutants (HAPs) and carbon monoxide have not been monetized in this analysis. 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, increased mercury methylation, as well as visibility impairment.

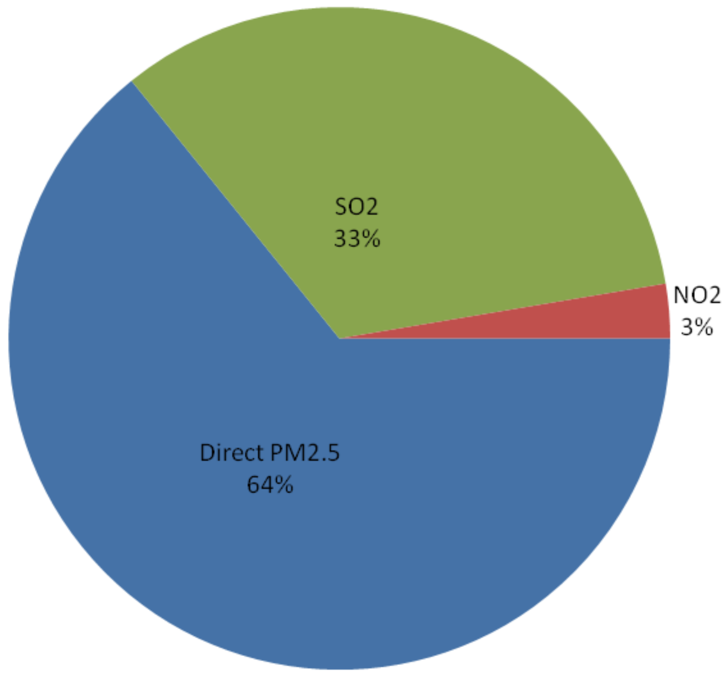

Figure 6-3. Breakdown of Monetized Benefits for the Proposed CISWI NSPS and Emissions Guidelines by $PM_{2.5}$ Precursor Pollutant and Source

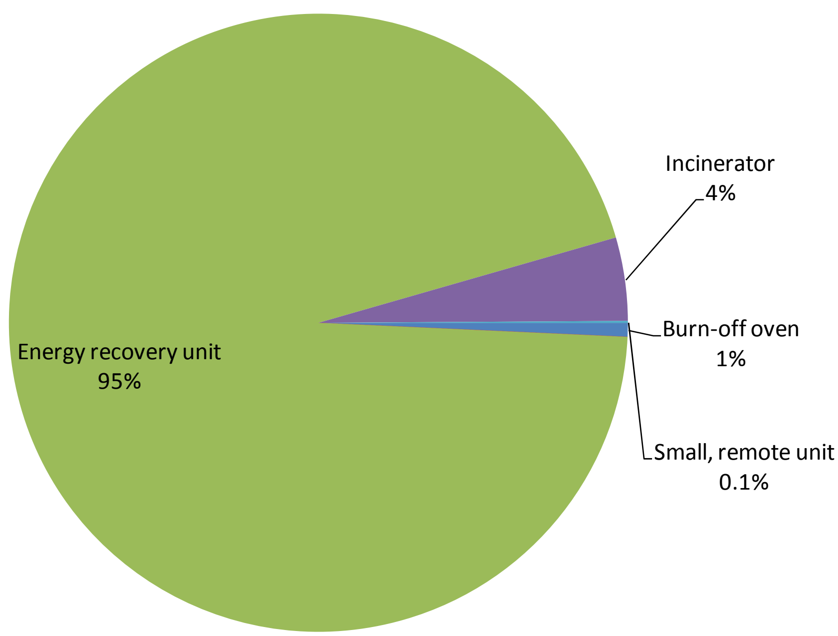

Figure 6-4. Breakdown of Monetized Benefits for the Proposed CISWI NSPS and Emissions Guidelines by Subcategory

6.3.1 Carbon Monoxide 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, resource, and methodological limitations, we were unable to estimate the benefits associated with the 24,000 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 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 between short-term exposure to CO and respiratory morbidity and mortality. The evidence is also suggestive of a causal relationship for birth outcomes and developmental effects following long-term exposure to CO, and for central nervous system effects linked to short- and long-term exposure to CO.

6.3.2 Other SO_2 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 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 $PM_{2.5}$ benefits associated with the reductions in SO_2 emissions.

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, 2008). 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. Based on our review of this information, we identified four short-term morbidity endpoints that the SO_2 ISA identified as a "causal relationship": asthma exacerbation, respiratory-related emergency department visits, and respiratory-related hospitalizations. The differing evidence and associated strength of the evidence for these different effects is described in detail in the SO_2 ISA. 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 pollutants.

SO_2 emissions also contribute to adverse welfare effects from acidic deposition, visibility impairment, and enhanced mercury methylation. Deposition of sulfur causes acidification, which can cause 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 for other consumers 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 cause reduced root growth, which restricts the ability of the plant to take up water and nutrients. These direct effects can, in turn, 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 habitat for threatened and endangered species (cultural), declines in forest aesthetics (cultural), declines in forest productivity (provisioning), and increases in forest soil erosion and reductions in water retention (cultural and regulating). (U.S. EPA, 2008d)

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 (Sisler, 1996). 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 (U.S. EPA, 2009c). 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.

6.3.3 HAP Benefits

Due to data, resource, and methodology limitations, we were unable to estimate the benefits associated with the hazardous air pollutants that would be reduced as a result of this rule. Available emissions data show that several different HAPs are emitted from CISWI. This rule is anticipated to reduce 560 tons of hydrochloric acid, 5.4 tons of cadmium, 6.0 tons of lead, 280 pounds of mercury, and 230 grams of total dioxins/furans each year in the primary approach.

6.3.3.1 Mercury

Mercury is a highly neurotoxic contaminant that enters the food web as a methylated compound, methylmercury (U.S. EPA, 2008d). 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 (U.S. EPA, 2008d). Current evidence indicates that in watersheds where mercury is present, increased sulfate 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 (U.S. EPA, 2008d).

In addition to the role of sulfate deposition on methylation, this proposed rule would also reduce mercury emissions. Mercury is emitted to the air from various man-made and natural sources. These emissions transport through the atmosphere and eventually deposit to land or water bodies. This deposition can occur locally, regionally, or globally, depending on the form of mercury emitted and other factors such as the weather. The form of mercury emitted varies depending on the source type and other factors. Available data indicate that the mercury emissions from these sources are a mixture of gaseous elemental mercury, inorganic ionic mercury, and particulate bound mercury. Gaseous elemental mercury can be transported very long distances, even globally, to regions far from the emissions source (becoming part of the global "pool") before deposition occurs. Inorganic ionic and particulate bound mercury have a shorter atmospheric lifetime and can deposit to land or water bodies closer to the emissions source. Furthermore, elemental mercury in the atmosphere can undergo transformation into ionic mercury, providing a significant pathway for deposition of emitted elemental mercury.

This source category emitted about 0.5 tons of mercury in the air in 2008 in the U.S. Based on the EPA's National Emission Inventory, about 103 tons of mercury were emitted from all anthropogenic sources in the U.S. in 2005. Moreover, the United Nations has estimated that about 2,100 tons of mercury were emitted worldwide by anthropogenic sources in 2005. We believe that total mercury emissions in the U.S. and globally in 2008 were about the same magnitude in 2005. Therefore, we estimate that in 2008, these sources emitted about 0.5% of the total anthropogenic mercury emissions in the U.S. and about 0.03% of the global emissions. Overall, this rule would reduce mercury emissions by about 280 pounds per year from current levels, and therefore, contribute to reductions in mercury exposures and health effects. Due to time and resource limitations, we were unable to model mercury dispersion, deposition, methylation, bioaccumulation in fish tissue, and human consumption of mercury-contaminated fish that would be needed in order to estimate the human health benefits from reducing mercury emissions.

Potential exposure routes to mercury emissions include both direct inhalation and consumption of fish containing methylmercury. In the U.S., the primary route of human exposure to mercury emissions from industrial sources is generally indirectly through the consumption of fish containing methylmercury. As described above, mercury that has been emitted to the air eventually settles into water bodies or onto land where it can either move directly or be leached into waterbodies. Once deposited, certain microorganisms can change it into methylmercury, a highly toxic form that builds up in fish, shellfish and animals that eat fish. Consumption of fish and shellfish are the main sources of methylmercury exposure to humans. Methylmercury builds up more in some types of fish and shellfish than in others. The levels of methylmercury in fish and shellfish vary widely depending on what they eat, how long they live, and how high they are in the food chain. Most fish, including ocean species and local freshwater fish, contain some methylmercury. For example, in recent studies by EPA and the U.S. Geological Survey (USGS) of fish tissues, every fish sample contained some methylmercury.

The majority of fish consumed in the U.S. are ocean species. The methylmercury concentrations in ocean fish species are primarily influenced by the global mercury pool. However, the methylmercury found in local fish can be due, at least partly, to mercury emissions from local sources. Research shows that most people's fish consumption does not cause a mercury-related health concern. However, certain people may be at higher risk because of their routinely high consumption of fish (e.g., tribal and other subsistence fishers and their families who rely heavily on fish for a substantial part of their diet). It has been demonstrated that high levels of methylmercury in the bloodstream of unborn babies and young children may harm the developing nervous system, making the child less able to think and learn. Moreover, mercury exposure at high levels can harm the brain, heart, kidneys, lungs, and immune system of people of all ages.

Several studies suggest that the methylmercury content of fish may reduce these cardio-protective effects of fish consumption. Some of these studies also suggest that methylmercury may cause adverse effects to the cardiovascular system. For example, the NRC (2000) review of the literature concerning methylmercury health effects took note of two epidemiological studies that found an association between dietary exposure to methylmercury and adverse cardiovascular effects.[10] Moreover, in a study of 1,833 males in Finland aged 42 to 60 years, Solonen et al. (1995) observed a relationship between methylmercury exposure via fish consumption and acute myocardial infarction (AMI or heart attacks), coronary heart disease, cardiovascular disease, and all-cause mortality.[11] The NRC also noted a study of 917 seven year old children in the Faroe Islands, whose initial exposure to methylmercury was *in utero* although post natal exposures may have occurred as well. At seven years of age, these children exhibited an increase in blood pressure and a decrease in heart rate variability.[12] Based on these and other studies, NRC concluded in 2000 that, while "the data base is not as extensive for cardiovascular effects as it is

[10] National Research Council (NRC). 2000. Toxicological Effects of Methylmercury. Committee on the Toxicological Effects of Methylmercury, Board on Environmental Studies and Toxicology. National Academies Press. Washington, DC. pp.168-173.

[11] Salonen, J.T., Seppanen, K. Nyyssonen et al. 1995. "Intake of mercury from fish lipid peroxidation, and the risk of myocardial infarction and coronary, cardiovascular and any death in Eastern Finnish men." Circulation, 91 (3):645-655.

[12] Sorensen, N, K. Murata, E. Budtz-Jorgensen, P. Weihe, and Grandjean, P., 1999. "Prenatal Methylmercury Exposure As A Cardiovascular Risk Factor At Seven Years of Age", Epidemiology, pp370-375.

for other end points (i.e. neurologic effects) the cardiovascular system appears to be a target for methylmercury toxicity."[13]

Since publication of the NRC report there have been some 30 published papers presenting the findings of studies that have examined the possible cardiovascular effects of methylmercury exposure. These studies include epidemiological, toxicological, and toxicokinetic investigations. Over a dozen review papers have also been published. If there is a causal relationship between methylmercury exposure and adverse cardiovascular effects, then reducing exposure to methylmercury would result in public health benefits from reduced cardiovascular effects.

In early 2010, EPA sponsored a workshop in which a group of experts were asked to assess the plausibility of a causal relationship between methylmercury exposure and cardiovascular health effects and to advise EPA on methodologies for estimating population level cardiovascular health impacts of reduced methylmercury exposure. The report from that workshop is in preparation.

6.3.3.2 Cadmium[14]

Breathing air with very high levels of cadmium can severely damage the lungs and may cause death. In the United States, where proper industrial hygiene is generally practiced, inhaling very high levels of cadmium at work is expected to be rare and accidental. Breathing air with lower levels of cadmium over long periods of time (for years) results in a build-up of cadmium in the kidney, and if sufficiently high, may result in kidney disease. Lung cancer has been found in some studies of workers exposed to cadmium in the air and studies of rats that breathed in cadmium. The U.S. Department of Health and Human Services (DHHS) has determined that cadmium and cadmium compounds are known human carcinogens. The International Agency for Research on Cancer (IARC) has determined that cadmium is carcinogenic to humans. The EPA has determined that cadmium is a probable human carcinogen.

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[13] National Research Council (NRC). 2000. Toxicological Effects of Methylmercury. Committee on the Toxicological Effects of Methylmercury, Board on Environmental Studies and Toxicology. National Academies Press. Washington, DC. p. 229.

[14] All health effects language for this section came from: Agency for Toxic Substances and Disease Registry (ATSDR). 2008. Public Health Statement for Cadmium. CAS# 1306-19-0. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service. Available on the Internet at <http://www.atsdr.cdc.gov/PHS/PHS.asp?id=46&tid=15>.

6.3.3.3 Lead[15]

The main target for lead toxicity is the nervous system, both in adults and children. Long-term exposure of adults to lead at work has resulted in decreased performance in some tests that measure functions of the nervous system. Lead exposure may also cause weakness in fingers, wrists, or ankles. Lead exposure also causes small increases in blood pressure, particularly in middle-aged and older people. Lead exposure may also cause anemia. At high levels of exposure, lead can severely damage the brain and kidneys in adults or children and ultimately cause death. In pregnant women, high levels of exposure to lead may cause miscarriage. High-level exposure in men can damage the organs responsible for sperm production.

We have no conclusive proof that lead causes cancer (is carcinogenic) in humans. Kidney tumors have developed in rats and mice that had been given large doses of some kind of lead compounds. The Department of Health and Human Services (DHHS) has determined that lead and lead compounds are reasonably anticipated to be human carcinogens based on limited evidence from studies in humans and sufficient evidence from animal studies, and the EPA has determined that lead is a probable human carcinogen. The International Agency for Research on Cancer (IARC) has determined that inorganic lead is probably carcinogenic to humans. IARC determined that organic lead compounds are not classifiable as to their carcinogenicity in humans based on inadequate evidence from studies in humans and in animals.

Children are more sensitive to the health effects of lead than adults. No safe blood lead level in children has been determined. Lead affects children in different ways depending on how much lead a child swallows. A child who swallows large amounts of lead may develop anemia, kidney damage, colic (severe "stomach ache"), muscle weakness, and brain damage, which ultimately can kill the child. In some cases, the amount of lead in the child's body can be lowered by giving the child certain drugs that help eliminate lead from the body. If a child swallows smaller amounts of lead, such as dust containing lead from paint, much less severe but still important effects on blood, development, and behavior may occur. In this case, recovery is likely once the child is removed from the source of lead exposure, but there is no guarantee that the child will completely avoid all long-term consequences of lead exposure. At still lower levels of exposure, lead can affect a child's mental and physical growth. Fetuses exposed to lead in the womb, because their mothers had a lot of lead in their bodies, may be born prematurely and have lower weights at birth. Exposure in the womb, in infancy, or in early childhood also may slow

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[15] All health effects language for this section came from: Agency for Toxic Substances and Disease Registry (ATSDR). 2007. Public Health Statement for Lead. CAS#: 7439-92-1. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service. Available on the Internet at <http://www.atsdr.cdc.gov/ToxProfiles/phs13.html>.

mental development and cause lower intelligence later in childhood. There is evidence that these effects may persist beyond childhood.

6.3.3.4 Hydrogen Chloride (HCl) [16]

Hydrogen chloride gas is intensely irritating to the mucous membranes of the nose, throat, and respiratory tract. Brief exposure to 35 ppm causes throat irritation, and levels of 50 to 100 ppm are barely tolerable for 1 hour. The greatest impact is on the upper respiratory tract; exposure to high concentrations can rapidly lead to swelling and spasm of the throat and suffocation. Most seriously exposed persons have immediate onset of rapid breathing, blue coloring of the skin, and narrowing of the bronchioles. Patients who have massive exposures may develop an accumulation of fluid in the lungs. Exposure to hydrogen chloride can lead to Reactive Airway Dysfunction Syndrome (RADS), a chemically- or irritant-induced type of asthma. Children may be more vulnerable to corrosive agents than adults because of the relatively smaller diameter of their airways. Children may also be more vulnerable to gas exposure because of increased minute ventilation per kg and failure to evacuate an area promptly when exposed. Hydrogen chloride has not been classified for carcinogenic effects.

6.3.3.5 Dioxins (Chlorinated dibenzodioxins (CDDs) [17]

A number of effects have been observed in people exposed to 2,3,7,8-TCDD levels that are at least 10 times higher than background levels. The most obvious health effect in people exposure to relatively large amounts of 2,3,7,8-TCDD is chloracne. Chloracne is a severe skin disease with acne-like lesions that occur mainly on the face and upper body. Other skin effects noted in people exposed to high doses of 2,3,7,8-TCDD include skin rashes, discoloration, and excessive body hair. Changes in blood and urine that may indicate liver damage also are seen in people. Alterations in the ability of the liver to metabolize (or breakdown) hemoglobin, lipids, sugar, and protein have been reported in people exposed to relatively high concentrations of 2,3,7,8-TCDD. Most of the effects are considered mild and were reversible. However, in some people these effects may last for many years. Slight increases in the risk of diabetes and abnormal glucose tolerance have been observed in some studies of people exposed to 2,3,7,8-TCDD. We do not have enough information to know if exposure to 2,3,7,8-TCDD would result

[16] All health effects language for this section came from: Agency for Toxic Substances and Disease Registry (ATSDR). Medical Management Guidelines for Hydrogen Chloride (HCl). CAS#: 7647-01-0. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service. Available on the Internet at <http://www.atsdr.cdc.gov/Mhmi/mmg173.html>.

[17] All health effects language for this section came from: Agency for Toxic Substances and Disease Registry (ATSDR). 1999. ToxFAQs for Chlorinated Dibenzo-p-dioxins (CDDs) (CAS#: 2,3,7,8-TCDD 1746-01-6). Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service. Available on the Internet at <http://www.atsdr.cdc.gov/tfacts104.html>.

in reproductive or developmental effects in people, but animal studies suggest that this is a potential health concern.

In certain animal species, 2,3,7,8-TCDD is especially harmful and can cause death after a single exposure. Exposure to lower levels can cause a variety of effects in animals, such as weight loss, liver damage, and disruption of the endocrine system. In many species of animals, 2,3,7,8-TCDD weakens the immune system and causes a decrease in the system's ability to fight bacteria and viruses at relatively low levels (approximately 10 times higher than human background body burdens). In other animal studies, exposure to 2,3,7,8-TCDD has caused reproductive damage and birth defects. Some animal species exposed to CDDs during pregnancy had miscarriages and the offspring of animals exposed to 2,3,7,8-TCDD during pregnancy often had severe birth defects including skeletal deformities, kidney defects, and weakened immune responses. In some studies, effects were observed at body burdens 10 times higher than human background levels.

6.3.3.6 Furans (Chlorinated dibenzofurans (CDFs)) [18]

Most of the information on the adverse health effects comes from studies in people who were accidentally exposed to food contaminated with CDFs. The amounts that these people were exposed to were much higher than are likely from environmental exposures or from a normal diet. Skin and eye irritations, especially severe acne, darkened skin color, and swollen eyelids with discharge, were the most obvious health effects of the CDF poisoning. CDF poisoning also caused vomiting and diarrhea, anemia, more frequent lung infections, numbness, effects on the nervous system, and mild changes in the liver. Children born to exposed mothers had skin irritation and more difficulty learning, but it is unknown if this effect was permanent or caused by CDFs alone or CDFs and polychlorinated biphenyls in combination.

Many of the same effects that occurred in people accidentally exposed also occurred in laboratory animals that ate CDFs. Animals also had severe weight loss, and their stomachs, livers, kidneys, and immune systems were seriously injured. Some animals had birth defects and testicular damage, and in severe cases, some animals died. These effects in animals were seen when they were fed large amounts of CDFs over a short time, or small amounts over several weeks or months. Nothing is known about the possible health effects in animals from eating CDFs over a lifetime.

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[18] All health effects language for this section came from: Agency for Toxic Substances and Disease Registry (ATSDR). 1995. ToxFAQs™ for Chlorodibenzofurans (CDFs). Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service. Available on the Internet at <http://www.atsdr.cdc.gov/tfacts32.html>.

6.4 Characterization of Uncertainty in the Monetized $PM_{2.5}$ 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 benefits. Therefore, the estimates of annual benefits should be viewed as representative of the magnitude of benefits expected, rather than the actual benefits that would occur every year.

We performed 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 benefits to assess the percent change from the default. We present the results of this sensitivity analysis in Table 6-5. 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 benefits for each input and the percent change from the default value for the primary approach.

Above we present the estimates of the total monetized 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 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:

Table 6-5. Sensitivity Analyses for Monetized $PM_{2.5}$ Health Benefits (in millions of 2008$)

		Total $PM_{2.5}$ Benefits	% Change from Default
Threshold Assumption (with Epidemiology Study)	No Threshold (Pope)	$240	N/A
	No Threshold (Laden)	$580	N/A
	Threshold (Pope)	$190	-21%
	Threshold (Laden)	$420	-28%
Discount Rate (with Epidemiology Study)	3% (Pope)	$240	N/A
	3% (Laden)	$580	N/A
	7% (Pope)	$210	-13%
	7% (Laden)	$520	-10%

1. $PM_{2.5}$ 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 $PM_{2.5}$ 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 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 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 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 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.

6.5 Comparison of Benefits and Costs

Using a 3% discount rate, we estimate the total monetized benefits of the proposed CISWI NSPS and Emissions Guidelines to be $240 million to $580 million in the implementation year (2015)(Table 6-6). Using a 7% discount rate, we estimate the total monetized benefits of the CISWI NSPS and Emissions Guidelines to be $210 million to $520 million. The annualized costs are $216 million at a 7% interest rate.[19] Thus, net benefits are $19 million to $360 million at a 3% discount rate for the benefits and $-2.4 million to $310 billion at a 7% discount rate. All estimates are in 2008$. Figures 6-5 and 6-6 show the full range of net benefits estimates (i.e., annual 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 24,000 tons of carbon monoxide, 560 tons of hydrochloric acid, 5.4 tons of cadmium, 6.0 tons of lead, 280 pounds of mercury, and 230 grams of total dioxins/furan each year have not been included in these estimates.

[19] For more information on the annualized costs, please refer to Section 4 of this RIA. There are no estimates of costs available at a 3% discount rate.

Table 6-6. Summary of the Monetized Benefits, Social Costs, and Net Benefits for the CISWI NSPS and Emissions Guidelines in 2015 (millions of 2008$)[1]

	Proposed Option	
	3% Discount Rate	7% Discount Rate
Total Monetized Benefits	$240 to $580[2]	$210 to $520[2]
Total Social Costs	$220[3]	$220
Net Benefits	$12 to $350	$-10 to $300

[1]All estimates are for the implementation year (2015), and are rounded to two significant figures.

[2] The total monetized benefits reflect the human health benefits associated with reducing exposure to $PM_{2.5}$ through reductions of 660 tons of directly emitted $PM_{2.5}$ and $PM_{2.5}$ precursors such as 1,400 tons of NO_x and 2,700 tons of SO_2. The benefits from reducing 24,000 tons of carbon monoxide, 560 tons of hydrochloric acid, 5.4 tons of cadmium, 6.0 tons of lead, and 280 pounds of mercury 230 grams of total dioxins/furans each year are not included in these estimates. In addition, the benefits from reducing ecosystem effects and visibility impairment are not included.

[3] The methodology used to estimate social costs for one year in the multimarket model using surplus changes results in the same social costs for both discount rates.

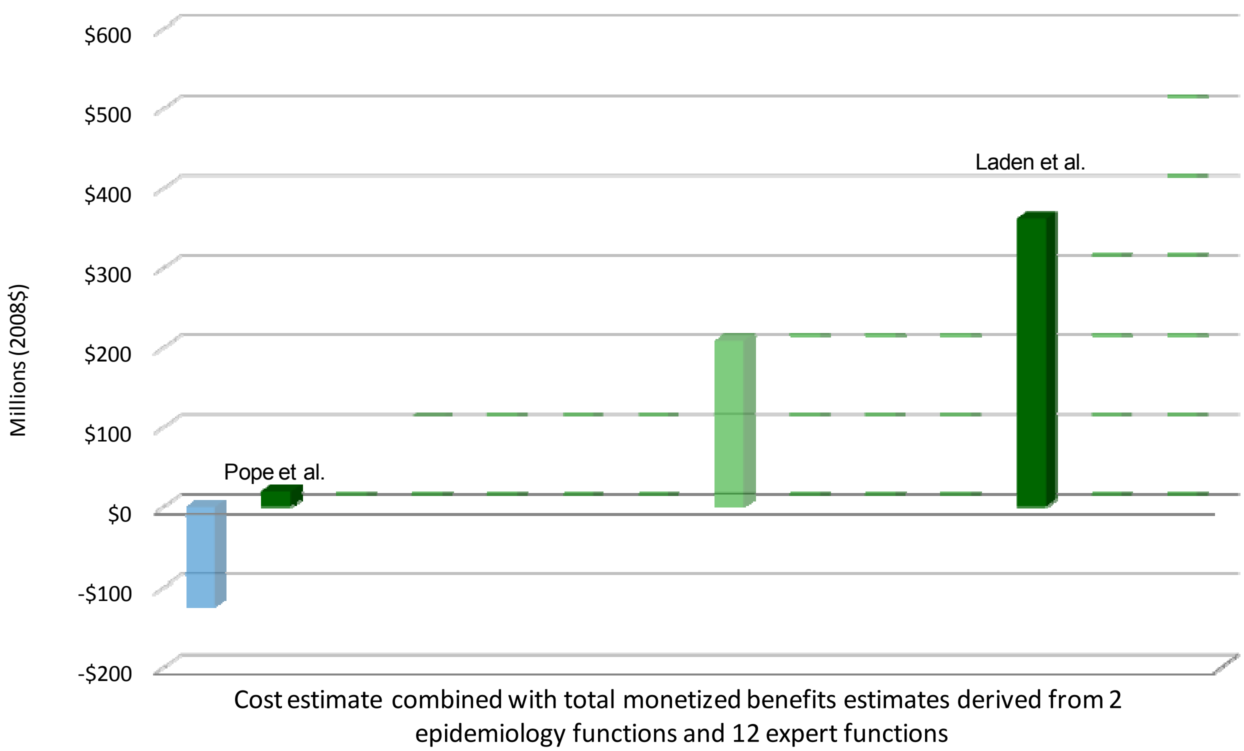

Figure 6-5. Net Benefits for the Proposed CISWI NSPS and Emissions Guidelines at 3% Discount Rate[a]

[a] Net Benefits are quantified in terms of $PM_{2.5}$ benefits for implementation year (2015). This graph shows 14 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 benefits incorporate the conversion from precursor emissions to ambient fine particles.

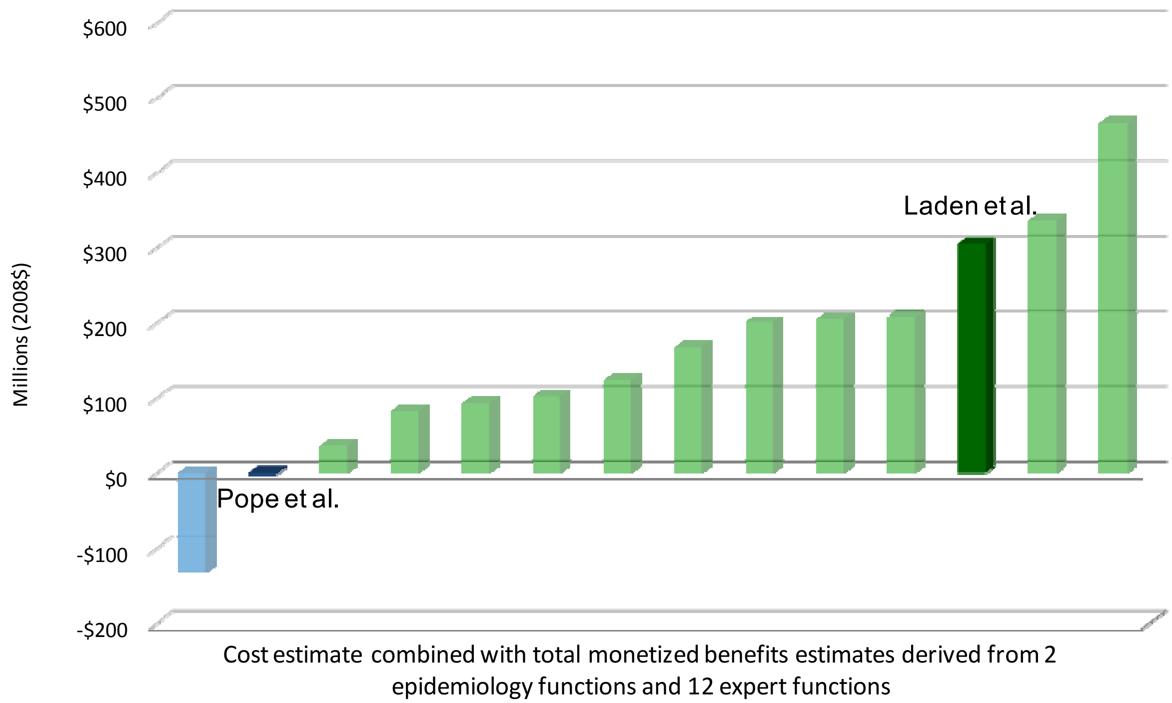

Figure 6-6. Net Benefits for the Proposed CISWI NSPS and Emissions Guidelines at 7% Discount Rate[a]

[a] Net Benefits are quantified in terms of $PM_{2.5}$ benefits for implementation year (2015). This graph shows 14 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 benefits incorporate the conversion from precursor emissions to ambient fine particles.

SECTION 7
SUPPLEMENTAL ECONOMIC ANALYSES FOR ALTERNATE APPROACH

EPA also considered an economic analysis for an "alternative approach" for defining non-hazardous solid waste. Under the alternative approach, the universe of sources in the energy recovery and waste burning cement kiln subcategories would change while the number of sources in the remaining three subcategories (i.e., incinerators, burn-off ovens, and small, remote incinerators) does not change. This section provides an overview of the results.

EPA estimated compliance costs for all existing units to add the necessary controls, monitoring equipment, inspections, and recordkeeping and reporting requirements to comply with the CISWI standards for the alternative approach. The estimates in this RIA reflect previous estimates of engineering costs with a capital investment of $1.9 billion (2008$) with an annualized engineering cost estimate of $476 million (2008$). The revised estimates are an annualized engineering cost estimate of $480 million (2008$), which results in a slight underestimate of the economic impacts.

7.1 Economic Impact Analysis Results

7.1.1 Market-Level Results

Market-level impacts include price and quantity adjustments including the changes in international trade (Table 7-1). The Agency's economic model suggests the average national market-level variables (prices, production-levels, consumption, and international trade) will not significantly change (e.g., are less than 0.1%).

7.1.2 Social Cost Estimates

In the near term, the Agency's economic model suggests that industries are able to pass on $117 million (2008$) of the costs to U.S. households in the form of higher prices (Table 7-2). Existing U.S. industries' surplus falls by $389 million, and the net loss for U.S. stakeholders is $506 million. As U.S. prices rise, other countries are affected through international trade relationships. Households that buy goods from the United States experience losses, while industries that sell goods to the United States benefit; the model estimates a net gain of $29 million. After accounting for international trade effects, the Agency's economic model projects the net surplus loss associated with the proposed rule is $477 million. The Agency also considered other elements of the engineering cost analysis that could not be modeled within the multimarket model (e.g., fuel savings benefits and total annualized compliance costs [unknown sources]). The net effect of the adjustments is approximately than $1 million.

Table 7-1. Market-Level Price and Quantity Changes: 2015 (Alternative Approach)

Industry Sector	Prices	Production	Imports	Consumption	Exports
Energy	less than 0.01%	less than 0.01%	less than 0.01%	less than 0.01%	less than 0.01%
Nonmanufacturing	less than 0.01%	less than 0.01%	less than 0.01%	less than 0.01%	less than 0.01%
Manufacturing					
Food, beverages, and textiles	less than 0.01%	less than 0.01%	less than 0.01%	less than 0.01%	less than 0.01%
Lumber, paper, and printing	0.07%	-0.03%	0.07%	-0.01%	-0.05%
Chemicals	less than 0.01%	less than 0.01%	less than 0.01%	less than 0.01%	less than 0.01%
Plastics and Rubber	less than 0.01%	less than 0.01%	less than 0.01%	less than 0.01%	less than 0.01%
Nonmetallic Minerals	0.02%	less than 0.01%	less than 0.01%	less than 0.01%	-0.02%
Primary Metals	less than 0.01%	less than 0.01%	less than 0.01%	less than 0.01%	less than 0.01%
Fabricated Metals	less than 0.01%	less than 0.01%	less than 0.01%	less than 0.01%	less than 0.01%
Machinery and Equipment	less than 0.01%	less than 0.01%	less than 0.01%	less than 0.01%	less than 0.01%
Electronic Equipment	less than 0.01%	less than 0.01%	less than 0.01%	less than 0.01%	less than 0.01%
Transportation Equipment	less than 0.01%	less than 0.01%	less than 0.01%	less than 0.01%	less than 0.01%
Other	less than 0.01%	less than 0.01%	less than 0.01%	less than 0.01%	less than 0.01%
Wholesale and Retail Trade	less than 0.01%	less than 0.01%	less than 0.01%	less than 0.01%	less than 0.01%
Transportation Services	less than 0.01%	less than 0.01%	less than 0.01%	less than 0.01%	less than 0.01%
Other Services	less than 0.01%	less than 0.01%	less than 0.01%	less than 0.01%	less than 0.01%

Table 7-2. Distribution of Social Costs (million, 2008$): 2015

Method	Alternative Approach
Partial Equilibrium Model (Multiple Markets)	
Change in U.S. consumer surplus	−$117
Change in U.S. producer surplus	−$389
Change in U.S. surplus	−$506
Net change in rest of world surplus	$29
Net change in total surplus	−$477
Direct Compliance Costs Method	
Total annualized costs, unknown sources (not modeled)	less than $1 Million
Fuel savings (not modeled)	$1
Change in Total Surplus	−$476

7.1.3 Job Effects

Near-term employment changes associated with the proposed rule are estimated to be less than 1,000 job losses (Table 7-3); over a longer time period, net employment effects range between 800 job losses to 1,700 job gains.

Table 7-3. Employment Changes (1,000 Jobs): 2015

Method	Alternative Approach
Partial equilibrium model (multiple markets) (demand effect only)	**−0.9**
Estimate Derived from Morgenstern, et al. (net effect [A + B +C below])	**+0.7 (−1.4 to +2.8)**
A. Estimate Derived from Morgenstern, et al: Demand effect	−1.7 (−3.6 to 0.2)
B. Estimate Derived from Morgenstern, et al: Cost effect	+1.2 (+0.4 to +1.9)
C. Estimate Derived from Morgenstern, et al: Factor shift effect	+1.3 (+0.0 to +2.5)

Note: Totals may not add due to independent rounding. 95 percent confidence intervals are shown in parenthesis.

7.2 Benefits Analysis Results

Table 7-4 provides a general summary of the alternate approach results by pollutant, including the emission reductions and monetized benefits-per-ton at discount rates of 3% and 7%. These estimates reflect EPA's most current interpretation of the scientific literature. Higher or lower estimates of benefits are possible using other assumptions, but most expert-derived estimates fall within these estimates. Data, resource, and methodological limitations prevented EPA from monetizing the benefits from several important benefit categories, including benefits from reducing hazardous air pollutants, ecosystem effects, and visibility impairment. The benefits from reducing hazardous air pollutants have not been monetized in this analysis, including reducing 130,000 tons of carbon monoxide, 430 tons of hydrochloric acid, 4.3 tons of cadmium, 3.4 tons of lead, and 2,400 pounds of mercury each year. Table 7-5 presents a summary of the monetized benefits, social costs, and net benefits for the alternate approach.

Table 7-4. Summary of Monetized Benefits for CISWI NSPS and Emission Guidelines in 2015 (2008$) (Alternate Approach)*

Pollutant	Emissions Reductions (tons)	Benefit per ton (Pope, 3%)	Benefit per ton (Laden, 3%)	Benefit per ton (Pope, 7%)	Benefit per ton (Laden, 7%)	Total Monetized Benefits (millions 2008$ at 3%)	Total Monetized Benefits (millions 2008$ at 7%)
Direct $PM_{2.5}$	11,962	$230,000	$560,000	$210,000	$500,000	$2,700 to $6,700	$2,500 to $6,000
$PM_{2.5}$ Precursors							
SO_2	205	$29,000	$72,000	$27,000	$65,000	$6.0 to $15	$5.5 to $13
NO_2	522	$4,900	$12,000	$4,400	$11,000	$2.5 to $6.2	$2.3 to $5.6
					Total	**$2,700 to $6,700**	**$2,500 to $6,000**

*All estimates are for the analysis year (fifth year after proposal 2015), 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 form $PM_{2.5}$. The monetized benefits incorporate the conversion from precursor emissions to ambient fine particles.

Table 7-5. Summary of the Monetized Benefits, Social Costs, and Net Benefits for the CISWI NSPS and Emissions Guidelines in 2015 (millions of 2008$) (Alternate Approach)[1]

Proposed Option with Alternate Approach		
	3% Discount Rate	7% Discount Rate
Total Monetized Benefits	$2,700 to $6,700[2]	$2,500 to $6,000[2]
Total Social Costs	$480[3]	$480
Net Benefits	$2,300 to $6,200	$2,000 to $5,600

[1]All estimates are for the implementation year (2015), and are rounded to two significant figures.

[2] The total monetized benefits reflect the human health benefits associated with reducing exposure to $PM_{2.5}$ through reductions of 12,000 tons of directly emitted $PM_{2.5}$ and $PM_{2.5}$ precursors such as 520 tons of NO_x and 205 tons of SO_2. The benefits from reducing 128,000 tons of carbon monoxide, 430 tons of hydrochloric acid, 4.3 tons of cadmium, 3.4 tons of lead, 1.2 tons of mercury, and 85 grams of total dioxins/furans each year are not included in these estimates. In addition, the benefits from reducing ecosystem effects and visibility impairment are not included.

[3] The methodology used to estimate social costs for one year in the multimarket model using surplus changes results in the same social costs for both discount rates.

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APPENDIX A
OAQPS MULTIMARKET MODEL TO ASSESS THE ECONOMIC IMPACTS OF ENVIRONMENTAL REGULATION

A.1 Introduction

An economic impact analysis (EIA) provides information about a policy's effects (i.e., social costs); emphasis is also placed on how the costs are distributed among stakeholders (EPA, 2000). In addition, large-scale policies require additional analysis to better understand how costs are passed across the economy. Although several tools are available to estimate social costs, current EPA guidelines suggest that multimarket models "…are best used when potential economic impacts and equity effects on related markets might be considerable" and modeling using a computable general equilibrium model is not available or practical (EPA, 2000, p. 146). Other guides for environmental economists offer similar advice (Berck and Hoffmann, 2002; Just, Hueth, and Schmitz, 2004).

Multimarket models focus on "short-run" time horizons and measure a policy's near term or transition costs (EPA, 1999). Recent studies suggest short-run analyses can complement full dynamic general equilibrium analysis.

The multimarket model described in this appendix is a new addition to the Office of Air quality Planning and Standards' (OAQPS's) economic model tool kit; it is designed to be used as a transparent tool that can respond quickly to requests about how stakeholders in 100 U.S. industries might respond to new environmental policy. Next, we provide an overview of the model, data, and parameters.

A.2 Multimarket Model

The multimarket model contains the following features:

- Industry sectors and benchmark data set
  - 100 industry sectors
  - a single benchmark year (2010)
  - estimates of industry carbon dioxide (CO_2) emissions
  - estimates of industry employment
- Economic behavior
  - industries respond to regulatory costs by changing production rates
  - market prices rise to reflect higher energy and other non-energy material costs
  - customers respond to these price increases and consumption falls
- Model scope

- 100 sectors are linked with each other based on their use of energy and other nonenergy materials. For example, the construction industry is linked with the petroleum, cement, and steel industries and is influenced by price changes that occur in each sector. The links allow EPA to account for indirect effects the regulation has on related markets.
  - Links come from input-output information used from OAQPS's computable general equilibrium model (EMPAX)
  - production adjustments influence employment levels
  - international trade (imports/exports) behavior considered
- Model time horizon ("short-run")
  - fixed production resources (e.g., capital) leads to an upward-sloping industry supply function
  - firms cannot alter input mixes; there is no substitution among production inputs (capital, labor, energy intermediates, and other intermediates)
  - price of labor (i.e., wage) is fixed
  - investment and government expenditures are fixed

A.2.1 Industry Sectors and Benchmark Data Set

The multimarket model includes 100 industries. For the benchmark year, the model uses information from OAQPS's computable general equilibrium model's balanced social accounting matrix (SAM) and the following accounting identity holds (EPA, 2008):

$$\text{Output} + \text{Imports} = \text{Consumption} + \text{Investment} + \text{Government} + \text{Exports} \tag{A.1}$$

If we abstract and treat each industry as a national market, the identity represents the pre-policy market-clearing condition, or benchmark "equilibrium"; supply equals demand in each market. In Table A-1, we identify the 100 industries for the multimarket model; Table A-2 provides the 2010 benchmark data set. Since the benchmark data are reported in value terms, we also use the common "Harberger convention" and choose units where are all prices are one in the benchmark equilibrium (Shoven and Whalley, 1995).

Table A-1. Industry Sectors Included in Multimarket Model

Industry Label	Description	Representative NAICS[a]
Energy Industries		
COL	Coal	2121
CRU	Crude Oil Extraction	211111 (exc. nat gas)
ELE	Electric Generation	2211
GAS	Natural Gas	211112 2212 4862
OIL	Refined Petroleum	324
Nonmanufacturing		
AGR	Agricultural	11
MIN	Mining	21 less others
CNS	Construction	23
Manufactured Goods		
Food, beverages, and textiles		
ANM	Animal Foods	3111
GRN	Grain Milling	3112
SGR	Sugar	3113
FRU	Fruits and Vegetables	3114
MIL	Dairy Products	3115
MEA	Meat Products	3116
SEA	Seafood	3117
BAK	Baked Goods	3118
OFD	Other Food Products	3119
BEV	Beverages and Tobacco	312
TEX	Textile Mills	313
TPM	Textile Product Mills	314
WAP	Wearing Apparel	315
LEA	Leather	316
Lumber, paper, and printing		
SAW	Sawmills	3211
PLY	Plywood and Veneer	3212
LUM	Other Lumber	3219
PAP	Pulp and Paper Mills	3221
CPP	Converted Paper Products	3222
PRN	Printing	323
Chemicals		
CHM	Chemicals and Gases	3251
RSN	Resins	3252
FRT	Fertilizer	3253
MED	Drugs and Medicine	3254
PAI	Paints and Adhesives	3255
SOP	Soap	3256
OCM	Other Chemicals	3259

(continued)

Table A-1. Industry Sectors Included in Multimarket Model (continued)

Industry Label	Description	Representative NAICS[a]
Plastics and Rubber		
PLS	Plastic	3261
RUB	Rubber	3262
Nonmetallic Minerals		
CLY	Clay	3271
GLS	Glass	3272
CEM	Cement	3273
LIM	Lime and Gypsum	3274
ONM	Other Non-Metallic Minerals	3279
Primary Metals		
I_S	Iron and Steel	3311 3312 33151
ALU	Aluminum	3313 331521 331524
OPM	Other Primary Metals	3314 331522 331525 331528
Fabricated Metals		
FRG	Forging and Stamping	3321
CUT	Cutlery	3322
FMP	Fabricated Metals	3323
BOI	Boilers and Tanks	3324
HRD	Hardware	3325
WIR	Springs and Wires	3326
MSP	Machine Shops	3327
EGV	Engraving	3328
OFM	Other Fabricated Metals	3329
Machinery and Equipment		
CEQ	Construction and Agricultural Equipment	3331
IEQ	Industrial Equipment	3332
SEQ	Service Industry Equipment	3333
HVC	HVAC Equipment	3334
MEQ	Metalworking Equipment	3335
EEQ	Engines	3336
GEQ	General Equipment	3339
Electronic Equipment		
CPU	Computers	3341
CMQ	Communication Equipment	3342
TVQ	TV Equipment	3343
SMI	Semiconductor Equipment	3344
INS	Instruments	3345
MGT	Magnetic Recording Equipment	3346
LGT	Lighting	3351
APP	Appliances	3352

(continued)

Table A-1. Industry Sectors Included in Multimarket Model (continued)

Industry Label	Description	Representative NAICS[a]
Electronic Equipment (continued)		
ELQ	Electric Equipment	3353
OEQ	Other Electric Equipment	3359
Transportation Equipment		
M_V	Motor Vehicles	3361
TKB	Truck Bodies	3362
MVP	Motor Vehicle Parts	3363
ARC	Aircraft	3364
R_R	Rail Cars	3365
SHP	Ships	3366
OTQ	Other Transport Equipment	3369
Other		
FUR	Furniture	337
MSC	Miscellaneous Manufacturing	339
Services		
Wholesale and Retail Trade		
WHL	Wholesale Trade	42
RTL	Retail Trade	44–45
Transportation Services		
ATP	Air Transportation	481
RTP	Railroad Transportation	482
WTP	Water Transportation	483
TTP	Freight Truck Transportation	484
PIP	Pipeline Transport	486
OTP	Other Transportation Services	485 487 488
Other Services		
INF	Information	51
FIN	Finance and Insurance	52
REL	Real Estate	53
PFS	Professional Services	54
MNG	Management	55
ADM	Administrative Services	56
EDU	Education	61
HLT	Health Care	62
ART	Arts	71
ACM	Accommodations	72
OSV	Other Services	81
PUB	Public Services	92

[a] NAICS = North American Industry Classification System. Industry assignments are based on data used in the EMPAX-modeling system, which relies on the commodity code system used in IMPLAN.

Table A-2. 2010 Benchmark Data Set (billion 2006$)

Industry Label	Industry Description	Output	Imports	Consumption	Investment and Government	Exports
ACM	Accommodations	$828	$6	$816	$17	$1
ADM	Administrative Services	$795	$37	$771	$61	Less than $1
AGR	Agricultural	$314	$53	$333	$5	$29
ALU	Aluminum	$65	$17	$70	$4	$8
ANM	Animal Foods	$45	Less than $1	$36	Less than $1	$9
APP	Appliances	$25	$19	$35	$6	$3
ARC	Aircraft	$217	$60	$58	$120	$98
ART	Arts	$252	Less than $1	$246	$3	$3
ATP	Air Transportation	$154	$28	$91	$32	$59
BAK	Baked Goods	$61	$3	$61	$2	Less than $1
BEV	Beverages and Tobacco	$133	$54	$186	Less than $1	$1
BOI	Boilers and Tanks	$27	$2	$19	$9	$2
CEM	Cement	$52	Less than $1	$47	$3	$2
CEQ	Construction and Agricultural Equipment	$70	$24	$47	$33	$14
CHM	Chemicals and Gases	$284	$75	$300	$10	$49
CLY	Clay	$8	$4	$10	$1	$2
CMQ	Communication Equipment	$73	$40	$47	$56	$11
CNS	Construction	$983	$77	$594	$465	Less than $1
COL	Coal	$44	$2	$42	Less than $1	$4
CPP	Converted Paper Products	$52	$2	$43	$6	$6
CPU	Computers	$145	$76	$132	$52	$37
CRU	Crude Oil Extraction	$67	$189	$255	Less than $1	Less than $1
CUT	Cutlery	$11	$5	$9	$5	$2
EDU	Education	$970	Less than $1	$257	$701	$13
EEQ	Engines	$36	$14	$30	$6	$13
EGV	Engraving	$21	Less than $1	$9	$5	$7
ELE	Electric Generation	$317	Less than $1	$287	$31	Less than $1
ELQ	Electric Equipment	$33	$16	$23	$17	$10
FIN	Finance and Insurance	$2,015	$106	$1,972	$43	$106
FMP	Fabricated Metals	$66	$1	$58	$7	$2
FRG	Forging and Stamping	$20	Less than $1	$17	$1	$2
FRT	Fertilizer	$42	$5	$33	$4	$10

(continued)

Table A-2. 2010 Benchmark Data Set (billion 2006$) (continued)

Industry Label	Industry Description	Output	Imports	Consumption	Investment and Government	Exports
FRU	Fruits and Vegetables	$74	$12	$76	$4	$5
FUR	Furniture	$66	$38	$84	$17	$2
GAS	Natural Gas	$139	$32	$160	$6	$6
GEQ	General Equipment	$54	$32	$47	$25	$14
GLS	Glass	$30	Less than $1	$18	$2	$10
GRN	Grain Milling	$77	$9	$74	$2	$10
HLT	Health Care	$1,863	Less than $1	$1,823	$20	$20
HRD	Hardware	$8	$4	$5	$4	$3
HVC	HVAC Equipment	$34	$9	$26	$10	$6
I_S	Iron and Steel	$125	$42	$143	$10	$13
IEQ	Industrial Equipment	$26	$14	$16	$14	$11
INF	Information	$1,305	$77	$1,217	$154	$11
INS	Instruments	$112	$44	$71	$65	$20
LEA	Leather	$4	$26	$29	Less than $1	$1
LGT	Lighting	$12	$11	$16	$5	$1
LIM	Lime and Gypsum	$7	Less than $1	$1	Less than $1	$5
LUM	Other Lumber	$41	$2	$32	$9	$2
M_V	Motor Vehicles	$272	$190	$313	$106	$43
MEA	Meat Products	$174	$9	$169	$5	$10
MED	Drugs and Medicine	$258	$102	$316	$18	$27
MEQ	Metalworking Equipment	$24	$11	$16	$14	$4
MGT	Magnetic Recording Equipment	$15	$2	$13	$2	$2
MIL	Dairy Products	$87	$3	$84	$4	$2
MIN	Mining	$53	$2	$30	$15	$11
MNG	Management	$469	Less than $1	$378	Less than $1	$92
MSC	Miscellaneous Manufacturing	$178	$129	$189	$73	$46
MSP	Machine Shops	$38	$2	$32	$5	$2
MVP	Motor Vehicle Parts	$220	$75	$226	$17	$52
OCM	Other Chemicals	$45	$2	$23	$9	$15
OEQ	Other Electric Equipment	$31	$16	$28	$7	$11
OFD	Other Food Products	$92	$7	$90	$2	$7
OFM	Other Fabricated Metals	$56	$28	$50	$22	$12

(continued)

Table A-2. 2010 Benchmark Data Set (billion 2006$) (continued)

Industry Label	Industry Description	Output	Imports	Consumption	Investment and Government	Exports
OIL	Refined Petroleum	$415	$106	$462	$12	$47
ONM	Other Non-Metallic Minerals	$13	$5	$15	$1	$2
OPM	Other Primary Metals	$40	$27	$52	$2	$12
OSV	Other Services	$2,321	Less than $1	$1,479	$598	$244
OTP	Other Transportation Services	$245	Less than $1	$202	$22	$22
OTQ	Other Transport Equip	$23	$10	$14	$13	$5
PAI	Paints and Adhesives	$36	$1	$28	$3	$6
PAP	Pulp and Paper Mills	$131	$21	$133	$5	$14
PFS	Professional Services	$2,103	$84	$1,715	$461	$10
PIP	Pipeline Transport	$37	$83	$20	$98	$1
PLS	Plastic	$145	$14	$139	$4	$15
PLY	Plywood and Veneer	$19	$8	$25	$1	$1
PRN	Printing	$51	$1	$34	$11	$6
PUB	Public Services	$1,099	$22	$355	$766	Less than $1
R_R	Rail Cars	$11	$2	$6	$6	$2
REL	Real Estate	$2,719	$2	$2,559	$131	$31
RSN	Resins	$107	$23	$98	$6	$26
RTL	Retail Trade	$1,440	$53	$1,412	$82	Less than $1
RTP	Railroad Transportation	$70	Less than $1	$42	$18	$11
RUB	Rubber	$38	$20	$36	$15	$6
SAW	Sawmills	$29	$9	$36	$1	$1
SEA	Seafood	$13	$3	$14	$1	$1
SEQ	Service Industry Equipment	$29	$23	$22	$24	$6
SGR	Sugar	$34	$6	$36	$2	$3
SHP	Ships	$36	$6	$13	$29	Less than $1
SMI	Semiconductor Equipment	$141	$69	$157	$12	$41
SOP	Soap	$82	$5	$74	$3	$9
TEX	Textile Mills	$29	$9	$31	$1	$6
TKB	Truck Bodies	$58	$12	$34	$32	$5
TPM	Textile Product Mills	$27	$19	$37	$7	$2
TTP	Freight Truck Transportation	$301	Less than $1	$211	$39	$51

(continued)

Table A-2. 2010 Benchmark Data Set (billion 2006$) (continued)

Industry Label	Industry Description	Output	Imports	Consumption	Investment and Government	Exports
TVQ	TV Equipment	$19	$37	$50	$3	$3
WAP	Wearing Apparel	$25	$94	$117	$1	Less than $1
WHL	Wholesale Trade	$1,309	$22	$1,021	$172	$138
WIR	Springs and Wires	$5		$2	$1	$3
WTP	Water Transportation	$45		$14	$12	$19

A.2.1.2 Employment Data

The model includes employment forecasts for each of the 100 sectors. Employment estimates are based on data from three sources: the AEO 2009 estimates of employment (AEO supplemental Table 126 and indicators of Macroeconomic Activity), and Global Insights, Inc., and the Bureau of Labor Statistics (BLS) 2008 end-of year-employment (Current Employment Statistics—CES [National]). Typically, 3-digit NAICS sectors' employment estimates are either directly reported in the updated AEO 2009 release or Global Insights For multimarket industries with finer NAICs detail, estimates were calculated by selecting a primary NAICS supersector estimate (AEO or Global Insights) and distributing total employment from the larger NAICS supersectors across more detailed NAICS sectors within the super-sector. The distributions were determined using observed 2008 BLS employment data. In the last step, In order to match aggregate U.S. employment numbers reported in the AEO 2009 release (140.1 million), a single adjustment factor was applied to all sectors that use Global Insights' supersector data.[1] Table A-4 reports the baseline employment for each of the 100 sectors.

[1] This step is required because Global Insight's data used by EPA are an older vintage than the forecasts used in the AEO.

Table A-4. 2010 U.S. Employment Projections

Industry Label	Industry Description	Projected Employment (1,000)
ACM	Accommodations	11,239
ADM	Administrative Services	9,274
AGR	Agricultural	1,607
ALU	Aluminum	87
ANM	Animal Foods	45
APP	Appliances	33
ARC	Aircraft	449
ART	Arts	1,939
ATP	Air Transportation	506
BAK	Baked Goods	247
BEV	Beverages and Tobacco	92
BOI	Boilers and Tanks	67
CEM	Cement	164
CEQ	Construction and Agricultural Equipment	176
CHM	Chemicals and Gases	147
CLY	Clay	38
CMQ	Communication Equipment	73
CNS	Construction	7,446
COL	Coal	79
CPP	Converted Paper Products	306
CPU	Computers	104
CRU	Crude Oil Extraction	384
CUT	Cutlery	34
EDU	Education	2,892
EEQ	Engines	75
EGV	Engraving	100
ELE	Electric Generation	219
ELQ	Electric Equipment	72
FIN	Finance and Insurance	6,051
FMP	Fabricated Metals	285
FRG	Forging and Stamping	75
FRT	Fertilizer	35
FRU	Fruits and Vegetables	153
FUR	Furniture	327

(continued)

Table A-4. 2010 U.S. Employment Projections (continued)

Industry Label	Industry Description	Projected Employment (1,000)
GAS	Natural Gas	98
GEQ	General Equipment	198
GLS	Glass	71
GRN	Grain Milling	55
HLT	Health Care	15,190
HRD	Hardware	20
HVC	HVAC Equipment	109
I_S	Iron and Steel	205
IEQ	Industrial Equipment	88
INF	Information	2,939
INS	Instruments	250
LEA	Leather	3
LGT	Lighting	26
LIM	Lime and Gypsum	10
LUM	Other Lumber	216
M_V	Motor Vehicles	170
MEA	Meat Products	450
MED	Drugs and Medicine	279
MEQ	Metalworking Equipment	139
MGT	Magnetic Recording Equipment	20
MIL	Dairy Products	113
MIN	Mining	599
MNG	Management	1,732
MSC	Miscellaneous Manufacturing	180
MSP	Machine Shops	251
MVP	Motor Vehicle Parts	485
OCM	Other Chemicals	92
OEQ	Other Electric Equipment	63
OFD	Other Food Products	144
OFM	Other Fabricated Metals	196
OIL	Refined Petroleum	70
ONM	Other Non-metallic Minerals	61
OPM	Other Primary Metals	87
OSV	Other Services	5,271
OTP	Other Transportation Services	1,064

(continued)

Table A-4. 2010 U.S. Employment Projections (continued)

Industry Label	Industry Description	Projected Employment (1,000)
OTQ	Other Transport Equipment	36
PAI	Paints and Adhesives	60
PAP	Pulp and Paper Mills	121
PFS	Professional Services	18,989
PIP	Pipeline Transport	43
PLS	Plastic	473
PLY	Plywood and Veneer	74
PRN	Printing	248
PUB	Public Services	21,787
R_R	Rail Cars	25
REL	Real Estate	2,158
RSN	Resins	102
RTL	Retail Trade	15,283
RTP	Railroad Transportation	236
RUB	Rubber	117
SAW	Sawmills	84
SEA	Seafood	36
SEQ	Service Industry Equipment	77
SGR	Sugar	62
SHP	Ships	140
SMI	Semiconductor Equipment	245
SOP	Soap	104
TEX	Textile Mills	110
TKB	Truck Bodies	126
TPM	Textile Product Mills	32
TTP	Freight Truck Transportation	1,429
TVQ	TV Equipment	15
WAP	Wearing Apparel	153
WHL	Wholesale Trade	5,869
WIR	Springs and Wires	36
WTP	Water Transportation	67
Total		144,100

A.2.2 Economic Behavior

A.2.2.1 U.S. Supply

In a postpolicy scenario, industry responds to changes in the new market-clearing "net" price for the good or service sold:

$$\%\Delta\text{"net" price} = \%\Delta \text{ market price} - \%\Delta \text{ direct costs} - \%\Delta \text{ indirect costs} \qquad \text{(A.2)}$$

The %Δ direct costs are approximated using the engineering cost analysis and baseline value of output. For example, a $1 billion increase in compliance costs for the electricity sector (ELE) would be represented in the model as follows:

$$\%\Delta \text{ direct costs} = \$1/\$317 = 0.03\% \qquad \text{(A.3)}$$

As shown in Figure A-1, the cost change provides the industry with incentives to alter production rates at current market prices; market prices must rise to maintain the original pre-policy production levels (Q).

The multimarket model also simultaneously considers how the policy influences other important production costs (via changes in energy and other intermediate material prices). As a result, the multimarket model can provide additional information about how policy costs are transmitted through the economy. As shown in Figure A-2, the indirect cost change provides the industry with additional incentives to alter production rates at current market prices.

The %Δ indirect effects associated with each input are approximated using an input "use" ratio and the price change that occurs in the input market.

$$\%\Delta \text{ indirect costs} = \text{input use ratio} \times \%\Delta \text{ input price} \qquad \text{(A.4)}$$

The social accounting matrix provides an internally consistent estimate of the use ratio and describes the dollar amount of an input that is required to produce a dollar of output. Higher ratios suggest strong links between industries, while lower ratios suggest weaker links. Given the short time horizon, we assume the input use ratio is fixed and cannot adjust their input mix; this is a standard assumption in public and commercial input-output (IO) and SAM multiplier models (Berck and Hoffmann, 2002). Morgenstern and colleagues (2004) and Ho and colleagues (2008) also use this assumption when examining near-term effects of environmental policy.

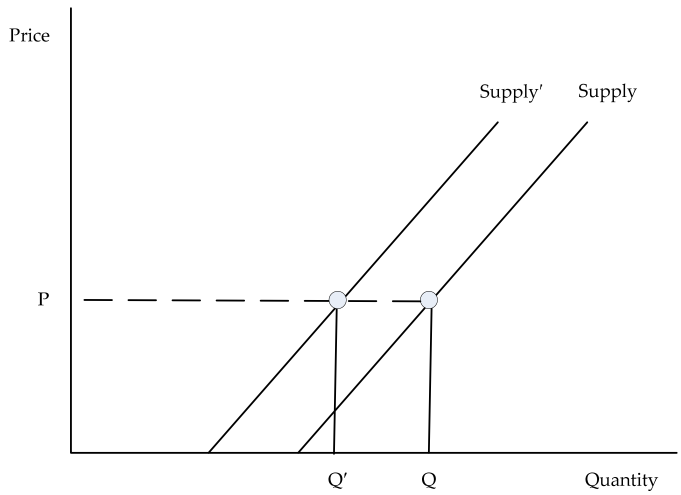

Figure A-1. Direct Compliance Costs Reduce Production Rates at Benchmark Prices

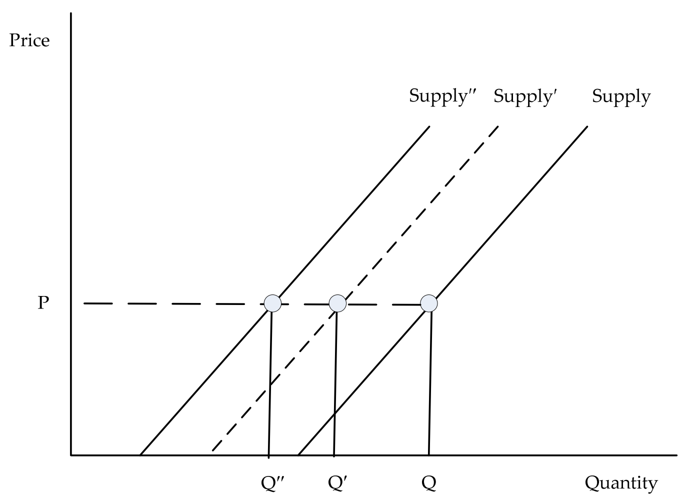

Figure A-2. Indirect Costs Further Reduce Production Rates at Benchmark Prices

Following guidance in the OAQPS economic resource manual (OAQPS, 1999), we use a general form for the U.S. industry supply function:

$$Q'_g = b\left(P'_g - t - \sum_{i=1}^{n} \alpha_{gi}(P'_i - P_i)\right)^{\varepsilon_g} \tag{A.5}$$

where

Q'_g = with-policy supply quantity (g)

b = calibrated scale parameter for the supply price relationship

P'_g = with-policy price for output (g)

t = direct compliance costs per unit of supply

α_{gi} = input use ratio (g using input i)

P'_i = with-policy input (i) price

P_i = benchmark input (i) price

ε_g = price elasticity of supply for output (g)

The key supply parameter that controls the industry production adjustments is the price elasticity of supply (ε_g). To our knowledge, there is no existing empirical work that estimates short-run supply elasticities for all industry groups used in the multimarket model. As a result, we assume the U.S. supply elasticities are a function of econometrically estimated rest-of-world (ROW) export supply elasticities (see discussion in the next section). We report the values currently available in the model in Table A-5.

A.2.2.2 International Competition

International competition is captured by a single ROW supply function:

$$Q'_g = c\left(P'_g\right)^{\varepsilon_g^{ROW}} \tag{A.6}$$

where

Q'_g = with-policy supply quantity (g)

c = calibrated scale parameter for the supply and price relationship

P'_g = with-policy U.S. price for output (g)

ε_g^{ROW} = price elasticity of supply of goods from the ROW to the United States (imports) (g)

The key supply parameter that controls the ROW supply adjustments is the price elasticity of supply (ε_g^{ROW}). We obtained these estimates for a variety of industry groups from a recently published article by Broda and colleagues (2008b).

Table A-5. Supply Elasticities

Industry Label	Industry Description	Rest of World (ROW)	U.S.
ACM	Accommodations	0.7	0.7
ADM	Administrative Services	0.7	0.7
AGR	Agricultural	1.0	1.0
ALU	Aluminum	0.8	0.5
ANM	Animal Foods	1.1	0.8
APP	Appliances	0.9	0.8
ARC	Aircraft	0.9	0.6
ART	Arts	0.7	0.7
ATP	Air Transportation	0.7	0.7
BAK	Baked Goods	0.8	0.7
BEV	Beverages and Tobacco	2.9	2.9
BOI	Boilers and Tanks	1.1	0.8
CEM	Cement	0.9	0.7
CEQ	Construction and Agricultural Equipment	0.8	0.6
CHM	Chemicals and Gases	1.1	0.8
CLY	Clay	0.8	0.6
CMQ	Communication Equipment	2.5	1.0
CNS	Construction	0.7	0.7
COL	Coal	2.2	2.2
CPP	Converted Paper Products	0.9	0.7
CPU	Computers	1.0	0.7
CRU	Crude Oil Extraction	3.7	3.7
CUT	Cutlery	1.4	1.1
EDU	Education	0.7	0.7
EEQ	Engines	1.2	1.0
EGV	Engraving	1.1	0.8
ELE	Electric Generation	2.0	2.0
ELQ	Electric Equipment	0.8	0.6
FIN	Finance and Insurance	0.7	0.7
FMP	Fabricated Metals	1.2	1.1
FRG	Forging and Stamping	1.6	1.5

(continued)

Table A-5. Supply Elasticities (continued)

Industry Label	Industry Description	Rest of World (ROW)	U.S.
FRT	Fertilizer	1.0	0.7
FRU	Fruits and Vegetables	1.0	0.7
FUR	Furniture	1.9	1.9
GAS	Natural Gas	12.2	12.2
GEQ	General Equipment	1.0	0.7
GLS	Glass	0.8	0.6
GRN	Grain Milling	1.7	1.5
HLT	Health Care	0.7	0.7
HRD	Hardware	1.1	0.8
HVC	HVAC Equipment	0.9	0.6
I_S	Iron and Steel	1.0	0.6
IEQ	Industrial Equipment	0.9	0.6
INF	Information	0.7	0.7
INS	Instruments	0.9	0.6
LEA	Leather	0.9	0.7
LGT	Lighting	1.1	0.7
LIM	Lime and Gypsum	0.9	0.7
LUM	Other Lumber	0.9	0.7
M_V	Motor Vehicles	1.3	0.7
MEA	Meat Products	1.2	3.9
MED	Drugs and Medicine	1.3	1.0
MEQ	Metalworking Equipment	0.7	0.5
MGT	Magnetic Recording Equipment	1.0	0.7
MIL	Dairy Products	1.1	0.9
MIN	Mining	2.2	2.2
MNG	Management	0.7	0.7
MSC	Miscellaneous Manufacturing	1.0	0.8
MSP	Machine Shops	1.1	0.8
MVP	Motor Vehicle Parts	0.9	0.6
OCM	Other Chemicals	1.1	0.6
OEQ	Other Electric Equipment	1.0	0.7
OFD	Other Food Products	1.1	0.7

(continued)

Table A-5. Supply Elasticities (continued)

Industry Label	Industry Description	Rest of World (ROW)	U.S.
OFM	Other Fabricated Metals	0.9	0.6
OIL	Refined Petroleum	1.0	0.7
ONM	Other Non-metallic Minerals	1.5	0.7
OPM	Other Primary Metals	0.7	0.5
OSV	Other Services	0.7	0.7
OTP	Other Transportation Services	0.7	0.7
OTQ	Other Transport Equipment	1.0	0.7
PAI	Paints and Adhesives	1.0	0.7
PAP	Pulp and Paper Mills	1.1	0.7
PFS	Professional Services	0.7	0.7
PIP	Pipeline Transport	2.0	2.0
PLS	Plastic	1.0	0.7
PLY	Plywood and Veneer	1.3	1.3
PRN	Printing	1.0	0.7
PUB	Public Services	0.7	0.7
R_R	Rail Cars	1.8	0.7
REL	Real Estate	0.7	0.7
RSN	Resins	1.0	0.7
RTL	Retail Trade	0.7	0.7
RTP	Railroad Transportation	0.7	0.7
RUB	Rubber	1.3	1.1
SAW	Sawmills	0.8	0.6
SEA	Seafood	1.1	0.8
SEQ	Service Industry Equipment	0.8	0.6
SGR	Sugar	1.1	0.8
SHP	Ships	1.0	0.7
SMI	Semiconductor Equipment	1.2	1.0
SOP	Soap	0.8	0.6
TEX	Textile Mills	1.0	0.7
TKB	Truck Bodies	3.2	3.1
TPM	Textile Product Mills	0.8	0.6
TTP	Freight Truck Transportation	0.7	0.7
TVQ	TV Equipment	5.8	5.4

(continued)

Table A-5. Supply Elasticities (continued)

Industry Label	Industry Description	Rest of World (ROW)	U.S.
WAP	Wearing Apparel	1.2	0.8
WHL	Wholesale Trade	0.7	0.7
WIR	Springs and Wires	1.9	0.8
WTP	Water Transportation	0.7	0.7

Note: RTI mapped Broda et al. data for their industry aggregation to the multimarket model's 100 industries. Domestic supply elasticities are typically assumed to be within one standard deviation of the sample of supply elasticities used for the ROW. In selected cases where this information is not available, the U.S. supply elasticity is set equal to the ROW.

Source: Broda, C., N. Limao, and D. Weinstein. 2008a. "Export Supply Elasticities." http://faculty.chicagobooth.edu/christian.broda/website/research/unrestricted/TradeElasticities/TradeElasticities.html. Accessed September 2009.

A.2.2.3 Price Elasticity of Supply: Rest of World (ROW)

Broda and colleagues (2008) provide an empirical basis for the multimarket model supply elasticities. Broda et al. provide over 1,000 inverse elasticities that RTI organized to be comparable with the 100-sector model. The first step was to match the Harmonized Trade System (HS) elasticities estimated in the article to the appropriate NAICS codes. Many of the HS codes correspond with a detailed NAICS codes (5- and 6-digit level), while the multimarket sector industries typically correspond with more aggregated sectors (NAICS 2-, 3-, or 4-digit levels). To adapt these labels to our model, we combined the 5- and 6- digit NAICS under their 3- and 4-digit codes and calculated an average inverse elasticity value for codes that fell within the multimarket model's aggregate industrial sectors. This gives a crude way to account for the variety of products detailed in the original data set. We also restricted the elasticity sample to those that Broda et al. classify as "medium" and "low" categories; these categories tend to have lower elasticity values that are consistent with the multimarket model's modeling horizon (i.e., in the short run importers are likely to have less flexibility to respond to price changes and elasticities are low).[1]

Our ideal preference was to use an exact 3- or 4-digit match from the medium category if one was available. If the multimarket model had a 4-digit code for which there was no direct match, we aggregated up a level and applied the relevant 3-digit elasticity. If a multimarket code was not covered in the medium set of elasticities, we used the low elasticity category. This method was sufficient for mapping the majority of the sectors in the model. After applying our inverse elasticity values to the multimarket sectors, we calculated the inverse of the value to

[1] Broda et al.'s intent was to use these categories to describe or proxy for domestic market power.

arrive at the actual supply elasticity. Since Broda et al.'s article focused on industrial production goods, some of the multimarket sectors were not covered in the elasticity data. These sectors included mainly service industries, transportation, and energy sources.

In order to fill these gaps, we turned to the source substitution elasticities from Purdue University's Global Trade Analysis Project (GTAP).[1] Although the elasticities in the GTAP model are a different type of international trade elasticity and cannot be directly applied in the multimarket model (e.g., they are based on the Armington structure[2]), the parameters provide us with some additional information about the relative trade elasticity differences between industry sectors. To use the GTAP information to develop assumptions about the multimarket model sectors with missing elasticities, we chose a base industrial sector (iron and steel) for which we had parameter value from Broda et al. Next, we developed industry-specific ratios for missing industries using the corresponding GTAP sector trade elasticities and the GTAP iron and steel sector. We multiplied the resulting ratio by the Broda et al. iron and steel parameter (1.0). For example, the GTAP trade elasticity for coal (6.10) is approximately 2.2 times the trade elasticity for iron and steel (2.95). As a result, the multimarket import supply elasticity for coal is computed as 2.2 (2.2 x 1.0).

A.2.2.4 Price Elasticity of Supply: United States

We also used Broda et al.'s elasticities to derive a set of domestic supply elasticities for the model. We have assumed that a product's domestic supply would be equal to or less elastic than other countries' supply of imports. When we aggregated and averaged the original elasticities to the 3- and 4- digit NAICS level for our foreign supply elasticities, we also calculated the standard deviation of each 3- and 4-digit NAICS sample. By adding the standard deviation to the corresponding foreign supply and then taking the inverse, we were able to calculate a domestic supply elasticity for each sector that was lower than its foreign counterpart while maintaining the structure of the original elasticities. For sectors in which no standard deviation was available,[3] we used professional judgment to apply the closest available substitute from a similar industry. Without a comparable way of scaling our foreign elasticities for the sectors in which we used the GTAP elasticities, we elected to keep the domestic and foreign supply elasticities the same.

[1]See Chapter 14 of the GTAP 7 Database Documentation for the full description of the parameters at https://www.gtap.agecon.purdue.edu/resources/download/4184.pdf; see Table 14.2 for elasticities.

[2]Detailed documentation of the entire GTAP 7 Database is available at https://www.gtap.agecon.purdue.edu/databases/v7/v7_doco.asp. The GTAP also uses a unique system of categorizing commodities that does not match the NAICS or HS system exactly.

[3]No standard deviations were calculated for the 3- and 4-digit codes that had only one observation (i.e., Broda et al.'s model used the exact 3- or 4-digit code).

A.2.2.5 Demand

Uses for industry output are divided into three groups: investment/government use, domestic intermediate uses, and other final use (domestic and exports). Given the short time horizon, investment/government does not change. Intermediate use is determined by the input use ratios and the industry output decisions.

$$Q_i' = \alpha_{gi} Q_g' \tag{A.7}$$

Q_i' = with-policy input demand quantity (i)

α_{gi} = input use ratio (g using input i)

Q_g' = with-policy output quantity (g)

Other final use does respond to market price changes. Following guidance in the OAQPS economic resource manual (OAQPS, 1999), we use a general form for the U.S. industry demand function:

$$Q_g' = a\left(P_g'\right)^{\eta_g} \tag{A.8}$$

where

Q_g' = with-policy demand quantity (g)

a = calibrated scale parameter for the demand and price relationship

P_g' = with-policy price for output (g)

η_g = price elasticity of demand (g)

The key parameter that controls consumption adjustments is the price elasticity of demand (η_g). To approximate the response, we use demand elasticities that were simulated with a general equilibrium model (Ho, Morgenstern, and Shih, 2008). Table A-6 reports the values currently available in the model.

A.2.2.6 Model Scope

The multimarket model includes 100 sectors covering energy, manufacturing, and service applications. Each sector's production technology requires the purchase of energy and other intermediate goods made by other sectors included in the model. Linking the sectors in this manner allows the model to trace direct and indirect policy effects across different sectors. Therefore, it is best used when potential economic impacts and equity effects on related markets might be important to stakeholders not directly affected by an environmental policy. However,

Table A-6. U.S. Demand Elasticities

Industry Label	Industry Description	Demand Elasticity η_g
ACM	Accommodations	−0.7
ADM	Administrative Services	−0.7
AGR	Agricultural	−0.8
ALU	Aluminum	−1.0
ANM	Animal Foods	−0.6
APP	Appliances	−2.6
ARC	Aircraft	−2.5
ART	Arts	−0.7
ATP	Air Transportation	−0.8
BAK	Baked Goods	−0.6
BEV	Beverages and Tobacco	−0.6
BOI	Boilers and Tanks	−0.5
CEM	Cement	−0.8
CEQ	Construction and Agricultural Equipment	−1.7
CHM	Chemicals and Gases	−1.0
CLY	Clay	−0.8
CMQ	Communication Equipment	−2.6
CNS	Construction	−0.8
COL	Coal	−0.1
CPP	Converted Paper Products	−0.7
CPU	Computers	−2.6
CRU	Crude Oil Extraction	−0.3
CUT	Cutlery	−0.5
EDU	Education	−0.7
EEQ	Engines	−1.7
EGV	Engraving	−0.5
ELE	Electric Generation	−0.2
ELQ	Electric Equipment	−2.6
FIN	Finance and Insurance	−0.7
FMP	Fabricated Metals	−0.5
FRG	Forging and Stamping	−0.5
FRT	Fertilizer	−1.0
FRU	Fruits and Vegetables	−0.6
FUR	Furniture	−0.7

(continued)

Table A-6. U.S. Demand Elasticities (continued)

Industry Label	Industry Description	Demand Elasticity η_g
GAS	Natural Gas	−0.3
GEQ	General Equipment	−1.7
GLS	Glass	−0.8
GRN	Grain Milling	−0.6
HLT	Health Care	−0.7
HRD	Hardware	−0.5
HVC	HVAC Equipment	−1.7
I_S	Iron and Steel	−1.0
IEQ	Industrial Equipment	−1.7
INF	Information	−0.7
INS	Instruments	−2.6
LEA	Leather	−1.1
LGT	Lighting	−2.6
LIM	Lime and Gypsum	−0.8
LUM	Other Lumber	−0.7
M_V	Motor Vehicles	−2.5
MEA	Meat Products	−0.6
MED	Drugs and Medicine	−1.0
MEQ	Metalworking Equipment	−1.7
MGT	Magnetic Recording Equipment	−2.6
MIL	Dairy Products	−0.6
MIN	Mining	−0.6
MNG	Management	−0.7
MSC	Miscellaneous Manufacturing	−1.7
MSP	Machine Shops	−0.5
MVP	Motor Vehicle Parts	−2.5
OCM	Other Chemicals	−1.0
OEQ	Other Electric Equipment	−2.6
OFD	Other Food Products	−0.6
OFM	Other Fabricated Metals	−0.5
OIL	Refined Petroleum	−0.1
ONM	Other Non-metallic Minerals	−0.8
OPM	Other Primary Metals	−1.0
OSV	Other Services	−0.7
OTP	Other Transportation Services	−0.8

(continued)

Table A-6. U.S. Demand Elasticities (continued)

Industry Label	Industry Description	Demand Elasticity η_g
OTQ	Other Transport Equip	−2.5
PAI	Paints and Adhesives	−1.0
PAP	Pulp and Paper Mills	−0.7
PFS	Professional Services	−0.7
PIP	Pipeline Transport	−0.8
PLS	Plastic	−1.0
PLY	Plywood and Veneer	−0.7
PRN	Printing	−0.7
PUB	Public Services	−0.7
R_R	Rail Cars	−2.5
REL	Real Estate	−0.7
RSN	Resins	−1.0
RTL	Retail Trade	−0.7
RTP	Railroad Transportation	−0.8
RUB	Rubber	−1.0
SAW	Sawmills	−0.7
SEA	Seafood	−0.6
SEQ	Service Industry Equipment	−1.7
SGR	Sugar	−0.6
SHP	Ships	−2.5
SMI	Semiconductor Equipment	−2.6
SOP	Soap	−1.0
TEX	Textile Mills	−1.1
TKB	Truck Bodies	−2.5
TPM	Textile Product Mills	−1.1
TTP	Freight Truck Transportation	−0.8
TVQ	TV Equipment	−2.6
WAP	Wearing Apparel	−2.4
WHL	Wholesale Trade	−0.7
WIR	Springs and Wires	−0.5
WTP	Water Transportation	−0.8

Note: RTI assigned an elasticity using the most similar industry from Ho and colleagues' industry aggregation.

Source: Ho, M. S, R. Morgenstern, and J. S. Shih. 2008. "Impact of Carbon Price Policies on US Industry." RFF Discussion Paper 08-37. Http://Www.Rff.Org/Publications/Pages/Publicationdetails.Aspx?. Publicationid=20680. Accessed August 2009. Table B.6.

the model can also be run in single-market partial equilibrium mode to support and provide insights for other types of environmental policies.

A.2.2.7 Model Time Horizon

The model is designed to address short-run and transitional effects associated with environmental policy. Production technologies are fixed; the model does not assess substitution among production inputs (labor, energy intermediates, and other intermediates) and assumes each investment cannot be changed during the time frame of the analysis. These issues are better addressed using other frameworks such as computable general equilibrium modeling. Similarly, government purchases from each sector do not adjust in response to changes in goods/service prices. Although, employment levels (number of jobs) adjust as production levels change, wages are assumed to be fixed.

APPENDIX B
COMPLIANCE COST ANALYSES FOR CISWI UNITS

MEMORANDUM

TO:	Charlene Spells, Toni Jones, Ketan Patel, U.S. Environmental Protection Agency
FROM:	Jason Huckaby, Amber Allen, Kristen James, Eastern Research Group, Inc.
DATE:	April 28, 2010
SUBJECT:	Compliance Cost Analyses for CISWI Units

BACKGROUND

The U.S. Environmental Protection Agency (EPA), under section 129 of the Clean Air Act (CAA), is required to regulate emissions of nine pollutants from Commercial and Industrial Solid Waste Incineration (CISWI) units: hydrogen chloride (HCl), carbon monoxide (CO), lead (Pb), cadmium (Cd), mercury (Hg), particulate matter (PM), dioxins/furans (CDD/CDF), nitrogen oxides (NO_x), and sulfur dioxide (SO_2).

On December 1, 2000, EPA adopted new source performance standards and emission guidelines for commercial and industrial solid waste incineration units established under Sections 111 and 129 of the Clean Air Act. In 2001 EPA was granted a petition for reconsideration regarding the definitions of "commercial and industrial waste" and "commercial and industrial solid waste incineration unit." In 2001, the United States Court of Appeals for the District of Columbia Circuit granted EPA's voluntary remand, without vacatur, of the 2000 rule. In 2005, EPA proposed and finalized the commercial and industrial solid waste incineration definition rule which revised the definition of "solid waste," "commercial and industrial waste," and "commercial and industrial waste incineration unit." In 2007, the United States Court of Appeals for the District of Columbia Circuit vacated and remanded the 2005 commercial and industrial solid waste incineration definition rule.

These proposed standards provide EPA's response to the voluntary remand that was granted in 2001 and the vacatur and remand of the commercial and industrial solid waste incineration definition rule in 2007. In addition, the standards re-development includes the 5-year technology review of the new source performance standards and emission guidelines required under Section 129. The EPA has developed a series of maximum achievable control technology (MACT) floor options to support that re-development. The development of the MACT floors used to determine these options is discussed in more detail in a separate memorandum.[1] The purpose of this memorandum is to present for existing sources the nationwide costs and nationwide cost effectiveness associated with these compliance options and with alternatives to compliance.
This memo is organized as follows:

I. Choosing Controls Needed for Each Unit to Meet MACT Floors
II. MACT Compliance Costs
  A. Emission Control Costs
  B. Stack Testing, Monitoring, and Recordkeeping Costs
    1. Stack Testing
    2. Monitoring Requirements
    3. Recordkeeping and Reporting
  C. Alternative Disposal Costs
III. Cost Effectiveness
IV. Beyond the Floor Options

I. CHOOSING CONTROLS NEEDED FOR EACH UNIT TO MEET MACT FLOORS

A significant portion of the total cost for industry compliance comes from the cost of installing new or improving existing pollution control devices for units not currently meeting the proposed limits. In order to determine the control costs, it was necessary to evaluate, for each CISWI unit, how much improvement for each pollutant would be needed to meet the proposed emissions limits.

The unit's average pollutant concentration value used to calculate baseline annual emissions[2] were compared with the proposed MACT floor emissions limits, and percentages were calculated to quantify the amount of improvement needed for the unit to meet the proposed MACT floors. Tables 1A – 1E contain the baseline pollutant concentration values used for each unit in each subcategory and the percentage improvement required to meet the proposed emissions limits for each unit for each pollutant. The existing CISWI units are subcategorized into five main groups: burn-off ovens, waste-burning kilns, energy recovery units, incinerators, and small, remote units. The pollutant- and subcategory-specific limits are shown in each header row of these tables.

Control methods and cost algorithms utilized in a recent rulemaking for another waste combustion source category, Hospital, Medical and Infectious Waste Incinerators (HMIWI) were updated and utilized generally for the CISWI source category, since most of these algorithms are applicable to waste combustion units found in the CISWI source category. There were some slight modifications for the energy recovery unit subcategory based on input from the boiler NESHAP development, since this subcategory contains units which, were they not firing wastes, would be considered boilers and process heaters. Based on these required improvements, pollutant-specific control methods were chosen as follows for units unable to meet the proposed MACT floors:

Metals (cadmium and lead) and PM: Adding fabric filters or improving existing fabric filters.

Mercury and dioxins/furans (CDD/CDF): Adding activated carbon injection (ACI) and adjusting the carbon addition rate to meet the amount of reduction required.

Hydrogen chloride (HCl): Adding wet scrubbers, or improving already installed wet scrubbers.

Carbon monoxide (CO): For burn-off ovens and incinerators, adding an afterburner retrofit; for waste-burning kilns, performing a tune-up. For energy recovery units, the control prescribed depends on the baseline CO concentration of the unit. For units in the 400 to 1,000 ppm range, adding advanced combustion controls (linkageless boiler management system) was prescribed. For units with CO concentrations over 1,000 ppm, a CO oxidation catalyst was assigned for control. No further improvement was needed for small, remote CISWI units.

Nitrogen oxides (NO_x): Adding selective non-catalytic reduction (SNCR) systems. For units requiring less than 10 percent improvement in NO_x control, minor adjustments were considered sufficient.

Sulfur dioxide (SO_2): Adding a wet scrubber for most units. For units with dry limestone injection or spray dryer absorbers that don't meet the proposed limit, adding lime was considered sufficient for improving SO_2 control. For units not meeting the proposed limit that already has a wet scrubber as a control, adding caustic was deemed necessary to improve SO_2 control.

Further descriptions of these controls and their associated costs are listed below in Section II.

II. MACT Compliance Costs

This section presents the nationwide costs estimated for existing CISWI for (A) the emission controls used to comply with the MACT floor; (B) the monitoring, testing, recordkeeping, and reporting activities used to demonstrate compliance; and (C) the alternatives to compliance. Total capital cost for all existing CISWI units to meet the MACT floor emission limits is estimated at approximately $701 million. Total annual cost for controls for all units in all subcategories is about $244 million, but is about $216 million for the lowest cost alternative. The existing CISWI units are subcategorized into five main groups: burn-off ovens, waste-burning kilns, energy recovery units, incinerators, and small, remote units. Tables 2A-2E present costs for emission controls, stack testing, monitoring, and reporting and recordkeeping for each unit within each subcategory, as well as costs for alternatives to compliance where applicable. Table 3 summarizes total compliance costs, as well as the lowest cost alternative (where alternative disposal methods are possible) for all units.

A. Emission Control Costs

Emission control technologies and other control measures that can be used to comply with the MACT floor options for existing CISWI units include wet scrubbers, fabric filters, selective non-catalytic reduction (SNCR), activated carbon injection (ACI), and various other control measures designed to obtain incremental emission reductions. This section presents the costs that were estimated for each of these control measures.

The retrofit factors for the capital costs were assumed to be 40 percent for wet scrubbers, fabric filters, and 20 percent for SNCR and ACI.[3, 4] Downtime costs for the retrofits were assumed to be negligible. Most CISWI are expected to be outdoors with adequate space to install an emission control system without shutting down the incinerator for an extended period. It was also expected that connecting the ductwork could be performed during a scheduled downtime for maintenance, thereby minimizing expected downtime.[5]

The capital and annual costs for the emission controls were estimated in units of dollars ($) and $/flow. The $/flow costs were calculated by dividing the capital/annual control cost estimate for each unit by the average gas flow rate assigned to that unit. Table 4A is a summary of the parameters used for each unit (e.g., incinerator charge rate, stack gas flow rate, incinerator operating hours, and concentrations). Additional information on the calculation of flue gas flow rates specifically for energy recovery units and waste-burning kilns can be found in Tables 4B and 4C.

Total capital cost for controls for all subcategories is estimated at approximately $683 million, and total annual cost for controls for all subcategories is about $234 million. Costs are on a 2008 basis, and annualized costs assumed an interest rate of 7 percent. Tables 5A-5H present a summary of the parameters and equations used in the cost algorithms for each emission control and alternative to compliance where applicable.

1. Adding a fabric filter.

Fabric filters can be installed either alone or with other add-on controls. The cost algorithm for installing a fabric filter for burn-off ovens, cement kilns, incinerators, and small remote units is presented in Table 5A and is based on algorithms in the *Model Plant Description and Control Cost Report* for HMIWI.[5] For energy recovery units, calculations were based on an algorithm originally utilized for HMIWI, but incorporating slight modifications to make them consistent with those being utilized by the boilers NEHSAP development. Calculations specific to fabric filter installations for energy recovery units are presented in Table 5B. The fabric filter capital costs range from approximately $722,000 to $31.3 million, and annual costs range from approximately $139,000/yr to $9.6 million/yr. Sources for specific cost data are noted below Table 5A.

2. Adding a wet scrubber.

Wet scrubbers can be installed alone or after a dry scrubber/fabric filter. The cost algorithm for installing a packed-bed wet scrubber is presented in Table 5B and is based on algorithms in the *Model Plant Description and Control Cost Report* for HMIWI. The packed-bed wet scrubber capital costs range from approximately $226,000 to $7.9 million, and annual costs range from approximately $61,000/yr to $5.7 million/yr. Sources for specific cost data are noted below Table 5B.

3. Adding a selective non-catalytic reduction (SNCR) system.

In an SNCR system, a nitrogen-based reducing agent, or reagent, such as ammonia or urea, is injected into the post-combustion flue gas through 3 nozzles mounted on the wall of the combustion unit. The cost algorithm for installing an SNCR system is presented in Table 5C and is based on algorithms in the *OAQPS Control Cost Manual*.[3] The SNCR capital costs range from approximately $48,000 to $3.9 million, and annual costs range from approximately $5,300/yr to $436,000/yr. Sources for specific cost data are noted below Table 5C.

4. Adding an activated carbon injection (ACI) system.

Injecting activated carbon before the fabric filter has been demonstrated to improve the removal efficiency of both Hg and CDD/CDF from CISWI. The cost algorithm for installing an ACI system is presented in Table 5D and is based on algorithms in the *Model Plant Description and Control Cost Report* for HMIWI.[5] Adjustments to the carbon injection rate were made to account for how much reduction was required to meet the proposed limit, and whether a packed-bed scrubber was either being added or would be improved, since those may also assist in reducing Hg emissions. The packed-bed scrubber adjustment is a ten percent Hg reduction, and is based on input from the boiler NESHAP development. The ACI factor compares the carbon grain loading originally assumed to achieve 90 percent control of mercury or 98 percent control of CDD/CDF to the amount of reduction the unit will need to meet the proposed emission limits. The highest factor (Hg or CDD/CDF) is then used to adjust the carbon injection rate calculation of the algorithm. ACI capital costs range from approximately $5,600 to $156,000, and annual costs range from approximately $2,900/yr to $3.2 million/yr. Sources for specific cost data are noted below Table 5D.

5. Adding afterburner/secondary chamber retrofit.

Afterburner, or secondary chamber, retrofits include retrofitting an incinerator or burn-off oven with a larger secondary chamber (with a longer gas residence time, e.g., 2 seconds) and operating it at a higher temperature (e.g., 1800°F). The cost algorithm for installing an afterburner retrofit with an incinerator is presented in Table 5E, and the cost algorithm for installing an afterburner retrofit with a burn-off oven is presented in Table 5F. Both are based on algorithms in the *Model Plant Description* *and Control Cost Report* for HMIWI.[5] Afterburner capital costs range from approximately $99,000 to $1.0 million, and annual costs range from approximately $20,000/yr to $485,000/yr. Sources for specific cost data are noted below Tables 5E and 5F.

6. Incremental Controls.

In some instances, it may not be necessary to install a new control system to achieve the emissions reductions necessary to comply with the control options. An incremental reduction in emissions may be achievable by improving existing controls, such as increasing the amount of caustic used in the wet scrubber, increasing the flow of lime prior to the fabric filter, increasing wet scrubber horsepower, improving fabric filter performance, or increasing the amount of NO_x reagent injected into the post-combustion flue gas. Table 5G presents the algorithms used to determine the annual cost of these incremental controls. There are no capital costs for incremental controls. Sources for specific cost data are noted below Table 5G.

a. *Improving the performance of an existing wet scrubber.*

One strategy to reduce PM emissions further is to increase the PM collection efficiency of the wet scrubber by increasing its pressure drop, which increases the energy demand (horsepower) of the scrubber system, specifically the fan and pump. Costs to increase scrubber horsepower were estimated based on fan and pump electricity equations for wet scrubbers in the *Model Plant Description and Control Cost Report* for HMIWI[5] and range from $126,000/yr to $2.2 million/yr.

b. *Improving the performance of an existing fabric filter.*

One strategy to reduce PM and metals emissions further is to improve the performance of the fabric filter by replacing the filter bags used to capture emitted particulate. Costs to improve fabric filter performance were estimated using the same equations for bag and cage replacement employed in costing fabric filters and range from $1,300/yr to $3.3 million/yr.

c. *Increasing lime.*

Emissions of acid gases such as HCl and SO2 may be reduced by increasing the feed rate of lime prior to the fabric filter. Estimated annual costs for increasing lime range from approximately $7,900/yr to $8,600/yr.

d. *Increasing caustic.*

One strategy to reduce acid gas emissions further is to increase the amount of caustic used in the wet scrubber to react with and neutralize the acid gases in the gas stream. The addition of caustic is assumed to sufficiently reduce emissions without requiring any changes to the wet scrubber. Costs to increase the amount of caustic were estimated using the same caustic equation employed in costing packed-bed wet scrubbers and range from approximately $390/yr to $1,650/yr.

7. Additional Control Options.

a. *Minor adjustments for NO_x control.*

Minor adjustments, such as air handling and distribution adjustments in the firebox, can be made to certain units to improve NO_x control. It was assumed these adjustments could be made at no additional cost.

b. *Adding advanced combustion controls.*

The costs to add a linkageless boiler management system (LBMS) are based on a 2008 quote provided to the U.S. Department of Energy. The installed cost for a LBMS on a 20 mmBtu/hr unit was $19,127. The DOE noted that costs are relatively fixed, regardless of the size of the unit. Therefore, this cost was used as a fixed capital cost estimate for CISWI units required to add advanced combustion controls.

c. *Adding a CO catalyst.*

Cost estimates for adding a CO oxidation catalyst were based on the *Air Pollution Control Cost Manual*.[7] Capital cost per unit ranges from $1.7 million to $1.9 million, and annual costs range from $794,000 to $924,000.

d. *Tune-up.*

Cost for performing a tune-up were based on a cost estimate provided in a report by Dr. H.M. Eckerlin and E.W. Soderberg[8]. This report indicated that the initial set-up for boiler tune-up was $3,000 to $7,000 per boiler, thereafter, annual tuning costs $1,000 per boiler. An average $5,000 per boiler initial set-up costs was annualized over 5 years at a 7 percent rate, and added to the subsequent year tune-up costs. Subsequently, an estimated flat cost of $1,580 annually was applied for units requiring tune-ups.

B. Stack Testing, Monitoring, and Recordkeeping Costs

1. <u>Monitoring Costs</u>

Initial and continuous compliance provisions for CISWI units were selected to be as consistent as possible with comparable regulations. For energy recovery units, requirements were developed to be consistent with proposed stack testing, monitoring, and recordkeeping requirements for major source boilers "biomass" units, since these units are likely to be similar in design and materials combusted, adapted to reflect the CAA section 129 pollutants. For waste-burning cement kilns, monitoring requirements were based on the Portland Cement proposed NESHAP requirements for cement kilns and adapted to reflect the CAA section 129 pollutants. For the other three subcategories, requirements were as consistent as possible with current CISWI and HMIWI provisions. This section presents the costs that were estimated for each of these requirements.

The total capital cost for stack testing, monitoring, and recordkeeping and reporting for all subcategories is estimated at approximately $18.0 million, and the total annual cost is about $10.4 million per year. Cost estimates were based on algorithms recently utilized in the HMIWI regulatory development. Costs were updated to a 2008 basis, and annualized costs assumed an interest rate of 7 percent. Tables 6A-6F present a summary of the parameters and equations used in the cost algorithms for each monitoring component, where applicable.

a. *Inspections.*

Consistent with HMIWI regulations, it was assumed that annual control device inspections will be required for any units having control devices in place or requiring further controls to meet the MACT floors. In this context, control devices include fabric filters, afterburners, wet scrubbers, ACI systems, or SNCR systems. The cost was estimated at a flat rate of $1000 per year. See Table 6A for further details and sources.

b. *Parameter monitors.*

Monitoring of operating parameters can be used to indicate whether air pollution control equipment and practices are functioning properly to minimize air pollution. Based on the existing CISWI regulations and HMIWI regulations, it was assumed that parameter monitoring will be mandatory for all units required to add fabric filters, wet scrubbers, SNCR systems, or ACI systems. Costs for each monitoring system were estimated as follows:

- For a fabric filter bag leak detection system, capital cost was estimated at $25,500 and annual cost at $9,700/yr.
- For a wet scrubber monitoring system, capital cost was estimated at $24,300 and annual cost at $5,600/yr.
- For an SNCR monitoring system, capital cost was estimated at $10,300 and annual cost at $3,200/yr.
- The cost for ACI monitoring depends on a unit's annual operational hours. There are no capital costs for ACI monitoring. Annual costs ranged from $200 to $20,200.

For default parameters and equations used for monitoring costs, see Table 6B. Sources for specific cost data are noted below the table.

c. *Continuous emissions monitoring systems (CEMS).*

The most direct means of monitoring compliance is the use of CEMS to measure the emissions of a pollutant on a continuous basis. The following text describes the CEMS options for each subcategory of existing CISWI units that will be included in the re-developed regulation. The costs for CO, PM, and Hg CEMS are presented in Table 6B.

- For energy recovery units, it was assumed no CO CEMS is currently in place for units that did not submit CO CEMS data in response to the Boiler/CISWI ICR. For any units where CEMS data for CO were not provided, costs for installing a CO CEMS were included in monitoring cost estimates. The capital cost was estimated at $134,000 and annual cost at $41,400/yr. PM CEMS would also be required for energy recovery units having capacities greater than 250 MMBtu. The capital cost for adding PM CEMS was estimated at $158,000 and annual cost at $56,100/yr.
- For waste-burning kilns, it was assumed all units will require Hg CEMS, but that they would likely have installed these already to comply with the requirements of the proposed Portland cement NESHAP. Capital cost was estimated at $231,000 and annual cost at $112,600/yr, but these were not applied to cement kilns.

2. <u>Testing Costs</u>

a. *Initial Stack Testing.*

It was assumed that initial stack testing will be required for each pollutant that the Phase 2 testing showed did not meet the proposed emission limit. Any unit having no test data for certain pollutants will also be required to perform an initial emissions test for those pollutants. Table 6C presents a summary of required initial stack testing for each unit. Costs for each required stack test were summed and multiplied by 2/3 to adjust for economies of scale when multiple pollutant tests were being performed on a unit. The annualized costs were calculated assuming a capital recovery factor of 0.10979 (15 years at 7 percent). The basis of these cost estimates for each stack test is summarized in Table 6D.

b. *Annual Stack Testing.*

It was assumed that all units, to some extent, will be required to demonstrate ongoing compliance with the emissions limits for certain pollutants. Based on existing CISWI regulations, it was assumed that all incinerators, burn-off ovens, and small, remote units will be required to conduct annual stack tests for PM, HCl, and opacity. The cost for this annual testing was estimated to be approximately $14,300/yr. Based on the Hg CEMs requirements and requirements for the Portland Cement NESHAP, it was assumed that waste-burning kilns will be required to conduct annual stack tests for NO_x, SO_2, PM, HCl, and opacity. Based on the proposed boiler NESHAP requirements, it was assumed that energy recovery units will be required to conduct annual stack tests for all section 129 pollutants except CO. The cost for this annual testing was estimated to be approximately $50,300/yr.

c. *Visible emissions testing.*

All CISWI units except for cement kilns will likely have ash handling operations. Therefore, these units would be required to demonstrate compliance to a 5 percent visible emissions limit for fugitive emissions generated during ash handling (similar to HMIWI). We are proposing that burn-off ovens, energy recovery units, incinerators, and small, remote units will be required to conduct annual performance tests for fugitive emissions from ash handling using EPA Method 22. Costs for this annual test include a capital cost of $250 and an annual cost of $200, based on the *Revised Compliance Costs and Economic Inputs for Existing HMIWI* memo.[6] Further details regarding this cost estimate are included in Table 6E.

3. Recordkeeping and Reporting Costs

For all units, a flat rate of $2,989 per year was estimated as the annual cost for recordkeeping and reporting. Further details regarding this cost estimate, including hourly labor assumptions, labor rates, and associated sources, are included in Table 6F.

C. Alternative Disposal Costs

Certain CISWI units may have waste disposal alternatives other than combustion available to them. These alternatives may prove to be less costly than the controls and monitoring required for compliance with the proposed CISWI standards. For example, facilities currently using burn-off ovens may be able to utilize sand blast chambers or some alternate technology to clean their parts. Likewise, other facilities may be able to simply divert their waste to a landfill or municipal waste combustor. To attempt to quantify the alternate waste disposal costs, for incinerators and small, remote units, the cost of alternative waste disposal methods such as landfilling or hauling waste to a MWC were also estimated.

For incinerators and small, remote units, unit capacity, annual operating hours, and a default tipping fee and hauling cost, were used to calculate annual costs for landfilling the waste that would otherwise be incinerated. Annual landfilling costs varied widely, reaching a maximum of about $165,000/yr. Table 7A summarizes the parameters and equations used to calculate these cost estimates.

An additional option for incinerators would be to haul the waste to an MWC. Unit capacity, annual operating hours, and a nationally averaged tipping fee were used to calculate annual costs, which ranged up to $2.5 million. Table 7B presents the basis for these cost estimates. In most cases, hauling waste to an MWC was found to be cheaper than complying with the proposed limits, but still more expensive than landfilling.

For burn-off ovens, sandblasting was considered as an alternative disposal method. As shown in Table 7C, an estimated operational cost of $53.75 over 2000 hrs per year for each burn-off oven was assumed, with an additional 10 percent assumed for contingency costs. The result was an estimated flat rate of $118,250 per year to utilize an abrasive blasting service.

To calculate the overall annual cost for each alternative disposal option, the costs associated with operating the incinerator and the annualized capital cost of the incinerator must also be accounted for. To address this, annual incinerator operational costs were subtracted from the annual alternative cost plus the annualized incinerator cost. The algorithms used for calculating the operational cost and annualized capital cost of the incinerator are shown in Table 7D. Intermittent operation was assumed for incinerators burning at least 1 ton per year of waste, and batch operation was assumed for burn-off ovens and incinerators burning less than 1 ton per year of waste. Unit-specific incinerator operational costs, annualized incinerator cost, and alternative disposal costs are listed in Tables 1A, 1D, and 1E.

III. COST EFFECTIVENESS

The cost effectiveness of the proposed MACT floors was calculated for each subcategory by dividing the total compliance cost (emission control, monitoring, testing, recordkeeping, and reporting) by the total emission reduction (HCl, CO, Pb, Cd, Hg, PM, CDD/CDF, NO_X, and SO_2) needed to meet the proposed emission limits. Note that the emission reductions were derived in a separate memorandum.[2] Tables 9A and 9B present the estimated cost effectiveness values for each subcategory, over all pollutants.

Table 9A shows the estimated costs and cost effectiveness for all units to meet the proposed MACT floor limits. The nationwide average cost effectiveness for all units to meet the MACT floors was estimated to be $191,000/ton for burn-off ovens, $6,000/ton for waste-burning kilns, $7,700/ton for energy recovery units, $47,000/ton for incinerators, and $1.8 million/ton for small, remote units. Over all subcategories, the average cost effectiveness was estimated to be $8,200/ton.

Table 9B shows the estimated costs and cost effectiveness for units to choose the most inexpensive option. As previously noted, Table 8 presents the most inexpensive option for each unit. The nationwide average cost effectiveness for all units to choose the lowest cost option between complying and using an alternative disposal method was estimated as follows: $57,700/ton for burn-off ovens, $6,000/ton for waste-burning kilns, $7,700/ton for energy recovery units, $2,500/ton for incinerators, and -$26,600/ton for small, remote units. The negative estimate for small, remote units reflects that our estimates indicate a net saving if these facilities cease combusting waste and divert the waste to a landfill. Over all subcategories, the average cost effectiveness was estimated to be $7,200/ton.

IV. BEYOND THE FLOOR OPTIONS

In developing this proposal, EPA considered for existing units the proposed CISWI NSPS emissions limits as a basis for the beyond-the-floor analysis for each subcategory. The CISWI NSPS limits are the MACT limits applicable to new CISWI units that are established through analysis of the best performing single source for each regulated pollutant. The development of NSPS limits for each subcategory are discussed in detail in a separate memorandum.[1]. For this proposal, potential intermediate beyond-the-floor options (i.e. emission limits between the existing source MACT floor and the emission limits consistent with the proposed NSPS) were not evaluated.

The beyond-the-floor analysis for each subcategory is based on an evaluation of the types of control approaches that would be necessary to achieve the NSPS level of control for the same subcategory. Specifically, for purposes of the analysis, different combinations of available emission control techniques, including additional add-on controls, that existing units would have to employ to meet the NSPS limits were considered in the analysis. Alternatively, facilities with units in the incinerators, small remote incinerators, or burn-off ovens subcategories could choose to stop using the units altogether and use alternative waste disposal options instead. To assess costs, the effect of the proposed MACT floors was considered as a baseline, and the additional controls needed to meet the beyond-the-floor emission limits were determined.

A. Consideration of Additional Emission Controls

The beyond-the-floor options were analyzed on a pollutant-by-pollutant basis. The controls considered, and the pollutants the control is effective for, are listed in Section I. However, some controls are not adequate for all units to meet the beyond-the-floor limits, which are discussed below.

All Subcategories:
For NO_x, SNCR was evaluated as the likely control technology that sources would apply to achieve the beyond-the-floor limits. The control option would be to add SNCR if there were none installed to meet the MACT floor, or to increase the reagent injection rate if the unit was already equipped with SNCR technology. We also considered whether selective catalytic reduction (SCR) could be utilized by sources to achieve the beyond-the-floor limits. SNCR is a proven technology for waste-combustion units, with typical effectiveness of 30 to 50%. These reductions are within the reach of the levels estimated to meet the MACT floor emission limits. However, to achieve lower reductions (i.e., greater than 50%) that the beyond-the-floor limits would require, SNCR may need to be applied in conjunction with combustion controls.[9] Feasibility of these combustion controls, such as low NO_x burners or combustion chamber modifications, are unit-specific and are likely not applicable to all existing units; therefore, compliance with the beyond-the-floor would likely require significant modification at considerable cost for some existing units. In contrast, new sources can be designed so that the combustion chamber and air flow characteristics reduce NO_x formation, which, in combination with SNCR controls, would be able to meet the new source NO_x limits. SCR is typically utilized in combustion units such as industrial boilers and process heaters, gas turbines, and reciprocating internal combustion engines.[10] We are not aware of any successful applications of SCR technology to waste-combustion units. This may be due to difficulties operating SCRs in operations where there is significant PM or sulfur loading in the gas stream. These two gas stream constituents can reduce catalyst activity, and lower the resulting effectiveness of the SCR, through catalyst poisoning and blinding/plugging of active sites by ammonia sulfur salts (formed from sulfur in the flue gas with the ammonia reagent) and particulate matter.[10] It was therefore determined that controls were not demonstrated adequately for existing CISWI units in any of the five subcategories to meet the beyond-the-floor NO_x emission limits.

Waste-burning Kilns:
Waste-burning kilns are not designed with secondary chamber or afterburners, so afterburner retrofits are not an applicable control for these units. For waste-burning kilns, a significant amount of CO emissions can result from the presence of organic compounds in the raw materials and not only from incomplete combustion, so good combustion controls and practices are not as effective. Oxidation catalysts have not been applied to waste-burning kilns and may not be as effective on waste-burning kilns as they are on other sources due to plugging problems. The only effective beyond-the-floor control we could identify for waste-burning kilns would be a regenerative thermal oxidizer (RTO). In the analysis for the proposed Portland Cement NESHAP, EPA notes that the additional costs and energy requirements associated with an RTO are significant, with an additional annualized cost of $3.8 million per year (see 74 FR 21153). Under the most cost effective scenario (existing unit emitting at 710 ppmv and a 98 percent CO reduction) the cost per ton of additional CO removal would be approximately $1,500. However, at the CO levels for most facilities the cost per ton could be much higher. In addition, RTO have significant additional energy requirements, and themselves create secondary emissions of CO, NO_x, SO_2, and PM due to their electrical demands (see 74 FR 21153). Given the cost and adverse environmental and energy

impacts, we could not identify any reasonable beyond-the-floor alternative to control CO emissions from waste-burning kilns.

We expect that waste-burning kilns would install scrubbers to meet the proposed MACT floor emission limits for HCl, and the proposed EG and NSPS limits for HCl are the same. The floor limits for waste-burning kilns are already at the quantification limits of the test method, and we are not aware of alternative methods to quantify additional reductions in HCl emissions. In addition, we are not aware of any control technologies available that would reduce HCl emission from existing cement kilns to levels below the floor levels. Therefore, we could not evaluate a beyond-the-floor option for HCl emissions from cement kilns.

The scrubbers needed to meet the CISWI MACT floor limits for HCl would also meet the CISWI MACT floor levels for SO_2. However, it is uncertain whether it is feasible for existing waste-burning kilns to utilize additional caustic in their scrubbers, or in their existing flue gas desulfurization devices, to be able to consistently meet the 3.6 ppm beyond-the-floor emission limit for SO_2. There are limits to the amounts of additional caustic or lime that are technically feasible, and the SO_2 content of the flue gas will vary depending on the fuel and the sulfur content of process raw materials that are charged to the waste-burning kiln. The only option for achieving additional SO_2 control is to add an additional SO_2 scrubbing device in series with the scrubber required to comply with the MACT floor limit. While we did not quantify the costs, we concluded that this level of control would pose unreasonable costs that would result in units ceasing to combust wastes in cement kilns. It was therefore determined that additional controls were not demonstrated to continuously meet the beyond-the-floor SO_2 emission limits at existing waste-burning kilns.

For PM, it is estimated that units would install fabric filter controls or improve existing fabric filters to meet the proposed CISWI MACT floor limits for PM and metals. To meet the metals floor limits, highly efficient fabric filters, and possibly membrane bags, would be needed. These controls are the best technology available to control PM, and we have not identified any additional controls that are available that would enable existing waste-burning kilns to continuously meet the beyond-the-floor PM emission limit (which is considerably lower than the MACT floor limit).

Energy Recovery Units:
Like waste-burning kilns, energy recovery units are not suitably designed for afterburner retrofits to control CO. The beyond-the-floor CO emission limit is 3 ppm. In comparison, the proposed MACT floor emission limit is 150 ppm. Therefore, the beyond-the-floor emission limit is approximately 98 percent less than the MACT floor emission limit. We are unaware of any technology that is able to continuously meet this limit for all existing energy recovery units. Variances in fuel composition and condition will have an effect on CO emissions in addition to the controls in place, so this limit may be achievable for the best source based on their particular unit design and fuel inputs, but not demonstrated to be achievable for any other existing units without unreasonable costs associated with modification of the units. As a comparison, the proposed boiler NESHAP limit varies by combustor design, but for biomass boilers, which burn fuels and have combustor designs that are similar to some CISWI energy recovery units, the limits are in the order of 200 to 700 ppm.

For PM, we estimate that existing units would install fabric filter controls or improve existing fabric filters to meet the proposed CISWI MACT floor limits for PM and metals. As with waste-burning kilns, the fabric filters would need to be highly efficient to meet the metals floor limits, and would likely need membrane filter bags. As stated above, membrane filters are the best technology available to control PM and metals. As such, the fabric filters we believe will be necessary to control the metals will likely achieve a level of performance that is better than the MACT floor limit for PM, resulting in additional PM reductions beyond the existing source floor level of control. For this reason, we believe that the PM emissions reductions associated with going beyond-the-floor to the new source limits is less than the 200 tons per year estimated based on the evaluation of the difference in PM emissions under the proposed existing source floor and the proposed new source floor. Furthermore, to achieve PM and metals emissions reductions greater than those required to meet the MACT floor emission limits, existing sources would likely need to install an additional particulate control device, such as a cartridge filtration system, which would require additional capital and operating expense, as well as require additional energy to power the fans for adequate draft. While we did not quantify these costs of an additional particulate control system in the table below, we believe that these additional controls would pose unreasonable costs.

B. Beyond-the-Floor Costs

The methodology for estimating the incremental cost of meeting the proposed beyond-the-floor limits is essentially the same as that described for the MACT floor limits. It was assumed that the best options for each unit shown in Table 8 would serve as the baseline for determining additional controls and costs required. Subcategory-specific considerations are listed below, and the following table presents the incremental costs, reductions, and cost effectiveness for units to comply with beyond-the-floor emission limits.

Burn-Off Ovens: Because a beyond-the-floor NO_x limit is not proposed, the cost of SNCR and SNCR monitoring were not incorporated into the beyond-the-floor costs for these units. However, meeting the other pollutant beyond-the-floor limits was still more expensive than the alternative of abrasive blasting. Hence, it was assumed that the units would shut down in this case, and incremental beyond-the-floor costs would be the total cost of sandblasting minus the lowest cost MACT floor costs, or about $612,000 for the whole subcategory. Unit-specific beyond-the-floor costs are listed in Table 10A.

Cement Kilns: Additional costs for cement kilns consisted of annual costs to add carbon for dioxin/furans control. As previously noted, there are technical reasons for not considering other controls for this subcategory. Unit-specific beyond-the-floor costs are listed in Table 10B.

Energy Recovery Units: As discussed above, the additional costs to meet beyond-the-floor limits for Cd, Pb and PM reflect additional fabric filter installations or improvements to existing fabric filter systems as well as additional bag leak detection system costs. Installation and operation of a secondary particulate control system are not reflected in the cost estimate. Additional ACI and ACI monitoring costs were calculated for meeting beyond-the-floor Hg and dioxin/furan limits. Lastly, for beyond-the-floor HCl and SO2 limits, additional costs reflect the additional installation or improvement of scrubbers or adding lime or caustic. Unit-specific beyond-the-floor costs are listed in Table 10C.

Incinerators: The best option for these units with respect to the MACT floor baseline was to shut down and use alternative disposal rather than comply with the proposed limits. Therefore, there is no additional beyond-the-floor cost for this subcategory.

Small, Remote Units: As with burn-off ovens, it was found to be less expensive for small, remote units to shut down and use an alternative disposal method rather than add additional controls to meet beyond-the-floor emission limits. In fact, all but two units were already assumed to be shutdown instead of complying with MACT floor limits. Incremental beyond-the-floor costs for the subcategory would be the total cost of landfilling minus the lowest cost MACT floor costs for these two units, or about $79,000. Unit-specific beyond-the-floor costs are listed in Table 10D.

Incremental Costs and Emission Reductions Expected for Existing Units to Comply with Beyond-the-Floor Emission Limits (Relative to the MACT Floor)

Pollutants	Subcategory	Additional Annual Costs ($/yr)	Additional Emissions Reductions (ton/year)	Incremental cost effectiveness (additional costs/additional emissions reductions, $/ton)
PM, Cd, Pb	Energy recovery unit	2,082,013	202	10,307
Hg, CDD/CDF	Energy recovery unit	18,562,287	0.03	618,742,900
	Waste-burning kiln	126,944,291	0.00002	>1 Billion
HCl, SO_2	Energy recovery unit	21,564,881	77	280,063

Total beyond-the-floor costs and alternative disposal costs for each unit are present in Table 11, and Table 12 presents the estimated incremental cost effectiveness values for each subcategory, over all pollutants.

V. ALTERNATIVE APPROACH

EPA's solid waste definition rule proposes to define which non-hazardous secondary materials that are used as fuels or ingredients in combustion units are solid wastes under Subtitle D of RCRA. In addition to the primary proposed approach set forth in the Solid Waste Definition rule, the rule solicits comments on an alternative approach for determining which secondary materials are solid waste under Subtitle D of RCRA, when combusted. To this point, this document has focused on the universe of CISWI consistent with the definition of non-hazardous waste proposed in EPA's concurrent notice under RCRA, or the "proposed approach." Total capital cost for all existing CISWI units to meet the MACT floor emission limits is estimated at approximately $1.9 billion. Total annual cost for controls for all units in all subcategories is about $508 million, but is about $480 million for the lowest cost alternative. Costs associated with the CISWI inventory that would result from RCRA's "alternative approach," however, are calculated using the same methodology described herein, and relevant summary tables for "alternative approach" costs are provided in Appendix C.

The beyond-the-floor options were analyzed on a pollutant-by-pollutant basis. As in the "proposed approach," EPA considered the NSPS limits calculated under the alternative approach as a basis for the beyond-the-floor approach for existing units in each subcategory. However, the technical feasibility issues which precluded the use of beyond-the-floor limits that applied to the proposed approach discussed above also apply in the alternative approach. In particular, see section IV of this memorandum for a discussion of why beyond-the-floor options (e.g., NO_x, CO for waste-burning kilns, etc.) are not feasible for.

In addition to the technical and costs feasibility considerations discussed for the proposed approach, for the alternative approach beyond-the-floor option, there are concerns about the feasibility of the beyond-the-floor emission limits for HCl and SO_2 for the energy recovery unit subcategory.

HCl. The NSPS limit for HCl is 0.036 ppmvd. We do not have information that suggests that all existing energy recovery units would be able to continuously achieve this limit. Assuming units would have to install or improve existing wet scrubbers in some cases to achieve the MACT floor emission limit, we do not believe that these same devices could be further improved to achieve an additional 99.9% reduction above that to reach the beyond-the-floor emission limit. The baseline average HCl concentration is 10 ppmvd, so achieving the beyond-the-floor limit would necessitate a 99.6% reduction in HCl emissions, or possibly more, depending on the chlorine content of the materials being combusted. We do not have the data that suggests this is consistently attainable for all existing energy recovery units.

SO_2. The NSPS limit for SO_2 is 0.04 ppmvd. We do not have information that suggests that all existing energy recovery units would be able to continuously achieve this limit. The average baseline SO_2 concentration is about 75 ppmvd, so an emissions reduction of over 99.9% would be necessary for some units to achieve this emission limit. The scrubbers needed to meet the CISWI MACT floor limits for HCl would also meet the CISWI MACT floor levels for SO_2. However, we are not certain that it is feasible for existing units to utilize additional caustic in their scrubbers, or in their existing flue gas desulfurization devices, to be able to consistently meet the 0.04 ppmvd beyond-the-floor emission limit for SO_2. There are limits to the amounts of additional caustic or lime that are technically feasible and the SO_2 content of the flue gas will vary depending on the fuel and wastes that are combusted in the unit. The only option for achieving additional SO_2 control is to add an additional SO_2 scrubbing device in series with the scrubber required to comply with the MACT floor limit. While we did not quantify the costs, we concluded that this level of control would pose unreasonable costs that would result in units ceasing to combust wastes in energy recovery units. Therefore, we determined that additional controls were not demonstrated to continuously meet the beyond-the-floor SO_2 emission limits at existing energy recovery units.

For the remaining pollutants where there may not be technical feasibility concerns, we developed incremental cost estimates and reductions. The methodologies are the same as was used in the proposed approach beyond-the-floor analysis, and are presented below.

Incremental Costs and Emission Reductions Expected for Existing Units to Comply with Beyond-the-Floor Emission Limits (Relative to the MACT Floor) for the Alternative Approach

Pollutants	Subcategory	Additional Annual Costs ($/yr)	Additional Emissions Reductions (ton/year)	Incremental cost effectiveness (additional costs/additional emissions reductions, $/ton)
PM, Cd, Pb	Energy recovery unit	$186,904,890	12,996	$14,382
Hg, CDD/CDF	Energy recovery unit	$398,773,806	0.97	$411 Million
	Cement kiln	$142,008,091	0.34	$418 Million

VI. NEW UNITS

Based on the results of our analysis for existing units and our experiences with other CAA Section 129 regulations, we do not anticipate that any new CISWI units will be constructed. As discussed earlier, many existing CISWI owners and operators may find that alternate disposal options are preferable to compliance with the proposed standards. Our experience with regulations for municipal waste combustors, HMIWI and, in fact, CISWI has shown that negative growth in the source category historically occurs upon implementation of CAA Section 129 standards. Since CISWI rules were promulgated in 2000 and have been in effect for existing sources since 2005, many existing units have closed. At promulgation in 2000, EPA estimated 122 units in the CISWI population. In comparison, the incinerator subcategory in this proposal, which would contain any such units subject to the 2000 CISWI rule, has 28 units. EPA is not aware of any construction of new units since 2000, and therefore does not believe there are any units that are currently subject to the 2000 CISWI NSPS. The revised CISWI rule is more stringent, so this trend is expected to continue. The same is expected to be true for the subcategories of units that would be newly affected by the proposed revised CISWI rules. Industrial or commercial operations considering waste disposal options for their facilities will likely choose not to construct new CISWI units and to use alternative waste disposal methods or alternative fuels that will not subject them to the CISWI rule. For example, tire-derived fuel from which the metal has been removed is not considered solid waste under the proposed definition of solid waste. Consequently, new cement kiln owners will assess their regulatory requirements under CISWI for burning whole tires or tire-derived fuel that does not have metals removed against the costs associated with removing the metal and complying with the applicable NESHAP instead of the CISWI rule. Our research suggests that metal removal is routinely practiced and would most likely be a viable option for new kiln owners so that they would not be subject to the CISWI regulations. Likewise, new sources could engineer their process to minimize waste generation in the first place, or to separate wastes so that the materials sent to a combustion unit would not meet the definition of solid waste to begin with. For waste that is generated, cost analyses have found that alternative waste disposal is generally available and less expensive.

VII. REFERENCES

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APPENDIX A. TABLES FOR "PROPOSED APPROACH" MACT FLOOR COST ANALYSES

The tables referenced throughout the body of this memo are presented in this section. They are organized as follows:

APPENDIX B. TABLES FOR "PROPOSED APPROACH" BEYOND-THE-FLOOR COST ANALYSES

10. Costs to Beyond-the-Floor Emission Limits

    10A: Burn-off Ovens
    10B: Cement Kilns
    10C: Energy Recovery Units
    10D: Small, Remote Units

11. Best Beyond-the-Floor Compliance Options by Unit
12. Incremental Cost Effectiveness of Beyond-the-Floor Emission Limits: Overall and By Subcontractory

APPENDIX C. TABLES FOR "ALTERNATIVE APPROACH" MACT FLOOR COST ANALYSES

13. Alternative Approach Costs to Meet MACT Floor

    13A: Burn-off Ovens
    13B: Cement Kilns
    13C: Energy Recovery Units
    13D: Incinerators
    13E: Small, Remote Units

14. Alternative Approach Best Compliance Options by Unit
15. Alternative Approach Cost Effectiveness of MACT Floors: Overall and by Subcategory

APPENDIX D. TABLES FOR "ALTERNATIVE APPROACH" BEYOND-THE-FLOOR COST ANALYSES

16. Costs to Beyond-the-Floor Emission Limits

    16A: Cement Kilns
    !6B: Energy Recovery Units

17. Alternative Approach Best Beyond-the-Floor Compliance Options by Unit
18. Alternative Approach Cost Effectiveness of Beyond-the-Floor Emission Limits: Overall and by Subcategory