# Regulatory Impact Analysis: Final Brick and Structural Clay Products NESHAP

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**CONTENTS**

**Section** **Page**

Appendix

## LIST OF FIGURES

## LIST OF TABLES

**Number** **Page**

# EXECUTIVE SUMMARY

## ES.1 Background

The U.S. Environment Protection Agency (EPA) is requiring that all major sources in Brick and Structural Clay Products Manufacturing category meet health-based standards for acid gas hazardous air pollutants; maximum achievable control technology standards for mercury and non-mercury metal hazardous air pollutants (or particulate matter surrogate); and work practice standards, where applicable. The final rules would protect air quality and promote public health by reducing emissions of the hazardous air pollutants listed in section 112 of the Clean Air Act. As part of the regulatory process, EPA is required to perform economic analysis and the Regulatory Impact Analysis (RIA) discusses the benefits and costs of the final rule.

## ES.2 Results

For the final rule, the key results of the RIA follow:

- **Engineering Cost Analysis**: EPA estimates the total annualized costs (2011$) for the final rule will be approximately $28 million.
- **Benefits Analysis:** The EPA monetized human health benefits of reducing cases of morbidity and premature mortality among populations exposed to $PM_{2.5}$. In addition, EPA estimated the energy disbenefits associated with emissions from the control devices' increased electricity usage. Using a 3% discount rate, we estimate the total monetized benefits of the final standards to be $83 million to $190 million. Using a 7% discount rate, we estimate the total monetized benefits to be $75 million to $170 million. Data, resource, and methodological limitations prevented EPA from monetizing the benefits from several important benefit categories, including benefits from reducing exposure to 375 tons of HAPs each year for the final standards and exposure, as well as ecosystem effects and visibility impairment. In addition to reducing emissions of PM precursors such as $SO_2$, this rule would reduce several non-mercury HAP metals emissions (i.e., antimony, arsenic, beryllium, cadmium, chromium, cobalt, lead, manganese, mercury, nickel, and selenium) each year.
- **Market Analysis and Closure Estimates**: Market-level impacts include the price and production adjustments for bricks. The average national price under the final standards increases by 1.8%, or $4.37 per 1,000 SBE, while overall domestic production falls by 1.5%, or 52 million bricks per year. Under the final standards, EPA estimated that two to four brick manufacturing facilities are at significant risk of closure.
- **Social Cost Analysis**: Under the final standards, the economic model suggests that industries are able to pass on $15.1 million (2011$) of the rule's costs to U.S. households in the form of higher prices. Existing U.S. industries' surplus falls by $12.1 million, and the total U.S. economic surplus loss is $27.2 million.

- **Comparison of Benefits and Costs**: The estimated monetized human health benefits outweigh the social costs. For the final standards, the net benefits are $56 million to $160 million at a 3% discount rate for the benefits and $48 million to $150 million at a 7% discount rate.

- **Final Regulatory Flexibility Analysis**: As required by section 604 of the Regulatory Flexibility Act (RFA), the EPA prepared a final regulatory flexibility analysis (FRFA) for this action. The FRFA addresses the issues raised by public comments on the IRFA for the proposed rule. The complete FRFA is included in Section 5 of this report.

## ES.3 Organization of this Report

The remainder of this report details the methodology and the results of the RIA. Section 1 provides an introduction, and Section 2 presents the industry profile. Section 3 describes engineering cost analysis, and Section 4 presents the benefits analysis. Section 5 presents market, employment impact, social cost, and small business impact analyses. Section 6 addresses statutory and Executive Order requirements, and Section 7 provides a summary of benefits and costs.

# SECTION 1
# INTRODUCTION

## 1.1 Background for the Final Rule

The Environmental Protection Agency (EPA) is finalizing national emission standards for hazardous air pollutants (NESHAP) for Brick and Structural Clay Products Manufacturing. All major sources in these categories must meet maximum achievable control technology (MACT) standards for mercury (Hg) and nonmercury (non-Hg) metal hazardous air pollutants (HAPs) (or particulate matter [PM] surrogates); health-based standards for acid gas HAPs; and work practice standards, where applicable. The final rule, which has been informed by input from industry and other stakeholders including small businesses, protects air quality and promotes public health by reducing emissions of HAPs listed in section 112 of the Clean Air Act (CAA). This Regulatory Impact Analysis (RIA) examines the estimated costs, benefits, and economic impacts of the final rule.

## 1.2 Statement of Need for Policy Action

### *1.2.1 Need for Regulatory Intervention Because of Market Failure*

In general, regulatory intervention is required only when markets fail to allocate resources efficiently. For markets to allocate resources efficiently, both buyers and sellers must have access to full information about the transaction; there must be many buyers and sellers so that neither buyers nor sellers have power to control prices; and the market must impose all the social costs of the transaction on the buyers and sellers in the market. In some situations, however, these conditions do not occur, and markets fail to allocate resources efficiently. One such market failure occurs in cases where a production or consumption activity imposes an external cost on members of society who are neither buyers nor sellers in the market for the good or service produced. In cases of external costs, or "externalities," some costs are imposed on members of society who are not part of the market. Because the market is not affected by these costs, it fails to account for these costs and thus does not allocate resources efficiently, and government must intervene to make the outcome more efficient. Environmental pollution that results from a production process is an example of an external cost borne by members of society who are neither producers nor consumers of the good whose production is generating the pollution.

In the case of bricks and structural clay products, manufacturing processes result in air emissions that impose external costs on individuals located near BSCP facilities who are exposed to the HAP emitted by the processes. Because these costs are borne by exposed individuals rather than by the BSCP manufacturers, they are not considered by manufacturers in their production decisions. As a result, BSCP manufacturers produce more, and emit more pollutants, than they would if they bore the costs of the air pollution they generate. Because the market does not provide a signal that properly limits the quantity of air pollutants emitted by BSCP manufacturers, a market failure exists that requires EPA to promulgate air pollution standards to limit their emissions.

## 1.3 Organization of the Report

The remainder of this economic analysis is organized as follows:

- Section 2 presents a profile of the bricks and structural clay products industry.
- Section 3 describes the final rule and the estimated costs of complying with it.
- Section 4 presents a qualitative discussion of the benefits of the final rule.
- Section 5 describes the estimated economic impacts of the final rule.
- Section 6 describes analyses EPA conducted to assess requirements of statutes and Executive Orders.
- Section 7 presents EPA's summary of benefits and costs.

# SECTION 2
# PROFILE OF THE AFFECTED INDUSTRY

Residential and commercial construction activities rely on bricks and structural clay materials. Most bricks are used as primary and secondary exterior wall materials, while other structural clay products are used in plumbing systems and roofing applications. Because over 80% of brick sales are associated with residential construction (Brick Industry Association, 2013a), trends in the industry are influenced by trends in residential construction markets.

## 2.1 Overview of Current Conditions

To provide a general overview of current conditions in the affected industry, we used the U.S. government's official measures reported in the Annual Survey of Manufactures (ASM), County Business Patterns, and Current Industrial Reports. Because the latest year of data (2011) differs from historical industry trends, it is unclear whether the industry without the final rule would be similar to the industry today. As a result, the profile provides information on a range of factors that may influence how the brick-related markets may evolve.

Federal statistical agencies classify business establishments in this industry using two North American Industry Classification System (NAICS) codes:[1]

- 327121 Brick and Structural Clay Tile Manufacturing
- 327123 Other Structural Clay Product Manufacturing

In 2011, the value of products shipped in the two industries was approximately $1.1 billion. Nearly all of the value was centered in NAICS 327121. The ASM reported that 218 establishments (174 in NAICS 327121 and 44 in NAICS 327123) employed 8,000 people with a total annual payroll of about $300 million (U.S. Census Bureau, 2013a,b).

During 2011, approximately 3 to 4 billion Standard Brick Equivalents (S.B.E.)[2] were produced by the industry (U.S. Census Bureau, 2011). Federal Reserve data and industry surveys suggest the capacity utilization rate for the brick industry is below 50% (Board of Governors of the Federal Reserve System, 2013; Brick Industry Association, 2013b) (see Figure 2-1). The current observed conditions are influenced by the recent steep declines in the residential

[1]In 2012, these industries were classified under NAICS 32710 Clay Building Material and Refractories Manufacturing. See http://www.census.gov/cgi-bin/sssd/naics/naicsrch?code=327120&search=2012.
[2]This is a common unit that accounts for various sizes of brick products. It measures 3-5/8″ x 2-1/4″” x 7-5/8″.

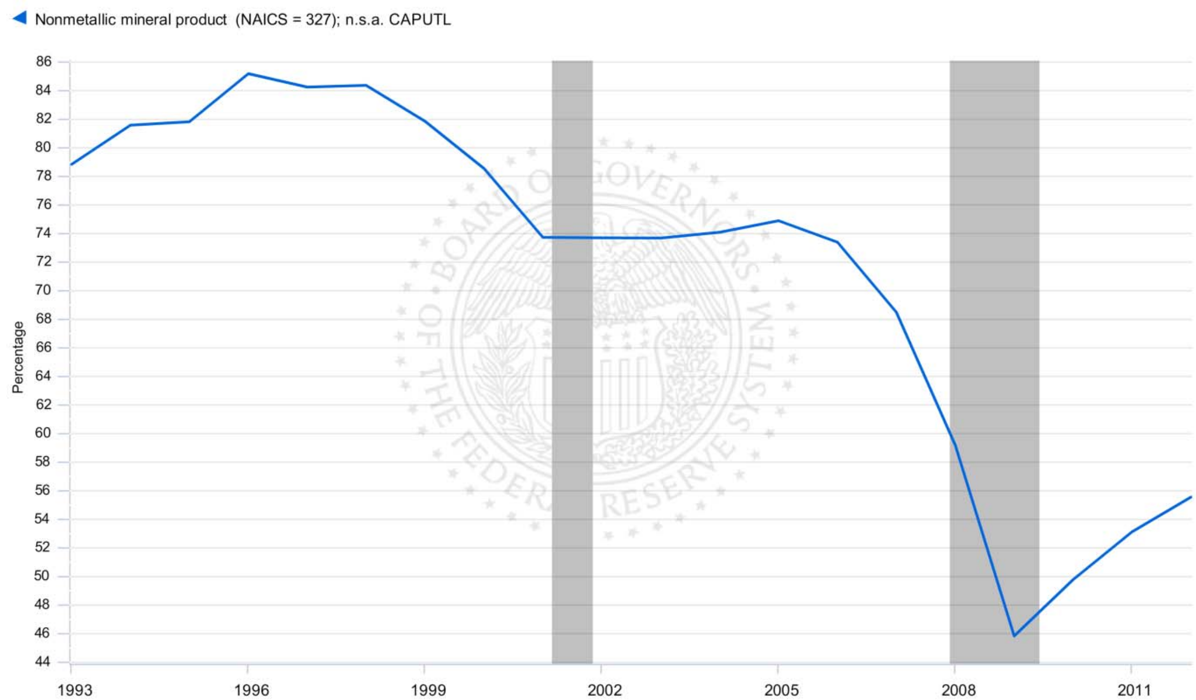


**Figure 2-1. Capacity Utilization for Nonmetallic Mineral Products (NAICS 327)**

Source: Federal Reserve Board, 2013

construction market. For example, 2011 new privately owned housing starts (608,800) units are well below levels observed in 2000 (1.6 million) and 1990 (1.2 million) (U.S. Census Bureau, 2013c). Since 2010, new residential housing starts have begun to grow again, but levels are still much lower than the previous two decades. New privately owned housing starts in July 2013 were at a seasonally adjusted annual rate of 852,000 (U.S. Census Bureau, 2013d).

## 2.2 Supply

To better understand the markets for affected products, we considered the group of sellers that provide goods to the market and common factors that influence supply (e.g., input prices) and quantity of goods supplied (e.g., output prices).

### *2.2.1 What Types of Products Does the Industry Provide?*

The U.S. Current Industrial Report provides descriptions of the types of clay construction goods supplied to U.S. and international markets. They include

- brick (building or common and face);
- structural facing tile and ceramic glazed brick, including glazed and unglazed;
- vitrified clay sewer pipe and fittings; and

- structural clay tile (except facing).

Bricks are the primary good produced in terms of value and physical quantities and include face brick, paving brick, building brick, and thin brick. Face brick accounts for over 90% of brick shipments.

#### *2.2.2 What Factors Influence Market Supply?*

The manufacturing process for brick and structural clay goods includes raw material processing (mining, grinding, screening, and blending) followed by forming, cutting, or shaping; drying; firing; cooling; and storage (U.S. EPA, 1997). Census data for NAICS 327121 Brick and Structural Clay Tile Manufacturing suggest that 70% of the product's value is associated with value-added activities (i.e., labor and capital earnings). During the last 5 years, labor costs have remained flat in the nonmetallic mineral products sector. The U.S. Bureau of Labor Statistics reports that average annual hourly earnings (adjusted for inflation) of all employees was about $20 per hour (U.S. Bureau of Labor Statistics, 2013a,b).

The value of intermediate goods used in these processes (i.e., raw materials like clay and shale) make up the remaining 30% of the industry's total product value (U.S. Census Bureau, 2013a). Intermediate production costs can be influenced by changes in raw clay material prices, but the prices of these materials have not fluctuated recently. Since 2008, common clay prices (primarily used in brick) have remained steady at $12 per ton. The U.S. Geological Survey (USGS) notes that brick companies often consider sources of raw materials when considering purchasing other companies. For example, the Belden Brick Co. purchase of Lawrenceville Brick Inc. included Lawrenceville Brick's clay reserves (USGS, 2011).

#### *2.2.3 What Factors Influence the Relationship Between Output Prices and the Quantity Supplied?*

All other things equal, brick manufacturers will likely offer to sell more bricks when the price of bricks rises. The price elasticity of supply measures how much the quantity of bricks supplied responds to changes in the brick price.[3] If manufacturers have a significant amount of flexibility to change the amount of bricks they produce when the price rises, the supply of bricks is elastic. In contrast, if the quantity of brick produced and supplied only changes by small amounts when the price rises, the supply of bricks is inelastic.

A key determinant of the price elasticity of supply is the length of the time period over which the product choices can be made. During shorter periods, it is more difficult for the firm to

[3]The measure is computed as the percentage change in quantity supplied divided by the percentage change in price.

adjust inputs and increase production. Put another way, the firm typically has some fixed factors of production that limit its ability to respond to price changes. Rutherford (2002) developed an equation that can be used to derive a benchmark price elasticity of supply that considers the fixed factor value as a share of total product value. In our example, consider the case of two production inputs, one input that is fixed during a short time period[4] and the other input that varies with production.

$$\text{Supply Elasticity} = \text{elasticity of substitution} \times \frac{1 - \text{fixed factor value share}}{\text{fixed factor value share}}.$$

To illustrate the approach, consider the value share of the fixed factor to be 50% to approximately match the non-labor value added reported in the U.S. Census data above. In cases where we lack data to estimate the elasticity of substitution, it is common to assume the elasticity is 1 (a Cobb-Douglas production function). This means that a 1% change in the ratio of factor prices would result in a 1% change in the ratio of factor shares. If we assume the elasticity of substitution between the fixed and variable input is one, the formula is

$$\text{Supply Elasticity} = 1 \times \frac{1 - 0.5}{0.5} = 1.$$

Using these values for the fixed factor's value share and elasticity of substitution, the supply elasticity is approximately one. This means if the price of brick rose by 1%, brick manufacturers would plan to sell 1% more bricks to the market. Given the current low capacity utilization rates and excess capacity available in the industry, this value may underestimate how responsive the brick industry would be to changes in the market price. As a result, the actual supply elasticity value may be elastic with a value higher than one.

## 2.3 Demand

Brick and structural clay products (BSCP) are primarily used in residential and commercial construction applications and are influenced by overall macroeconomic trends and conditions in the residential housing industry. Facing bricks are used in overall building structures (e.g., exterior walls), while clay pipe; structural clay tile; and drain, sewer, and roof tiles are used in elements of the building structure such as plumbing systems, fireplaces, and roofs. Because the vast majority of affected products are brick products and available data for other structural clay products are more limited, we focus on brick demand characteristics.

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[4]The fixed factor generally includes plant and capital equipment; factors that vary with production could include materials or labor.

### *2.3.1 Who Uses Brick?*

According to the Brick Industry Association, the vast majority of affected brick products are sold for residential end uses and nonresidential building uses (Brick Industry Association, 2013b). The pattern of shipments varies by brick type: approximately half of the industry shipments go to dealers or distributors who sell the products to final consumers and the other half is sold directly to end users like construction companies (Brick Industry Association, 2013b). Over half of the shipments flow to two census regions (South Atlantic and West South Central), and Texas is the largest consumer of face brick and paver shipments (Brick Industry Association, 2013b).

### *2.3.2 What Factors Influence the Market Demand?*

BSCP have a variety of characteristics desirable in building materials. According to the Brick Industry Association, brick's desirable attributes include its durability, flexibility, resistance to fire, weather, and pests; and little required maintenance. (Brick Industry Association, 2013a) A recent National Association of Homebuilders (NAHB) survey of buyers of new homes found that "To get brick, respondents reported they would add $7,500 in additional costs" (NAHB, 2013).

#### *2.3.2.1 Price of Related Goods*

In exterior wall applications, vinyl siding, stone, stucco, wood, and fiber cement are substitute building materials. Historically, brick has maintained a 25% market share in the exterior wall application market (Brick Industry Association, 2013b). A recent NAHB survey found that "On a national level, respondents ranked brick highest at 34 percent, vinyl siding at 21 percent, stone at 16 percent, stucco at 12 percent, wood at 7 percent and fiber cement at 5 percent" (NAHB, 2013).

#### *2.3.2.2 Income*

Homeowners purchasing more expensive homes are more likely to choose brick exteriors. A recent NAHB survey found that "Ranked by price point [sale price of the home], brick topped other home exteriors in the $150,000–$499,000 range, while vinyl was preferred in the $150,000 or less range; brick ranked second to stone in the $500,000+ range with stucco following in third place" (NAHB, 2013). This suggests demand for brick exterior is likely influenced by income levels.

### *2.3.3 What Factors Influence the Relationship Between Prices and the Quantity Demanded?*

All other things equal, consumers will likely buy fewer BSCP when the price of the product rises. The price elasticity of demand measures the size of the price response.[5] Several factors influence how sensitive consumers are to price changes. If consumers can easily switch from one product to another because there are many close substitutes, demand tends to be more elastic. This is particularly true for more narrow market definitions (king versus modular brick) and over longer time horizons for the consumption decision (months versus years).

Currently, EPA has not identified statistically estimated price elasticities of demand for BSCP. However, economy-wide simulation models have suggested the nonmetallic mineral industry demand elasticity is approximately −0.8, a 1% change in price results in a 0.8% decline in the quantity demanded (Ho, Morgenstern, and Shih, 2008). Because the market definition for the product is broad, the price response for BSCP is likely more elastic than this value.

## 2.4 Firm Behavior and Organization of Industry

### *2.4.1 Market Definition*

Market definition boundaries are commonly defined in two dimensions: product substitution and geography. Based on product substitution characteristics and available data, we rely on the Census definitions to define three groups of markets in which buyers are more likely to view products as substitutes:

- Brick
  - Brick (building or common and face)
- Other Structural Clay Products
  - Structural facing tile and ceramic glazed brick, including glazed and unglazed
  - Vitrified clay sewer pipe and fittings
- Other Clay Structural, Floor, and Wall Tile
  - Structural clay tile (except facing)

Given the weight of bricks, transportation costs are high, relative to value. For this reason, bricks are more likely to be bought and sold within regions because of the cost of transportation across long distances. We found that international trade represented only a small fraction of economic activity (see Section 2.5), and the latest Census data show that a majority of

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[5]The measure is computed as the percentage change in quantity demanded divided by the percentage change in price.

nonmetallic mineral products were shipped less than 100 miles (U.S. Department of Transportation, 2010).[6] As shown in Table 2-1, approximately 75% of the total tons shipped are shipped in NAICS 327 is less than 50 miles. A comparison of Census region average prices for bricks shows substantial differences between regions in the average price of brick products shipped. To the extent these price differences persist over time, these differences may be consistent with regional markets for brick.

**Table 2-1. Distance Shipped Statistics: NAIC 327 (Nonmetallic Mineral Product Manufacturing)**

| Distance Shipped | 2007 Value (million $) | 2007 Tons (thousands) | Share of Total Tons |
|---|---|---|---|
| Total | 124,713 | 1,060,926 | ---- |
| Less than 50 miles | 53,721 | 796,412 | 75.1% |
| 50–99 miles | 12,351 | 82,342 | 7.8% |
| 100–249 miles | 21,760 | 113,384 | 10.7% |
| 250–499 miles | 15,117 | 39,645 | 3.7% |
| 500–749 miles | 8,495 | 16,040 | 1.5% |
| 750–999 miles | 4,872 | 6,039 | 0.6% |
| 1,000–1,499 miles | 3,790 | 4,722 | 0.4% |
| 1,500–2,000 miles | 2,364 | 1,344 | 0.1% |
| More than 2,000 miles | 2,246 | 998 | 0.1% |

Source: U.S. Department of Transportation (2010). Table 15.

### *2.4.2 Firm Pricing Behavior*

Economists have developed a system for grouping markets that helps describe the pricing behavior of firms. At one end of the spectrum, firms have little control over pricing for their products. Put another way, firms are price takers, and price is determined by supply and demand conditions. This basic model is more likely to hold when the industry has a large number of sellers, goods are identical, and barriers for entry and exit (laws, high capital requirements, or patents) are low. At the other end of the spectrum, there is a single firm that searches for the price-output combination that maximizes its profit. This basic model is more likely to hold when there are significant barriers to entry (industries with economies of scale or ownership of a patent).

[6]The data include other products such as cement, so it is unclear from this data whether brick and structural clay products face the same transportation and shipment patterns as cement products.

When markets have a small number of firms selling identical products, firms may not necessarily be price takers; instead, they may be able to determine their price while considering how competitors may respond to their own decisions. To assess the extent to which affected markets may be concentrated among a small number of sellers, we compiled and estimated national and regional market share statistics using historical kiln survey data. Across the United States, a large number of companies (50 companies) own and operate over 200 kilns. The largest U.S. market share for a U.S. company is low (about 16%). This is consistent with the latest 5-year Census statistics describing U.S. concentration at the 6-digit NAICS code level, which found that both affected industries are well below levels that government agencies consider moderately concentrated (U.S. Census Bureau, 2013e).

As Table 2-2 indicates, looking within regions, the New England region has only two operating companies, while the South Atlantic region has 17. In several Census regions, a single parent company accounts for a majority of estimated regional production. To the extent that brick product markets are defined at the regional level versus national level, the price-taking model of firm decisions may not describe business decisions as well as other economic models of pricing behavior.

**Table 2-2. Market Share Statistics**

| Census Region | Number of Companies | Maximum Company Share of Region Production |
|---|---|---|
| East North Central | 12 | 38% |
| East South Central | 9 | 49% |
| Mid-Atlantic | 5 | 66% |
| Mountain | 6 | 50% |
| New England | 2 | NA |
| Pacific | 4 | 40% |
| South Atlantic | 17 | 27% |
| West North Central | 9 | 31% |
| West South Central | 5 | 52% |

Source: U.S. EPA estimates and calculations.

### *2.4.3 Affected Facilities and Ultimate Parent Companies*

Based on historical kiln inventory survey data, over 13 million tons of BSCP are produced by the industry, which includes over 200 major and area source kilns. EPA has identified 44 ultimate parent companies with facilities that will need new or modified control devices to meet new emission standards. The companies own 85 facilities and operate 168 kilns (see Table 2-3). The South Atlantic region accounts for a significant share of existing production capacity; 23 facilities and 53 kilns are operated in this region.

**Table 2-3. Production Statistics by Census Region**

| Census Region | Total S.B.E Shipped in 2010 (1000s) | Number of Affected Kilns | Number of Affected Facilities | Estimated Affected Production Share within Region |
|---|---|---|---|---|
| East North Central | 285,508 | 29 | 11 | 81% |
| East South Central | 388,685 | 28 | 14 | 100% |
| Mid-Atlantic | 213,583 | 8 | 5 | 69% |
| Mountain | 114,154 | 4 | 3 | 50% |
| New England | 37,034 | 0 | 0 | 0% |
| Pacific | 74,563 | 6 | 4 | 85% |
| South Atlantic | 1,307,601 | 53 | 23 | 92% |
| West North Central | 183,247 | 15 | 11 | 100% |
| West South Central | 891,232 | 25 | 14 | 100% |
| **United States** | **3,495,607** | **168** | **85** | **90%** |

Source: U.S. Census Bureau, 2011 and U.S. EPA calculations.

### *2.4.3.1 Small Businesses*

The Regulatory Flexibility Act (RFA) as amended by the Small Business Regulatory Enforcement Fairness Act (SBREFA) requires federal departments and agencies to evaluate if and/or how their regulations affect small business entities. Specifically, the Agency must determine if a regulation is expected to have a significant economic impact on a substantial number of small entities. Small entities include small businesses, small organizations, and small governmental jurisdictions. The business is defined as the owner company, rather than the facility; the size of the owner company determines the resources it has available to comply with the rule.

Affected parent companies fall under the Clay Building Material and Refractories Manufacturing (NAICS 327120) industry, and the Small Business Administration (SBA) (2013) defines a small business as having fewer than 750 employees. There are 36 parent companies that are small businesses (see Table 2-4).

## Table 2-4. Ultimate Parent Companies for Affected Facilities

| Company | ICR NAICS | Affected Facilities | Affected Kilns | Sales (million $) | Employment | Small |
|---|---|---|---|---|---|---|
| Acme Brick Company | 327121 | 11 | 19 | 260.1 | 2,602 | No |
| American Eagle Brick Co. | 327121 | 1 | 1 | NA | NA | Yes |
| Belden Brick Company | 327121 | 2 | 11 | 87.5 | 751 | No |
| Brampton Brick, Ltd. | 327121 | 1 | NA | NA | <750 | Yes |
| Boral Bricks Inc. | 327121 | 11 | 20 | 3,922.0 | 14,740 | No |
| Certainteed Corporation | 327123 | 1 | 1 | 1,330.8 | Over 10,000 | No |
| Cherokee Brick & Tile Co. | 327121 | 1 | 4 | 43.5 | 175 | Yes |
| Columbus Brick Co. | 327121 | 1 | 3 | 4.9 | 50 | Yes |
| Commercial Brick Corp. | 327121 | 1 | 3 | 17.5 | 175 | Yes |
| Continental Brick Co. | 327121 | 1 | 2 | 15.0 | 75 | Yes |
| Elgin-Butler Brick Co. | 327122 | 1 | 2 | 2.7 | 30 | Yes |
| Endicott Clay Products Co. | 327122 | 1 | 3 | 23.4 | 180 | Yes |
| General Finance, Inc. | 327121 | 1 | 1 | 212.2 | 229 | Yes |
| General Shale Brick, Inc. | 327121 | 7 | 16 | 285.4 | 1,900 | No |
| Glen Gery | 327121 | 6 | 10 | 83.3 | N/A | No |
| Hanson Brick East, LLC | 327121 | 8 | 12 | 51.2 | 1,021 | No |
| Hebron Brick Company | 327121 | 1 | 1 | NA | 55 | Yes |
| Henry Brick Company, Inc. | 327121 | 1 | 2 | 5.3 | 60 | Yes |
| International Chimney Corp. | 327121 | 1 | 1 | 27.9 | 250 | Yes |
| Ironrock Capital (formerly Metropolitan Ceramics, Inc.) | 327122 | 1 | 4 | NA | 175 | Yes |
| Kansas Brick and Tile Co. | 327121 | 1 | 1 | 3.5 | 35 | Yes |
| Kasten Clay Products Co. | 327121 | 1 | 1 | 3.8 | 42 | Yes |
| L.P. McNear Brick Co, Inc. | 327121 | 1 | 1 | 11.0 | 75 | Yes |
| Lee Brick and Tile Co. | 327121 | 1 | 4 | 35.0 | 175 | Yes |
| Logan Clay Products | 327123 | 0 | 0 | 13.5 | 175 | Yes |
| Marion Ceramics, Inc. | 327123 | 1 | 1 | 5.3 | 75 | Yes |
| McAvoy Brick Co. | 327121 | 1 | 1 | 1.8 | 7 | Yes |
| Mohawk Industries | 327122 | 2 | 5 | 5,788.0 | NA | No |
| Mutual Materials Co. | 327121 & 327123 | 2 | 2 | 7.5 | 35 | Yes |
| Old Virginia Brick Co. | 327121 | 2 | 3 | 22.1 | 175 | Yes |

(continued)

## Table 2-4. Ultimate Parent Companies for Affected Facilities (continued)

| Company | ICR NAICS | Affected Facilities | Affected Kilns | Sales (Million $) | Employment | Small |
|---|---|---|---|---|---|---|
| Pacific Clay Products | 327121 | 1 | 3 | 27.2 | 175 | Yes |
| Pine Hall Brick Co., Inc. | 327121 | 1 | 6 | 30.2 | 35 | Yes |
| Ragland Clay Products, LLC | 327121 | 1 | 1 | 1.9 | 35 | Yes |
| Richards Brick Co. | 327121 | 1 | 2 | 18.1 | 75 | Yes |
| Sioux City Brick and Tile Co. | 327121 | 2 | 3 | 7.5 | 35 | Yes |
| Statesville Brick Co. | 327121 | 1 | 2 | 35.0 | 175 | Yes |
| Summit Pressed Brick and Tile Co. | 327121 | 1 | 1 | 8.5 | 75 | Yes |
| Summitville Tiles, Inc. | 327122 | 1 | 4 | 300.0 | 175 | Yes |
| Superior Clay Corp. | 327121 | 0 | 0 | 7.4 | 75 | Yes |
| The Stiles & Hart Brick Company | 327121 | 0 | 0 | 4.8 | 44 | Yes |
| Triangle Brick | 327121 | 2 | 5 | 29.8 | 203 | Yes |
| Watsontown Brick Co. | 327121 | 1 | 2 | 4.1 | 35 | Yes |
| Whitacre Greer | 327121 | 1 | 2 | 8.7 | 75 | Yes |
| Yankee Hill Brick and Tile | 327121 | 1 | 1 | NA | 75 | Yes |

NA = No annual sales data

Sources: Data on total number of ultimate parent company employees and annual sales were gathered from Hoover's, Manta, and company Web sites.

## 2.5 Market Data and Trends

This section presents historical market data for select bricks and structural clay products. Historical market data include U.S. volumes for manufacturers' shipments,[7] foreign trade, and apparent consumption. Data were obtained from various years of *Current Industrial Reports* published by the U.S. Bureau of the Census. Table 2-5 provides data for common, building, and face bricks, while Table 2-6 presents data for structural facing tile and ceramic glazed brick, including unglazed and glazed, and vitrified clay and sewer pipe. Table 2-7 focuses on structural clay tile (except facing), and Table 2-8 is for clay floor and wall tile.

[7] The source reports list both shipment and production quantities. Here we have chosen shipment quantities over production quantities, even though these do not differ by much in each year or show different trends over time. The reason to choose shipment numbers over production numbers is that shipment quantity is the number that is relevant for final consumption. In fact, when the data source reports calculate "apparent consumption," they use shipment numbers, not production numbers.

**Table 2-5. Historical Data for Brick (Building or Common and Face) ($10^3$ bricks[a]): 1993–2010**

| Year | Shipment of Bricks[b] | Exports | Imports | Apparent Consumption[b] |
|---|---|---|---|---|
| 1993 | 6,655,400 | 42,643 | 10,170 | 6,622,927 |
| 1994 | 7,237,982 | 43,733 | 8,967 | 7,203,216 |
| 1995 | 6,890,321 | 43,627 | 16,867 | 6,863,561 |
| 1996 | 7,619,279 | 42,759 | 20,629 | 7,597,149 |
| 1997 | 7,732,971 | 46,518 | 20,267 | 7,706,720 |
| 1998 | 8,241,086 | 40,631 | 18,243 | 8,218,698 |
| 1999 | 8,931,700 | 34,171 | 24,920 | 8,922,449 |
| 2000 | 8,616,784 | 30,712 | 47,472 | 8,633,544 |
| 2001 | 7,941,432 | 30,547 | 27,579 | 7,938,464 |
| 2002 | 7,986,393 | 37,135 | 25,164 | 7,974,422 |
| 2003 | 8,519,678 | 46,286 | 20,807 | 8,494,199 |
| 2004 | 9,388,648 | 75,297 | 33,436 | 9,346,787 |
| 2005 | 9,418,759 | 52,008 | 49,432 | 9,416,183 |
| 2006 | 8,899,594 | 36,421 | 75,717 | 8,938,890 |
| 2007 | 7,237,176 | 40,613 | 70,914 | 7,267,477 |
| 2008 | 5,053,935 | 47,898 | 97,739 | 5,103,776 |
| 2009 | 3,585,481 | 37,640[d,f] | 74,479[e,f] | 3,622,320 |
| 2010 | 3,495,657 | 37,532[d,f] | 79,054[e,f] | 3,537,179 |

Note: This table presents data for brick (building or common and face), which, by the 2007 NAICS definition, is associated with NAICS 327121, Brick and Structural Clay Tile Manufacturing.

[a] Bricks are 2 1/4″ by 3 5/8″ by 7 5/8″ brick equivalent.

[b] This represents shipment quantity of bricks. The definition of value of shipments can be found on the "definitions" Web page for Current Industrial Reports at Census Bureau's Web site (http://www.census.gov/manufacturing/cir/definitions/index.html). The relevant item is "quantity and value of shipments." The figures on quantity and value of shipments represent physical shipments of all products sold, transferred to other establishments of the same company, or shipped on consignment, whether for domestic or export sale. The value represents the net sales price, f.o.b. plant, to the customer or branch to which the products are shipped, net of discounts, allowances, freight charges, and returns. Shipments to a company's own branches are assigned the same value as comparable appropriate allocation of company overhead and profit. Products bought and resold without further manufacture are excluded.

[c] Apparent Consumption = Shipments of Bricks − Exports + Imports

[d] The export data were not available for 2009 and 2010. The numbers here are estimates based on past trends. The export numbers seem to have the same pattern as shipment numbers. In particular, during 2001–2002 and 2007–2008 when brick shipment numbers were low, brick export numbers were also low. So we have estimated the numbers for 2009 and 2010 based on the regression $exports = a + b*shipments$, using 1993 to 2008 data. Another source of information for estimating export quantities is that, in the *Current Industrial Reports*, the values of exports for all years, including 2009 and 2010, are available. However, because we lack reliable data on export prices for those years, we do not estimate the quantities of exports for 2009 and 2010 from the values data.

(continued)

### Table 2-5. Historical Data for Brick (Building or Common and Face) ($10^3$ bricks[a]): 1993–2010 (continued)

[e] The import data were not available for 2009 and 2010. The numbers here are estimates based on past trends. The import numbers do not seem to be correlated with shipment numbers. For example, during 2001–2002 and 2007–2008 when brick shipment numbers were low, brick import numbers were not that low. In fact, plotting the numbers suggests that imports show an increasing trend since 1993. So we have extrapolated to estimate the numbers for 2009 and 2010 assuming a linear trend beginning in the year 1993. We fond imports to be lower in 2009 and 2010 compared with 2008, because the linear trend starts in 1993, and the unusually high 2008 number is only an outlier outside this trend. Another source of information for estimating import quantities is that, in the *Current Industrial Reports*, the values of imports for all years, including 2009 and 2010, are available. The value of imports drops approximately 50% from 2008 to 2009. However, because we lack data on import prices for those years, we did not estimate the quantities of imports for 2009 and 2010 from these values.

[f] Another method we tried for computing export and import quantities was based on the observation that although for 2009 and 2010 the industrial reports only list export and import values and not quantities, they do report both quantities and values for shipment. So with the latter information, we were able to compute the unit price for shipments and then use that to get the export and import quantities. We explored any systematic differences in the unit price for shipments, the unit price for exports, and the unit price for imports. We looked at industrial reports before 2009 to find out whether the unit prices are systematically different and adjusted for those differences. We then divided the export and import values for 2009 and 2010 by the export and import unit prices to obtain the export and import quantities. However, the export quantities (47,775 for 2009 and 65,099 for 2010) and import quantities (26,069 for 2009 and 23,956 for 2010) we obtained as a result of this method seemed to be quite different from past-year trends. So we decided to opt for the regression method of estimation.

[g] As previous notes indicate, export and import numbers for 2009 and 2010 are estimates. So the annual growth rates are computed for both 1993 to 2008 and 1993 to 2010.

Sources: U.S. Department of Commerce, Census Bureau. 2011. *Current Industrial Reports for Clay Construction Products*—Summary 2010.

U.S. Department of Commerce, Census Bureau. 2009. *Current Industrial Reports for Clay Construction Products*—Summary 2008.

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As shown in Table 2-5, the brick market shows declines in the quantity of shipments and apparent consumption between 1993 and 2010 with a marked decreases during the recessions beginning in 2007. An examination of the data during the time period 1993 to 2010 shows that brick shipment and apparent consumption increased during some years and decreased during other years. However, because of the steep declines beginning in 2007, 2010 values are only about 53% of 1993 values. Brick shipments steadily increased from about 6.6 billion bricks in 1993 to 8.6 billion bricks in 2000, dropped somewhat in 2001 and remained below the 2000 level until 2003, and rose again in 2004 and 2005 before beginning a steady decline starting in 2006.

## Table 2-6. Historical Data for Facing Tile and Ceramic Glazed Brick (Including Unglazed and Salt Glazed) and Vitrified Clay Sewer Pipe and Fittings (short tons): 1993–2010

| Year | Shipments of Select Structural Clay Products[a] | Exports[b] | Imports[b] | Apparent Consumption[c] |
|---|---|---|---|---|
| 1993 | 193,500 | 287 | 648 | 193,861 |
| 1994 | 188,039 | 3,187 | 915 | 185,767 |
| 1995 | 183,967 | 1,543 | 388 | 182,812 |
| 1996 | 204,908 | 1,610 | 345 | 203,643 |
| 1997 | 218,013 | 1,334 | 888 | 217,568 |
| 1998 | 207,815 | 2,291 | 291 | 205,815 |
| 1999 | 231,876 | 1,176 | 389 | 231,089 |
| 2000 | 217,448 | 2,092 | 346 | 215,702 |
| 2001 | 216,685 | 1,219 | 220 | 215,686 |
| 2002 | 177,558 | 1,583 | 607 | 176,582 |
| 2003 | 177,620 | 1,258 | 374 | 176,736 |
| 2004 | 210,981 | 1,473 | 915 | 210,423 |
| 2005 | 258,393 | 1,218 | 526 | 257,701 |
| 2006 | 219,911 | 1,041 | 341 | 219,211 |
| 2007 | 195,064 | 1,102 | 536 | 194,497 |
| 2008 | 132,181 | 1,164 | 463 | 131,480 |
| 2009 | 98,439[d] | 1,138[e,g] | 512[f,g] | 97,813[h] |
| 2010 | 73,183[d] | 1,098[e,g] | 512[f,g] | 72,597[h] |

Note: This table presents data for facing tile and ceramic glazed brick, including unglazed and salt glazed, which, according to the 2007 NAICS definition, is associated with NAICS 327121, Brick and Structural Clay Tile Manufacturing, and vitrified clay and sewer pipe, which, according to the 2007 NAICS definition, is associated with NAICS 327123, Other Structural Clay Products Manufacturing. According to our communication with Casey Bretz at the Census Bureau, in all the Table 1s in the Current Industrial Reports, the category listed as "Structural facing tile and ceramic glazed brick" should in fact be "Structural facing tile and ceramic glazed brick, including unglazed and salt glazed." The Current Industrial Reports since 1998 omitted the phrase "including unglazed and salt glazed" and only mentioned structural facing tile and ceramic glazed brick.

Calculation rules used when computing numbers from the Industrial reports for this table are 1 million brick equivalent = 2,000 short tons and 1 metric ton = 1.10231131 short ton. The source for the first formula is http://midlandbrick.wikidot.com/standard-brick-equivalent, which says that 1 standard brick equivalent is equal to a 4 pound brick. Because 1 short ton is equal to 2,000 pounds, this implies the conversion ratio used here.

(continued)

## Table 2-6. Historical Data for Facing Tile and Ceramic Glazed Brick (Including Unglazed and Salt Glazed) and Vitrified Clay Sewer Pipe and Fittings (short tons): 1993–2010 (continued)

[a] This represents shipment quantity of select structural clay products. The definition of value of shipments can be found on the "definitions" Web page for Current Industrial Reports at the Census Bureau's Web site (http://www.census.gov/manufacturing/cir/definitions/index.html). The relevant item is quantity and value of shipments. The figures on quantity and value of shipments represent physical shipments of all products sold, transferred to other establishments of the same company, or shipped on consignment, whether for domestic or export sale. The value represents the net sales price, f.o.b. plant, to the customer or branch to which the products are shipped, net of discounts, allowances, freight charges, and returns. Shipments to a company's own branches are assigned the same value as comparable appropriate allocation of company overhead and profit. Products bought and resold without further manufacture are excluded.

[b] For export and import numbers between 1998 and 2008, the export and import data for facing tile and ceramic glazed brick including unglazed and salt glazed are not available in the source reports (marked as (X) in the source reports), so the export and import numbers are computed with vitrified clay sewer pipe and fittings data only.

[c] Apparent Consumption = Shipments of Select SCP − Exports + Imports

[d] Readers should interpret these numbers carefully. For the 2009 and 2010 shipment numbers, the shipment data for facing tile and ceramic glazed brick are not available in the source report and are marked as "(S)." "(S)" means that the numbers did not meet publication standards. We talked to Casey Bretz at the Census Bureau and learned that these numbers involved over 50% of imputation, which is the reason they were not published. However, these imputed numbers were available upon our request, and the 2009–2010 shipment numbers in this table were calculated using these numbers for facing tile and ceramic glazed brick including unglazed and salt glazed. Numbers for vitrified clay sewer pipe and fittings are available in the source reports.

[e] Because the export quantity data for vitrified clay sewer pipe and fittings are not available for 2009 and 2010, the numbers for 2009 and 2010 are estimates for vitrified clay sewer pipe and fittings exports. The export numbers for vitrified clays do not seem to be correlated to shipment numbers. In particular, during the 2002–2003 and 2007–2008 recessions when shipment numbers are low, the vitrified clay export numbers are not low. Further, plotting the numbers suggests that the exports have decreased over time and exhibit smaller fluctuations over time since 1993. So we have extrapolated the numbers for 2009 and 2010 assuming a linear trend beginning in the year 1993. Another source of information for estimating export quantities is that, in the Current Industrial Reports, the values of exports for all years, including 2009 and 2010, are available. However, because we lack reliable data on export prices, we do not estimate quantities of exports for 2009 and 2010 from these values.

[f] Because import quantity data for vitrified clay sewer pipe and fittings are not available for 2009 and 2010, the numbers here are based on estimates. The import numbers do not seem to have the same pattern as the shipment numbers. In particular, during 2002–2003 and 2007–2008 when shipment numbers were obviously low, the import numbers were not. Plotting the numbers suggests that imports of structural clay products have fluctuated widely. So we simply set these numbers at their historical average. Another source of information for estimating import quantities is that, in the Current Industrial Reports, the values of imports for all years, including 2009 and 2010, are available. Similar to bricks, the value of imports for vitrified clay sewer pipe and fittings dropped by about 50% from 2008 to 2009. However, because we lack reliable data on import prices, we did not estimate the quantities of imports for 2009 and 2010 from these values.

[g] Another method we tried for computing export and import quantities was based on the observation that although for 2009 and 2010 the industrial reports only list export and import values and not quantities, they do report both quantities and values for shipment. So with the latter information we were able to compute the unit price for shipments and then use that to get the export and import quantities. We explored any systematic differences in the unit price for shipments, the unit price for exports, and the unit price for imports. We looked at industrial reports before 2009 to find out whether the unit prices are systematically different and adjusted for those differences. We then divided the export and import values for 2009 and 2010 by the export and import unit prices to obtain the export and import quantities. However, the export quantities (725 for 2009 and 1,346 for 2010) and import quantities (206 for 2009 and 206 for 2010) we obtained as a result of this method seemed to be quite different from past-year trends. So we used the regression method of estimation for exports and historical average method for imports.

[h] These are based on estimates. Please see notes e, f, and g.

[i] As previous notes suggest, data for 2009 and 2010 are based on estimates. So the annual growth rates were computed for both 1993 to 2008 and 1993 to 2010.

Sources: U.S. Department of Commerce, Census Bureau. 2011. *Current Industrial Reports for Clay Construction Products*—Summary 2010.

U.S. Department of Commerce, Census Bureau. 2009. *Current Industrial Reports for Clay Construction Products*—Summary 2008.

U.S. Department of Commerce, Census Bureau. 2007. *Current Industrial Reports for Clay Construction Products*—Summary 2006.

(continued)

**Table 2-6. Historical Data for Facing Tile and Ceramic Glazed Brick (Including Unglazed and Salt Glazed) and Vitrified Clay Sewer Pipe and Fittings (short tons): 1993–2010 (continued)**

U.S. Department of Commerce, Census Bureau. 2005. *Current Industrial Reports for Clay Construction Products*—Summary 2004.

U.S. Department of Commerce, Census Bureau. 2004. *Current Industrial Reports for Clay Construction Products*—Summary 2003.

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Both exports and imports of bricks increased between 1993 and 2008. The largest quantity of brick exports are to Canada (approximately 78% in 2010) (U.S. International Trade Commission [USITC], 2013). The largest quantities of brick and structural clay imports are from Germany (40% in 2010) and Mexico (37% in 2010)[8] (USITC, 2013). The average annual growth rate for exports was 3.16% during this time period. The growth rate for imports was much larger at 22.61%. In 1993, imports were about 10 million and jumped to 98 million by 2010, with significant increases happening in 1995, 2000, 2006, and 2008. This difference between brick export and import growth rates is also evident if we examine exports and imports as proportions of shipments instead of their levels. Exports started at 0.64% of shipments in the year 1993 but had dropped to 0.41% by 2006. Imports started at 0.15% of shipments in 1993 but rose to 0.85% of shipments in 2006. After 2006, both these ratios rose. By 2010, exports and imports as a percentage of shipments rose to 1.07% and 2.26%, respectively. But the rises since 2006 were driven more by decreases in shipments, rather than by changes in the levels of exports and imports.

[8]Although these two countries typically are the largest source of imports, the country shares vary from year to year. For example, in 2012, Germany and Mexico again accounted for more than 65% of imports, but Mexico represented 40% and Germany accounted for 24%.

**Table 2-7. Historical Data for Structural Clay Tile (Except Facing) (short tons): 1993–2010**

| Year | Shipments of Structural Clay Tile (Except Facing) |
|---|---|
| 1993 | (D) |
| 1994 | (D) |
| 1995 | 53,727 |
| 1996 | 50,990 |
| 1997 | 49,729 |
| 1998 | 49,098 |
| 1999 | 47,156 |
| 2000 | 47,009 |
| 2001 | 49,453 |
| 2002 | 49,563 |
| 2003 | 40,330 |
| 2004 | 40,050 |
| 2005 | 47,704 |
| 2006 | 37,491 |
| 2007 | 35,477 |
| 2008 | 23,410 |
| 2009 | 16,749 |
| 2010 | 12,140 |
| **Average Annual Growth Rates** | |
| 1995–2010 | −8.31% |

Note: This table presents data for structural clay tile (except facing), which, by 2007 NAICS definition, is associated with NAICS 327121, Brick and Structural Clay Tile Manufacturing. Unlike Table 2-7 and Table 2-8, this table does not show exports, imports, or apparent consumption, because the export and import data for structural clay tile (except facing) are not available (marked as (X) in the source reports). "(D)" means that the number is "withheld to avoid disclosing data of individual companies" in the source report.

Sources: U.S. Department of Commerce, Census Bureau. 2011. *Current Industrial Reports for Clay Construction Products*—Summary 2010

U.S. Department of Commerce, Census Bureau. 2009. *Current Industrial Reports for Clay Construction Products*—Summary 2008

U.S. Department of Commerce, Census Bureau. 2007. *Current Industrial Reports for Clay Construction Products—Summary 2006*

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The market for other structural clay products is much smaller than the brick market, but it still represents an important sector of the BSCP industry. As Table 2-6 shows, both shipments and apparent consumption of structural clay products in 2010 were less than 38% of 1993 values. Similar to the trend in the brick market, structural clay product shipments exhibited a steady increase from 194 thousand short tons in 1993 to 232 thousand short tons in 1999, dropped somewhat during the recession in 2002 and 2003, rose between 2003 and 2006, and began a steady decline starting in 2007.

Although structural clay product shipments and consumption declined over the time period 1993 to 2008, the average annual growth rate of exports was high at 67.42%. Although this growth rate looks large, it is relatively small in absolute terms. This high average growth rate is largely due to a substantial increase in exports of vitrified sewer pipe and fittings from 1993 to 1994. In 1993, 287 short tons of vitrified sewer pipe and fittings were exported from the United States, and in 1994, this number rose dramatically to 3,187 short tons. Since 1995, exports have mostly stayed between 1,000 and 2,000 short tons. Imports of structural clay products are small, never exceeding a thousand short tons in any year between 1993 and 2008.

The shipments of structural clay tile (except facing) are even smaller than other structural clay products (which are presented in Table 2-6). As Table 2-7 shows, the average annual growth rate of shipments of structural clay tile (except facing) is approximately −8.3% for the years 1995 to 2010. More specifically, the shipments exhibit a steady decrease from 54 thousand short tons in 1995 to 35 thousand short tons in 2007, during which period the average annual growth rate is only −2.9%. Then in the years 2008, 2009, and 2010, the shipment levels dropped sharply by 34.0%, 28.5%, and 27.5%, respectively.

As the data in Tables 2-5, 2-6, and 2-7 show, the quantities of all BSCP experienced declines starting in 2007, the year the recent economic crisis set in, and continued to decline post-crisis. The data show that shipment levels had recovered after the 2002–2003 recession and held steady for the years prior to 2007. The decline since 2007 also appears to be due to the 2007–2008 recession rather than to structural changes within the industry. We expect the industry to come back to its prerecession levels in the future. This is supported by the fact that shipment levels for all BSCP were low during 2001–2003, when the early 2000s recession happened in the United States and the European Union. However, these shipment levels bounced back after the recession. This prediction is also supported by the recent annual reports of large companies producing these products. For example, the annual reports of large companies such as Boral Limited and Saint-Gobain show them recovering after exhibiting declines during the recession.

Boral Limited is an international building and construction materials group headquartered in Australia, and its U.S. operations manufacture clay bricks, concrete, and clay roof tiles and manufactured stone veneer for residential and mid-rise commercial buildings.[9] The 2012 annual report of Boral Limited compares U.S. housing starts and Boral U.S.A.'s earnings before interest and taxes (EBIT) during the years 2006–2012 and finds them to be highly correlated (Boral Limited, 2012). Both the numbers for U.S. housing starts and Boral U.S.A.'s EBIT in the United States declined simultaneously between 2006 and 2011 but rose in 2012. U.S. housing starts went from 2,030 thousand in fiscal year 2006 to 570 thousand in fiscal year 2011, and Boral U.S.A.'s EBIT declined to −$99 million in 2011 from $139 million in 2006. Boral U.S.A.'s EBIT rose to −$87 million in fiscal year 2012 when U.S. housing starts increased to 685 thousand.

Saint-Gobain S.A, which produces construction products marketed in the United States under the CertainTeed brand, is a Europe-based multinational company and does not provide its U.S. operations data separately. However, its overall data exhibit synchronization with the economic cycles. Its net sales declined from 30,274 million euros in 2002 (Saint-Gobain, 2003; 2013) to 29,590 million euros in 2003, showed a steady recovery after that to 43,800 million euros in 2008, declined in 2009 to 37,786 million euros, and then recovered in 2011 and 2012 to 42,116 million euros and 43,198 million euros, respectively (Saint-Gobain, 2013).

Although their annual reports do not provide data on quantities in shipment, production, or exports as the Current Industrial Reports do, the recent trends in the financial performance of these large companies, in particular the profit and sales data, support that this industry will improve as the effects of the recession recede and the building and construction industry revives.

In addition, our prediction that the BSCP industry is only experiencing a temporary setback and will come back to prerecession levels is supported by existing reports for the clay and shale industry, which is upstream of the BSCP industry. Put another way, raw materials typically used in manufacturing BSCP include common clay and shale (Midwest Research Institute, 2001). A recent advance report published in 2013 by the U.S. Department of the Interior and USGS suggests that once statistical data become available, the country may see a moderate growth in common clay sales in 2012 (U.S. Department of the Interior, 2013). In their

[9]This information is from the company's Web site, http://www.boral.com. According to the Web site, Boral's operations include the largest brick manufacturer and the largest clay tile manufacturer in the United States; through the 50% owned MonierLifetile, it is also the largest concrete roof tile manufacturer in the United States.

analysis, the factors supporting the growth are the increases in housing starts and construction spending for commercial buildings similar to what is evident from the Boral USA example.

### *2.5.1 Market Prices*

Average prices for brick and structural products vary by product type and over time. In 2010, the average price of brick was approximately $248 per 1,000 S.B.E., clay floor and wall tile was approximately $1.30 per square foot, and vitrified clay sewer pipe and fitting were $496 per short ton (Table 2-8). There is substantial variation in average brick prices across Census regions ($183 to $541), as shown in Table 2-9. Since 2005, average nominal prices for bricks and clay floor and wall tile have remained flat or fallen (Figure 2-2), while average nominal prices for other structural clay products have risen to higher levels.

**Table 2-8. Average Price of Principal Brick and Structural Clay Products Shipped: 2010**

| Product | Average Price | Units |
|---|---|---|
| Brick, building or common and facing | $248 | $ per 1,000 S.B.E. |
| Vitrified clay sewer pipe and fittings | $496 | $ per short ton |

Sources: U.S. Census Bureau, 2011.

**Table 2-9. Regional Variation in Average Prices of Brick, Building or Common and Facing: 2010**

| Census Region | $ per 1,000 S.B.E. |
|---|---|
| New England | $379 |
| Middle Atlantic | $324 |
| East North Central | $297 |
| West North Central | $272 |
| South Atlantic | $227 |
| East South Central | $183 |
| West South Central | $225 |
| Mountain | $355 |
| Pacific | $541 |
| **United States** | **$248** |

Sources: U.S. Census Bureau, 2011.

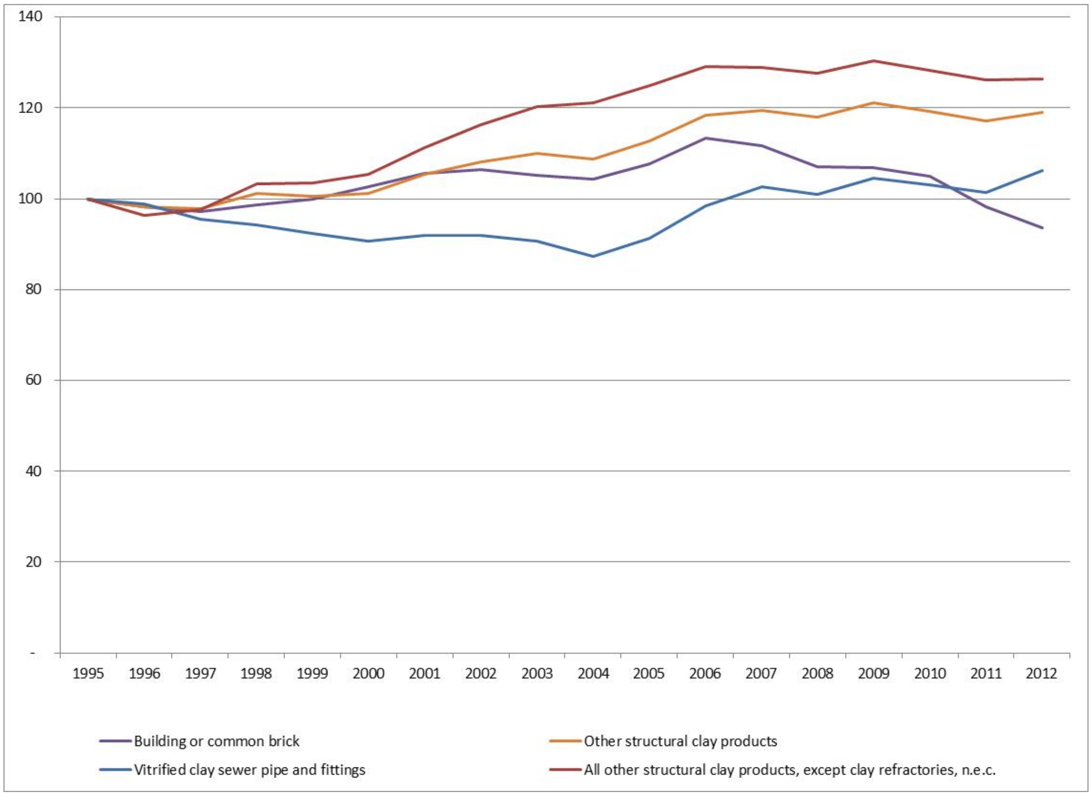


**Figure 2-2. Real Price Trends for Brick and Structural Clay Products**

Source: U.S. Bureau of the Labor Statistics, 2013a,b

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# SECTION 3
# ENGINEERING COST ANALYSIS

Production of BSCP results in emissions of pollutants such as hydrogen fluoride (HF), hydrogen chloride (HCl), chlorine ($Cl_2$), mercury (Hg), and non-Hg hazardous air pollutant (HAP) metals from the kilns used in the production process. To control these emissions, EPA has developed emission standards for these HAPs under the authority of Section 112 of the CAA. This section explains how the estimates of compliance costs associated with this regulation were developed, and it is organized as follows:

- Section 3.1, Summary of National Costs by Regulatory Approach: This section describes the regulatory approaches considered in this analysis and presents the annual cost for each of the compliance options and the various regions of the country. It also describes the air pollution control devices (APCDs) and the pollutants targeted because they are key to understanding how the annual costs were obtained.

- Section 3.2, Summary of Costs by Control Device: There are various APCD implementation options to meet the compliance requirements. This section presents the overall capital and annual costs for those implementation options. It also provides key considerations for how the costs were derived.

## 3.1 Summary of National Costs by Regulatory Approach

EPA evaluated costs for affected BSCP facilities under three regulatory approaches:

- Option 1 (Proposed Rule):
  - Acid gases: Meet HBS.
  - Hg: Choice of MACT limit in lb/ton, concentration, or lb/hr.
  - PM/total non-Hg HAP metals: Choice of MACT limits for PM in lb/ton or gr/dscf (calculated based on data from kilns with fabric filter-based APCD, up to 12 percent of the kilns in the industry) or non-Hg HAP metals in lb/hr for all kilns.
- Option 2 Final Rule:
  - Acid gases: Meet HBS.
  - Hg: Choice of MACT limit, with consideration of raw material variability, in lb/ton, concentration, or lb/hr.
  - PM/total non-Hg HAP metals: Choice of MACT limits for PM in lb/ton or gr/dscf or non-Hg HAP metals lb/hr for small and large kilns (calculated based on 12 percent of the data in the subcategory).

- Option 3 (Final Rule but without size subcategories for PM/total non-Hg HAP metals):
  - Acid gases: Meet HBS.
  - Hg: Choice of MACT limit, with consideration of raw material variability, for Hg in lb/ton, concentration, or lb/hr.
  - PM/total non-Hg HAP metals: Choice of MACT limits for PM in lb/ton or gr/dscf or non-Hg HAP metals lb/hr for all kilns (calculated based on 12 percent of the data in the industry).

All approaches have separate Hg numeric limits for large and small kilns, and the HBS applies to all kilns at the facility for all compliance options. All approaches assume the facility would choose to become a Synthetic Area (SA) by installing dry limestone adsorbers (DLAs) on uncontrolled kilns if that is less expensive than installing the control needed to comply with the compliance option.

These costs include the implementation of various APCDs. The following are the APCDs considered:

- Dry injection fabric filter (DIFF). DIFFs are used to remove HF, HCl, $Cl_2$, sulfur dioxide ($SO_2$), and PM. They work by injecting hydrated lime (a dry lime powder) into the kiln exhaust. The lime and kiln exhaust mix in a reaction chamber or an exhaust duct and are ducted to a fabric filter. The lime reacts with and removes HF, HCl, $Cl_2$, and $SO_2$ from the exhaust stream.

- Dry lime scrubber/fabric filter (DLS/FF). DLS/FFs are used to control HF, HCl, $Cl_2$, $SO_2$, and PM emissions. These systems mix hydrated lime and water in a conditioning drum and then inject the lime/water slurry into a reaction chamber, where the slurry mixes with the kiln exhaust. Acid gas removal takes place in the reaction chamber, subsequent ductwork, and across the lime-caked fabric filter bags. From the reaction chamber, the exhaust stream is ducted to a fabric filter for PM removal.

- Dry limestone adsorber (DLA). DLAs are used to control HF, HCl, $Cl_2$, and $SO_2$ emissions. Limestone is fed into the top of a reaction chamber countercurrent to the kiln exhaust gases. The limestone cascades through multiple baffles within the chamber and reacts with and removes HF and, to a lesser degree, HCl, $Cl_2$ and $SO_2$ from the kiln exhaust. The system does not provide a mechanism for controlling PM.

- Fabric filter (FF). FFs are used to control PM emissions. Most FFs use long, cylindrical bags made of a woven material that acts as a filter medium. Gas enters the FF and is drawn through the bags, and PM accumulates in layers on the surface of the filter media until gas can no longer move through the bag. When the system reaches a sufficient pressure drop due to PM build-up, the bag will be cleaned. The system does not provide a mechanism for controlling Hg, HCl, $Cl_2$, or $SO_2$.

- Activated carbon injection (ACI). An ACI system would pneumatically inject activated carbon into the flue gas ductwork of a kiln. The activated carbon adsorbs the vaporized mercury from the flue gas and is then collected with the fly ash in a particulate collection device. This device is assumed to work with a fabric filter for particulates collection.

Cost estimates were developed for each BSCP facility assuming the APCDs are implemented according to various scenarios. In general, an FF and ACI were assumed to be the APCD needed to meet the MACT limits for an uncontrolled kiln. Table 3-1 presents the general implementation scenarios for tunnel kilns required to meet MACT for all pollutants.

**Table 3-1. APCD Implementation Scenarios to Meet MACT Limits**

| APCD | Meets Non-Hg HAP Metals or PM Limit | Meets Mercury Limit | APCD Implementation Scenario |
|---|---|---|---|
| None | Yes | No | Install new FF with ACI |
| None | No | Yes | Install new FF |
| None | No | No | Install new FF with ACI |
| Existing DIFF | Yes | Yes | No action |
| Existing DIFF | Yes | No | Add ACI |
| Existing DIFF | No | Yes | Retrofit DIFF for PM control |
| Existing DIFF | No | No | Retrofit DIFF for PM control; add ACI |
| Existing DLS/FF | Yes | Yes | No action |
| Existing DLA | Yes | No | Add FF with ACI |
| Existing DLA | No | Yes | Add FF |
| Existing DLA | No | No | Add FF with ACI |

The option to "Install new DLA" was evaluated for facilities to become an SA. All scenarios in Table 3-1 assume meeting the HBS for acid gases.

The following are the scenarios considered to meet the HBSs:

- If a kiln can meet the non-Hg HAP metals or PM and Hg MACT limits and is located at a facility that can meet the health-based limits, no additional costs would be incurred.

- If an uncontrolled kiln or a kiln with a DLA is located at a facility that can meet the health-based limits, then only an FF would be needed to meet the non-Hg HAP metals or PM MACT limit, and activated carbon injection would be needed to meet the Hg MACT limit.

- Because the health-based limits are on a facility-wide basis, the owner or operator of a facility not meeting the health-based limits with current controls may not have to add an APCD to every uncontrolled kiln and enhance every existing APCD. Engineering judgment was used to assign minimum control “actions needed” based on a review of the contribution of each emission point’s to the allowable HCl-equivalent emissions. Additional information about this assessment is presented in the memorandum “Development of Cost and Emission Reduction Impacts for the Final BSCP NESHAP” included in the docket.

Table 3-2 presents the annual cost for each of the regulatory approaches.

**Table 3-2. National Annual Costs of Compliance (2011 million USD)**

| | Regions | Option 1 | Option 2 Final Rule | Option 3 |
|---|---|---|---|---|
| NEG | New England | $0 | $0 | $0 |
| MID | Middle Atlantic | $2 | $2 | $2 |
| ENC | East North Central | $3 | $3 | $6 |
| WNC | West North Central | $1 | $1 | $3 |
| SAC | South Atlantic | $8 | $9 | $16 |
| ESC | East South Central | $4 | $4 | $7 |
| WSC | West South Central | $6 | $5 | $9 |
| MTN | Mountain | $0 | $0 | $1 |
| PAC | Pacific | $0 | $0 | $2 |
| USA | United States | $24 | $25 | $47 |
| USA | United States, with recordkeeping and reporting | $27 | $28 | $50 |

## 3.2 Summary of Costs by Control Device

A key component of the total annual costs presented in Table 3-1 is the implementation cost of the APCDs required to (1) meet the MACT limits for Hg and for non-Hg HAP metals or PM, (2) become an SA source, and/or (3) meet an HBS for acid gases, according to the compliance options. This section provides an overview of how the capital and annual costs of implementation were estimated. Additional information about those estimates is provided in the memorandum “Development of Cost and Emission Reduction Impacts for the Final BSCP NESHAP” included in the docket.

Consistent with the information presented in Section 3.1, the following are the APCD implementation scenarios considered in this analysis:

- Install new DLA
- Install new FF
- Install new ACI
- Install new FF and ACI
- Retrofit with DIFF
- Retrofit with DIFF and ACI
- No action

Table 3-3 presents the capital and annual costs of each implementation option.

**Table 3-3. Capital and Annual Costs of APCD Implementation Scenarios (2011 USD)**

| | Capital Costs | | Annual Costs | |
|---|---|---|---|---|
| **Control Options** | **Small APCD** | **Large APCD** | **Small APCD** | **Large APCD** |
| Install new DLA | $1,096,473 | $1,489,548 | $358,556 | $459,886 |
| Install new FF | $1,200,000 | $1,500,000 | $503,144 | $579,541 |
| Install new ACI | $102,224 | $146,697 | $81,307 | $105,763 |
| Install new FF and ACI | $2,800,000 | $3,820,000 | $804,907 | $1,017,978 |
| Retrofit with DIFF | $2,902,224 | $3,966,697 | $886,214 | $1,123,741 |
| Retrofit with DIFF and ACI | $1,096,473 | $1,489,548 | $358,556 | $459,886 |

Costs are presented for small and large APCDs. A small control device would be used if the operating capacity of the kiln(s) being routed to that device is less than 10 tons of bricks per hour. A large control device would be used if the operating capacity of the kiln(s) being routed to that device is 10 tons of bricks or more per hour. Capital cost data were generally obtained from the Information Collection Request (ICR) and supplemented with information from literature sources.

The estimates of annual cost include

- operation and maintenance (O&M) labor;

- materials;
- electricity;
- waste disposal;
- overhead; and
- property taxes, insurance, and administration.

Information pertaining to cost data sources and how they were used to develop unit costs for each APCD is provided in the memorandum "Methodology and Assumptions Used to Estimate the Final Model Costs and Impacts of BSCP Air Pollution Control Devices."

Annualization of the capital costs involves establishing an annual "payment" sufficient to finance the investment over the expected lifetime of the equipment or loan period. This payment is typically referred to as the "capital recovery cost." The three key inputs into the capital recovery costs are the capital costs, the interest rate, and the equipment life. This analysis assumed a 20-year equipment life and a 7% interest rate, which corresponds to the interest rate used in OAQPS's analyses.

### 3.3 Summary of Results

This section presents total annualized costs for each regulatory approach. Total annualized cost is the sum of the annualized capital cost and the annual costs. The following is a summary of those results:

- Option 1: approximately $27 million
- Option 2 Final Rule: approximately $28 million
- Option 3: approximately $50 million

Annual costs listed above for each compliance option also include costs for testing and monitoring, along with recordkeeping and reporting costs incurred by facilities that have testing and monitoring costs[1].

The consideration of raw material variability in the Hg limits in Options 2 and 3 results in less stringent limits compared to Option 1, but the difference is not great enough to have a significant impact on the nationwide costs. In addition, compared to Option 1, Option 2 has more

[1] Recordkeeping and reporting costs reflect the annualized present value of the stream of recordkeeping and reporting labor costs (reported in Section 6.3). between 2015 and 2038 ($3 million).

stringent PM/total non-Hg HAP metals limits for large kilns but less stringent PM/total non-Hg HAP metals limits for small kilns. Therefore, more small kilns would be expected to meet the PM/total non-Hg HAP metals limits under Option 2, but fewer large kilns would be expected to meet the PM/total non-Hg HAP metals limits under Option 2. As a result, the overall costs are slightly higher under Option 2 because more of the APCD being installed are larger, more expensive units.

The only difference between Option 2 and Option 3 is that Option 3 does not have size subcategories for PM/total non-Hg HAP metals limits. The PM/total non-Hg HAP metals limits for all kilns under Option 3 are either equivalent or very close to the large kiln PM/total non-Hg HAP metals limits for large kilns under Option 2. This has the effect of requiring all small kilns to meet a significantly more stringent limit under Option 3, and as shown in Table 3-4, more than twice the number of APCD would be needed to meet Option 3 compared to Options 1 or 2. Over half of the APCD expected to be installed would be DLA installed on uncontrolled kilns for purposes of becoming SA facilities.

When looking at annual costs per region of the country, the South Atlantic region (SAC) consistently exhibits the highest cost and the Pacific region (PAC) the lowest nonzero cost.

Retrofitting with DIFF and ACI is the option that exhibits the highest cost and installing a new ACI system the lowest, which is consistent with the capital cost results.

We provide additional details on the number of stacks required to take action to achieve compliance (Table 3-4). Additional details on existing baseline control devices is presented in the memorandum “Development of Cost and Emission Reduction Impacts for the Final BSCP NESHAP” included in the docket.

**Table 3-4. Number of Stacks Taking Actions to Achieve Compliance (2011 USD)**

| | | Action to Achieve Compliance | | | | | |
|---|---|---|---|---|---|---|---|
| **Standards** | **Parameter** | **Install DLA (become SA)** | **Install FF** | **Install FF + ACI** | **Add ACI to Existing APCD** | **Retrofit with DIFF** | **Totals** |
| Option 1 | Number of Stacks | 15 | 9 | 15 | 5 | 1 | 45 |
| | Capital Cost | $19.6 | $13.2 | $24.7 | $0.733 | $3.82 | $62.0 |
| | Annual Cost | $6.19 | $5.14 | $10.3 | $0.529 | $1.02 | $23.2 |
| Option 2 | Number of Stacks | 8 | 13 | 16 | 5 | 1 | 43 |
| | Capital Cost | $11.9 | $19.5 | $26.3 | $0.733 | $3.82 | $62.3 |
| | Annual Cost | $3.68 | $7.53 | $11.0 | $0.529 | $1.02 | $23.7 |
| Option 3 | Number of Stacks | 54 | 24 | 14 | 4 | 1 | 98 |
| | Capital Cost | $63.5 | $33.6 | $23.1 | $0.587 | $3.82 | $128 |
| | Annual Cost | $20.5 | $13.3 | $9.59 | $0.423 | $1.02 | $45.8 |

## SECTION 4
## HUMAN HEALTH BENEFITS OF EMISSIONS REDUCTIONS

### Synopsis

Implementation of emissions controls required by the Brick and Structural Clay NESHAP is expected to reduce direct emissions of particulate matter (including $PM_{2.5}$) and sulfur dioxide ($SO_2$) that are the result of emissions limits that are being tightened for a number of categories, and imposed for the first time for other categories. In this section, we quantify the monetized co-benefits for this rule associated with reducing exposure to ambient fine particulate matter ($PM_{2.5}$) by reducing emissions of precursors. The total $PM_{2.5}$ and $SO_2$ reductions are the consequence of the expected design changes to the affected manufacturing plants needed in order to meet the multiple limits. We estimate the total monetized co-benefits of the final rule to be $83 million to $190 million at a 3% discount rate and $75 million to $170 million at a 7% discount rate in 2018, including consideration of energy disbenefits. All estimates are in 2011$ as they are summarized in Table 4-1. These estimates reflect the monetized human health benefits of reducing cases of morbidity and premature mortality among populations exposed to $PM_{2.5}$ reduced by this rule. Data, resource, and methodological limitations prevented EPA from monetizing the benefits from several important benefit categories, including benefits from reducing exposure up to 375 tons of HAP (acid gases and metals) each year, as well as reducing ecosystem effects and visibility impairment.

### 4.1 $PM_{2.5}$-Related Human Health Co-benefits

This rule is expected to reduce direct emissions of PM and emissions of $SO_2$, which is a precursor to formation of ambient $PM_{2.5}$. Therefore, reducing these emissions would also reduce human exposure to ambient $PM_{2.5}$ and the incidence of $PM_{2.5}$-related health effects. In this section, we provide an overview of the $PM_{2.5}$-related benefits. A full description of the underlying data, studies, and assumptions is provided in the PM NAAQS RIA (U.S. EPA, 2012a).

In implementing this rule, emission controls may lead to reductions in ambient $PM_{2.5}$ concentrations below the National Ambient Air Quality Standards (NAAQS) for PM in some areas and assist other areas with attaining the PM NAAQS. Because the PM NAAQS RIA (U.S. EPA, 2012a) also calculated PM benefits, there are important differences worth noting in the design and analytical objectives of each RIA. The NAAQS RIAs illustrate the potential costs and benefits of attaining a revised air quality standard nationwide based on an array of emission reduction strategies for different sources including known and unknown controls, incremental to implementation of existing regulations and controls need to attain the current standards. In short, NAAQS RIAs hypothesize, but do not predict, the reduction strategies that States may choose to enact when implementing a revised NAAQS. The setting of a NAAQS does not directly result in costs or benefits, and as such, the NAAQS RIAs are merely illustrative and the estimated costs and benefits are not intended to be added to the costs and benefits of other regulations that result in specific costs of control and emission reductions. However, it is possible that some costs and benefits associated with the required emission controls estimated in this RIA may account for the same air quality improvements as estimated in the illustrative PM NAAQS RIA.

By contrast, the emission reductions for implementation rules such as this rulemaking are generally for specific, well-characterized sources. In general, EPA is more confident in the magnitude and location of the emission reductions for implementation rules. As such, emission reductions achieved under these and other promulgated implementation rules will ultimately be reflected in the baseline of future NAAQS analyses, which would reduce the incremental costs and benefits associated with attaining revised future NAAQS. EPA remains forward looking towards the next iteration of the 5-year review cycle for the NAAQS. As a result, EPA does not re-issue NAAQS RIAs that retroactively update the baseline to account for implementation rules promulgated after a NAAQS RIA outside of the NAAQS review process. For more information on the relationship between the NAAQS and implementation rules such as analyzed here, please see Section 1.3 of the PM NAAQS RIA (U.S. EPA, 2012a).

### *4.1.1 Health Impact Assessment*

The *Integrated Science Assessment for Particulate Matter* (PM ISA) (U.S. EPA, 2009) identified the human health effects associated with ambient $PM_{2.5}$, which include premature morality and a variety of morbidity effects associated with acute and chronic exposures. Table 4-1 provides the quantified and unquantified benefits captured in EPA's benefits estimates for reduced exposure to ambient $PM_{2.5}$. Although the table below does not include entries for the unquantified health effects such as exposure to ozone and $NO_2$ nor welfare effects such as ecosystem effects and visibility impairment, these effects are itemized in Chapters 5 and 6 of the PM NAAQS RIA (U.S. EPA, 2012a). It is important to emphasize that the list of unquantified benefit categories is not exhaustive, nor is quantification of each effect complete.

## Table 4-1. Human Health Effects of Ambient $PM_{2.5}$

| Category | Specific Effect | Effect Has Been Quantified | Effect Has Been Monetized | More Information in PM NAAQS RIA |
|---|---|---|---|---|
| ***Improved Human Health*** | | | | |
| Reduced incidence of premature mortality from exposure to $PM_{2.5}$ | Adult premature mortality based on cohort study estimates and expert elicitation estimates (age >25 or age >30) | ✓ | ✓ | Section 5.6 |
| | Infant mortality (age <1) | ✓ | ✓ | Section 5.6 |
| Reduced incidence of morbidity from exposure to $PM_{2.5}$ | Non-fatal heart attacks (age > 18) | ✓ | ✓ | Section 5.6 |
| | Hospital admissions—respiratory (all ages) | ✓ | ✓ | Section 5.6 |
| | Hospital admissions—cardiovascular (age >20) | ✓ | ✓ | Section 5.6 |
| | Emergency room visits for asthma (all ages) | ✓ | ✓ | Section 5.6 |
| | Acute bronchitis (age 8–12) | ✓ | ✓ | Section 5.6 |
| | Lower respiratory symptoms (age 7–14) | ✓ | ✓ | Section 5.6 |
| | Upper respiratory symptoms (asthmatics age 9–11) | ✓ | ✓ | Section 5.6 |
| | Asthma exacerbation (asthmatics age 6–18) | ✓ | ✓ | Section 5.6 |
| | Lost work days (age 18–65) | ✓ | ✓ | Section 5.6 |
| | Minor restricted-activity days (age 18–65) | ✓ | ✓ | Section 5.6 |
| | Chronic Bronchitis (age >26) | --[a] | --[a] | Section 5.6 |
| | Emergency room visits for cardiovascular effects (all ages) | --[a] | --[a] | Section 5.6 |
| | Strokes and cerebrovascular disease (age 50–79) | --[a] | --[a] | Section 5.6 |
| | Other cardiovascular effects (e.g., other ages) | -- | -- | PM ISA[b] |
| | Other respiratory effects (e.g., pulmonary function, non-asthma ER visits, non-bronchitis chronic diseases, other ages and populations) | -- | -- | PM ISA[b] |
| | Reproductive and developmental effects (e.g., low birth weight, pre-term births, etc.) | -- | -- | PM ISA[b,c] |
| | Cancer, mutagenicity, and genotoxicity effects | -- | -- | PM ISA[b,c] |

[a] We assess these benefits qualitatively due to time and resource limitations for this analysis. In the PM NAAQS RIA, these benefits were quantified in a sensitivity analysis, but not in the core analysis.

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

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

We follow a "damage-function" approach in calculating benefits, which estimates changes in individual health endpoints (specific effects that can be associated with changes in air quality) and assigns values to those changes assuming independence of the values for those individual endpoints. Because EPA rarely has the time or resources to perform new research to measure directly either the health outcomes or their values for regulatory analyses, our estimates are based on the best available methods of benefits transfer, which is the science and art of adapting primary research from similar contexts to estimate benefits for the environmental quality change under analysis.

The health impact assessment (HIA) quantifies the changes in the incidence of adverse health impacts resulting from changes in human exposure to $PM_{2.5}$ or other air pollutants. We use the environmental *Ben*efits *M*apping and *A*nalysis *P*rogram (BenMAP) to systematize health impact analyses by applying a database of key input parameters, including population projections, health impact functions, and valuation functions (Abt Associates, 2012). For this assessment, the HIA is limited to those health effects that are directly linked to ambient $PM_{2.5}$ concentrations. Epidemiological studies generally provide estimates of the relative risks of a particular health effect for a given increment of air pollution (often per 10 $\mu g/m^3$ for $PM_{2.5}$). These relative risks can be used to develop risk coefficients that relate a unit reduction in $PM_{2.5}$ to changes in the incidence of a health effect. We refer the reader to section 5.6 of the PM NAAQS RIA for more information regarding the epidemiology studies and risk coefficients applied in this analysis (U.S. EPA, 2012a), and we briefly elaborate on adult premature mortality below. The size of the mortality effect estimates from epidemiological studies, the serious nature of the effect itself, and the high monetary value ascribed to prolonging life make mortality risk reduction the most significant health endpoint quantified in this analysis.

Considering a substantial body of published scientific literature, reflecting thousands of epidemiology, toxicology, and clinical studies, the PM ISA documents the association between elevated $PM_{2.5}$ concentrations and adverse health effects, including increased premature mortality (U.S. EPA, 2009). The PM ISA, which was twice reviewed by the Clean Air Scientific Advisory Committee of EPA's Science Advisory Board (SAB-CASAC) (U.S. EPA-SAB, 2009b, 2009c), concluded that there is a causal relationship between mortality and both long-term and short-term exposure to $PM_{2.5}$ based on the entire body of scientific evidence. The PM ISA also 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.

For mortality, we use the effect coefficients from the most recent epidemiology studies examining two large population cohorts: the American Cancer Society cohort (Krewski et al., 2009) and the Harvard Six Cities cohort (Lepeule et al., 2012). The PM ISA (U.S. EPA, 2009) concluded that the ACS and Six Cities cohorts provide the strongest evidence of the association between long-term $PM_{2.5}$ exposure and premature mortality with support from a number of additional cohort studies. The SAB's Health Effects Subcommittee (SAB-HES) also supported using these two cohorts for analyses of the benefits of PM reductions (U.S. EPA-SAB, 2010a). As both the ACS and Six Cities cohort studies have inherent strengths and weaknesses, we present benefits estimates using relative risk estimates from both these cohorts (Krewski et al., 2009; Lepeule et al., 2012).

As a characterization of uncertainty regarding the $PM_{2.5}$ -mortality relationship, EPA graphically presents benefits derived from EPA's expert elicitation study (Roman et al., 2008; IEc, 2006). The primary goal of the 2006 study was to elicit from a sample of health experts probabilistic distributions describing uncertainty in estimates of the reduction in mortality among the adult U.S. population resulting from reductions in ambient annual average $PM_{2.5}$ levels. In that study, twelve experts provided independent opinions of the $PM_{2.5}$ -mortality concentration-response function. Because the experts relied upon the ACS and Six Cities cohort studies to inform their concentration-response functions, the benefits estimates derived from the expert responses generally fall between results derived from the these studies (see Figure 7-1). We do not combine the expert results in order to preserve the breadth and diversity of opinion on the expert panel. This presentation of the expert-derived results is generally consistent with SAB advice (U.S. EPA-SAB, 2008), which recommended that the EPA emphasize that "scientific differences existed only with respect to the magnitude of the effect of $PM_{2.5}$ on mortality, not whether such an effect existed" and that the expert elicitation "supports the conclusion that the benefits of $PM_{2.5}$ control are very likely to be substantial." Although it is possible that newer scientific literature could revise the experts' quantitative responses if elicited again, we believe that these general conclusions are unlikely to change.

### *4.1.2 Economic Valuation*

After quantifying the change in adverse health impacts, we estimate the economic value of these avoided impacts. Reductions in ambient concentrations of air pollution generally lower the risk of future adverse health effects by a small amount for a large population. Therefore, the appropriate economic measure is willingness to pay (WTP) for changes in risk of a health effect. For some health effects, such as hospital admissions, WTP estimates are generally not available, so we use the cost of treating or mitigating the effect. These cost-of-illness (COI) estimates generally (although not necessarily in every case) understate the true value of reductions in risk of a health effect. They tend to reflect the direct expenditures related to treatment but not the value of avoided pain and suffering from the health effect. The unit values applied in this analysis are provided in Table 5-9 of the PM NAAQS RIA for each health endpoint (U.S. EPA, 2012a).

Avoided premature deaths account for 98% of monetized PM-related benefits. The economics literature concerning the appropriate method for valuing reductions in premature mortality risk is still developing. The adoption of a value for the projected reduction in the risk of premature mortality is the subject of continuing discussion within the economics and public policy analysis community. Following the advice of the SAB's Environmental Economics Advisory Committee (SAB-EEAC), the EPA currently uses the value of statistical life (VSL) approach in calculating estimates of mortality benefits, because we believe this calculation provides the most reasonable single estimate of an individual's willingness to trade off money for reductions in mortality risk (U.S. EPA-SAB, 2000). The VSL approach is a summary measure for the value of small changes in mortality risk experienced by a large number of people.

EPA continues work to update its guidance on valuing mortality risk reductions, and the Agency consulted several times with the SAB-EEAC on the issue. 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, EPA 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)[11] 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 $6.3 million (2000$).[12]

We then adjust this VSL to account for the currency year used in this RIA and to account for income growth from 1990 to the analysis year. The adjusted value for VSL is $9.7 million ($2011). Further details on the methodology are available in section 5.6.8 of the PM RIA (U.S.EPA, 2012a).

[11]In the updated *Guidelines for Preparing Economic Analyses* (U.S. EPA, 2010e), 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.

[12]In 1990$, this VSL is $4.8 million.

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. In the process, the Agency has identified a number of important issues to be considered in updating its mortality risk valuation estimates. These are detailed in a white paper on "Valuing Mortality Risk Reductions in Environmental Policy," (U.S. EPA, 2010c) which recently underwent review by the SAB-EEAC. A meeting with the SAB on this paper was held on March 14, 2011 and formal recommendations were transmitted on July 29, 2011 (U.S. EPA-SAB, 2011). Draft guidance responding to SAB recommendations will be developed shortly.

In valuing premature mortality, we discount the value of premature mortality occurring in future years using rates of 3% and 7% (OMB, 2003). We assume that there is a "cessation" lag between changes in PM exposures and the total realization of changes in health effects. The distributed lag accounts for the expected distribution of avoided deaths according to the cause of death. The lag assumes that the initial proportion of deaths is due to cardiovascular outcomes, while the latter proportion is due to lung cancer. Although the structure of the lag is uncertain, the 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, 2004c). Changes in the cessation lag assumptions do not change the total number of estimated deaths but rather the timing of those deaths.

### *4.1.3 Benefit-per-Ton Estimates*

Due to analytical limitations, it was not possible to conduct air quality modeling for this rule. Instead, we used a "benefit-per-ton" approach to estimate the benefits of this rulemaking. EPA has applied in several previous RIAs (e.g., U.S. EPA, 2011b, 2011d, 2012b). These benefit-per-ton estimates provide the total monetized human health benefits (the sum of premature mortality and premature morbidity) of reducing one ton of $PM_{2.5}$ (or $PM_{2.5}$ precursor such as $NO_x$ or $SO_2$) from a specified source. Specifically, in this analysis, we multiplied the estimates from the "Other Non-EGU Point" sector[13,14] by the corresponding emission reductions. The method used to derive these estimates is described in the Technical Support Document (TSD) on estimating the benefits-per-ton of reducing $PM_{2.5}$ and its precursors from 17 sectors (U.S. EPA,

[13]As explained in the TSD (U.S. EPA, 2013), we only have benefit-per-ton estimates for certain analysis years (i.e., 2005, 2016, 2020, 2025, and 2030). For this RIA, we selected the benefit-per-ton estimate closest to the analysis year for this RIA.

[14][Data from year 2016 was used as closest to full implementation year 2018 for this rule, and the sector was matched with Non EGU Others category]

2013). One limitation of using the benefit-per-ton approach is an inability to provide estimates of the health benefits associated with exposure to HAP, CO, $NO_2$, or ozone.

The benefit-per-ton estimates described in the TSD (U.S. EPA, 2013) were derived using the approach published in Fann et al. (2012), but they have since been updated to reflect the studies and population data in the final PM NAAQS RIA (U.S. EPA, 2012a). The approach in Fann et al. (2012) is similar to the work previously published by Fann et al. (2009), but the newer study includes improvements that EPA believes would provide more reliable estimates of $PM_{2.5}$-related health benefits for emissions reductions in specific sectors. Specifically, the air quality modeling data reflect sectors that are more narrowly defined. In addition, the updated air quality modeling data reflects more recent emissions data (2005 rather than 2001) and has higher spatial resolution (12km rather than 36 km grid cells).

The benefit-per-ton of reducing directly emitted $PM_{2.5}$ from this sector represented by the above mentioned category is close to the median of the distribution of all 17 BPT values (TSD Table 7). For example, the sector's BPT for directly emitted $PM_{2.5}$ is close to the value for the Cement Kilns sector and smaller than the Ferroalloys sector, but greater than the value for the Coke Ovens or the Iron and Steel sectors. The size of the benefit-per-ton estimate is influenced in part by factors including: proximity of sources to population receptors; the baseline health status of the population receptors; and, dispersion characteristics of the emitting source.

As noted below in the characterization of uncertainty, all benefit-per-ton estimates have inherent limitations. Specifically, all national-average benefit-per-ton estimates reflect the geographic distribution of the modeled emissions, which may not exactly match the emission reductions in this rulemaking, and they may not reflect local variability in population density, meteorology, exposure, baseline health incidence rates, or other local factors for any specific location. The photochemical modeled emissions of the bricks sector-attributable $PM_{2.5}$ concentrations used to derive the BPT values may not match well the change in air quality resulting from the emissions controls described in Section 3. For this reason, the health benefits reported here may be larger, or smaller, than those realized by this rule.

Even though we assume that all fine particles have equivalent health effects, the benefit-per-ton estimates vary between precursors depending on the location and magnitude of their impact on $PM_{2.5}$ levels, which drive population exposure. The sector-specific modeling does not provide estimates of the $PM_{2.5}$-related benefits associated with reducing VOC emissions, but these unquantified benefits are generally small compared to other $PM_{2.5}$ precursors (U.S. EPA, 2012a).

### *4.1.4 $PM_{2.5}$ Co-benefits Results*

Table 4-2 summarizes the monetized PM-related health benefits by precursor pollutant, including the emission reductions and benefit-per-ton estimates using discount rates of 3% and 7%. Table 4-3 provides a summary of the reductions in health incidences associated with these pollution reductions. Figure 4-1 provides a visual representation of the range of $PM_{2.5}$-related benefits estimates using concentration-response functions from Krewski et al. (2009) and Lepeule et al. (2012) as well as the 12 functions supplied by experts. In Table 4-4, we provide the benefits using our anchor points of Krewski et al., and Lepeule et al., as well as the results from the 12 experts' elicitation on PM mortality.

### *4.1.5 Characterization of Uncertainty in the Monetized $PM_{2.5}$ Co-benefits*

In any complex analysis using estimated parameters and inputs from numerous models, there are likely to be many sources of uncertainty. This analysis is no exception. This analysis includes many data sources as inputs, including emission inventories, air quality data from models (with their associated parameters and inputs), population data, population estimates, health effect estimates from epidemiology studies, economic data for monetizing benefits, and assumptions regarding the future state of the world (i.e., regulations, technology, and human behavior). Each of these inputs may be uncertain and would affect the benefits estimate. When the uncertainties from each stage of the analysis are compounded, even small uncertainties can have large effects on the total quantified 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.

This RIA does not include the type of detailed uncertainty assessment found in the PM NAAQS RIA (U.S. EPA, 2012a) because we lack the necessary air quality input and monitoring data to run the benefits model. However, the results of the uncertainty analyses presented in the PM NAAQS RIA can provide some information regarding the uncertainty inherent in the benefits results presented in this analysis. Sensitivity analyses conducted for the PM NAAQS RIA indicate that alternate cessation lag assumptions could change the $PM_{2.5}$-related mortality benefits discounted at 3% by between 10% and −27% and that alternate income growth adjustments could change the $PM_{2.5}$-related mortality benefits by between 33% and −14%.

**Table 4-2. Summary of Monetized $PM_{2.5}$ and its Precursor $SO_2$- Related Health Co-benefits Estimates for the Brick and Structural Clay Rule in 2018 (2011$)[a,b]**

| Options | Pollutant | Emissions Reductions (tons) | Benefit-per-ton (Krewski, 3%) | Benefit-per-ton (Lepeule, 3%) | Benefit-per-ton (Krewski, 7%) | Benefit-per-ton (Lepeule, 7%) | Monetized Benefits (millions 2011$ at 3%) | Monetized Benefits (millions 2011$ at 7%) |
|---|---|---|---|---|---|---|---|---|
| Option 1 | Directly emitted $PM_{2.5}$ | 235 | $260,000 | $600,000 | $240,000 | $540,000 | $62 to $140 | $56 to $130 |
| | $PM_{2.5}$ Precursors | | | | | | | |
| | $SO_2$ | 168 | $41,000 | $92,000 | $37,000 | $83,000 | $6.8 to $15 | $6.1 to $14 |
| | $NO_x$ | -41 | $6,300 | $14,000 | $5,700 | $13,000 | -$0.26 to -$0.59 | -$0.23 to -$0.53 |
| | | | | | | **Total** | **$69 to $160** | **$62 to $140** |
| Final Rule: Option 2 | Directly emitted $PM_{2.5}$ | 308 | $260,000 | $600,000 | $240,000 | $540,000 | $82 to $180 | $74 to $170 |
| | $PM_{2.5}$ Precursors | | | | | | | |
| | $SO_2$ | 72 | $41,000 | $92,000 | $37,000 | $83,000 | $2.9 to $6.6 | $2.6 to $6.0 |
| | NOx | -46 | $6,300 | $14,000 | $5,700 | $13,000 | -$0.29 to -$0.66 | -$0.26 to -$0.59 |
| | | | | | | **Total** | **$84 to $190** | **$76 to $170** |
| Option 3 | Directly emitted $PM_{2.5}$ | 415 | $260,000 | $600,000 | $240,000 | $540,000 | $110 to $250 | $100 to $220 |
| | $PM_{2.5}$ Precursors | | | | | | | |
| | $SO_2$ | 568 | $41,000 | $92,000 | $37,000 | $83,000 | $23 to $52 | $21 to $47 |
| | NOx | -77 | $6,300 | $14,000 | $5,700 | $13,000 | -$0.49 to -$1.1 | -$0.44 to -$0.99 |
| | | | | | | **Total** | **$130 to $300** | **$120 to $270** |

[a] All estimates are rounded to two significant figures so numbers may not sum across columns. It is important to note that the monetized benefits do not include reduced health effects from direct exposure to $NO_2$, ozone exposure, ecosystem effects, or visibility impairment. All fine particles are assumed to have equivalent health effects, but the benefit per ton estimates vary depending on the location and magnitude of their impact on $PM_{2.5}$ levels, which drive population exposure. The monetized benefits incorporate the conversion from precursor emissions to ambient fine particles. Confidence intervals are unavailable for this analysis because of the benefit-per-ton methodology.

[b] These estimates reflect the net emissions impact after consideration of electricity disbenefits. These estimates do not include monetized $CO_2$ disbenefits, which range from $0.3 to $5 million depending on the option and discount rate.

### Table 4-3. Summary of Reductions in Health Incidences from $PM_{2.5}$ and its Precursor $SO_2$- Related Co-benefits for Brick and Structural Clay Rule in 2018[a]

| | Option 1 | Final Rule: Option 2 | Option 3 |
|---|---|---|---|
| **Avoided Premature Mortality** | | | |
| Krewski et al. (2009) (adult) | 8 | 10 | 15 |
| Lepeule et al. (2012) (adult) | 18 | 22 | 34 |
| **Avoided Morbidity** | | | |
| Emergency department visits for asthma (all ages) | 4 | 5 | 8 |
| Acute bronchitis (age 8–12) | 12 | 15 | 23 |
| Lower respiratory symptoms (age 7–14) | 150 | 190 | 290 |
| Upper respiratory symptoms (asthmatics age 9–11) | 220 | 270 | 420 |
| Minor restricted-activity days (age 18–65) | 6,100 | 7,500 | 12,000 |
| Lost work days (age 18–65) | 1,000 | 1,300 | 2,000 |
| Asthma exacerbation (age 6–18) | 230 | 280 | 430 |
| Hospital admissions—respiratory (all ages) | 2 | 3 | 4 |
| Hospital admissions—cardiovascular (age > 18) | 3 | 3 | 5 |
| *Non-Fatal Heart Attacks (age >18)* | | | |
| Peters et al. (2001) | 8 | 10 | 16 |
| Pooled estimate of 4 studies | 1 | 1 | 2 |

[a] All estimates are rounded to whole numbers with two significant figures. Confidence intervals are unavailable for this analysis because of the benefit-per-ton methodology. These estimates reflect the net impact after consideration of electricity disbenefits.

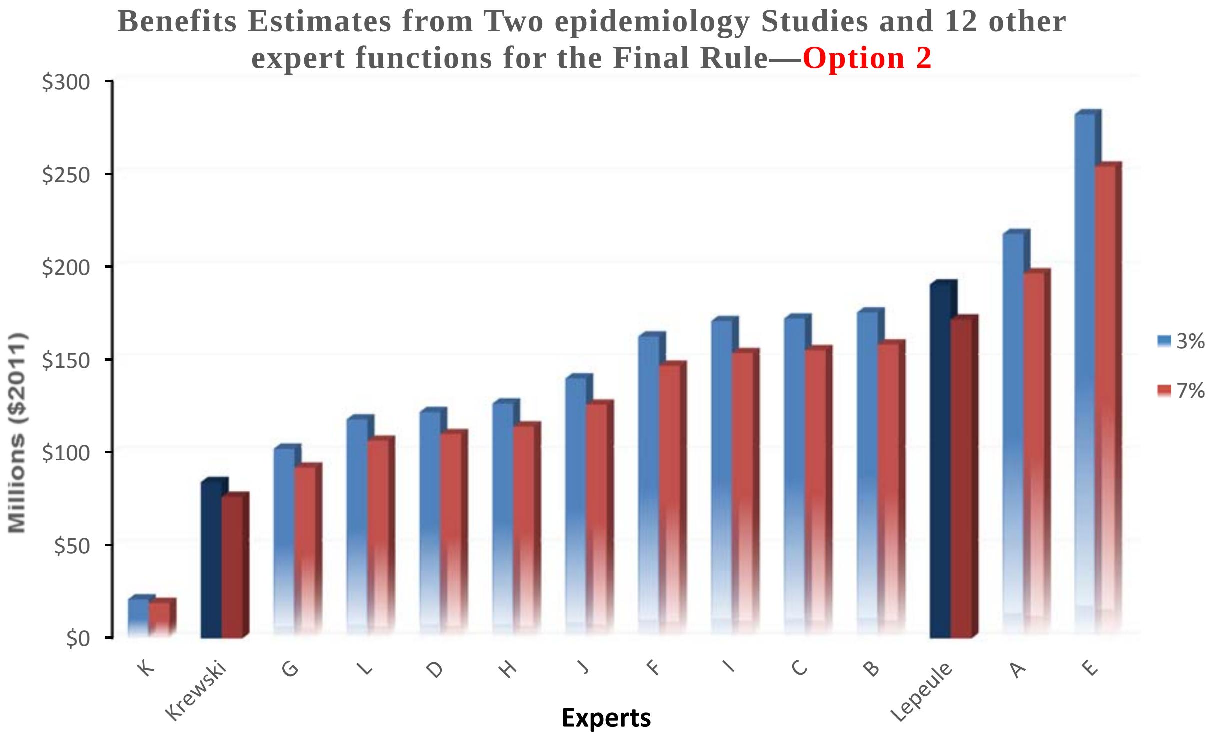


**Figure 4-1. Total Monetized $PM_{2.5}$ Co-benefits of Final Brick and Structural Clay Rule in 2018 [a,b]**

[a] This graph shows the estimated benefits at discount rates of 3% and 7% using effect coefficients derived from the Krewski et al. study and the Lepeule 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 functions provided in those studies.

[b] These estimates reflect the net emissions impact after consideration of electricity disbenefits. These estimates do not include monetized $CO_2$ disbenefits, which range from $0.3 to $5 million depending on the option and discount rate.

**Table 4-4. All $PM_{2.5}$ Benefits Estimates for the Brick and Structural Clay Rule in 2018 at Discount Rates of 3% and 7% Averaged ($2011 millions)[a,b]**

| | Option 1 | | Final Rule: Option 2 | | Option 3 | |
|---|---|---|---|---|---|---|
| | 3% | 7% | 3% | 7% | 3% | 7% |
| **Benefit-per-ton Coefficients Derived from Epidemiology Literature** | | | | | | |
| Krewski | $69 | $62 | $84 | $76 | $130 | $120 |
| Lepeule | $160 | $140 | $190 | $170 | $300 | $270 |
| **Benefit-per-ton Coefficients Derived from Expert Elicitation** | | | | | | |
| Expert A | $180 | $160 | $220 | $200 | $340 | $310 |
| Expert B | $140 | $130 | $180 | $160 | $280 | $250 |
| Expert C | $140 | $130 | $170 | $160 | $270 | $240 |
| Expert D | $99 | $90 | $120 | $110 | $190 | $170 |
| Expert E | $230 | $210 | $280 | $250 | $440 | $400 |
| Expert F | $130 | $120 | $160 | $150 | $260 | $230 |
| Expert G | $83 | $75 | $100 | $92 | $160 | $140 |
| Expert H | $100 | $93 | $130 | $110 | $200 | $180 |
| Expert I | $140 | $130 | $170 | $150 | $270 | $240 |
| Expert J | $110 | $100 | $140 | $130 | $220 | $200 |
| Expert K | $17 | $16 | $21 | $19 | $33 | $30 |
| Expert L | $96 | $87 | $120 | $110 | $180 | $170 |

[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.

[b] These estimates reflect the net emissions impact after consideration of electricity disbenefits. These estimates do not include monetized $CO_2$ disbenefits, which range from $0.3 to $5 million depending on the option and discount rate.

Unlike the PM NAAQS RIA, we do not have data on the specific location of the air quality changes associated with this rulemaking. As such, it is not feasible to estimate the proportion of benefits occurring in different locations, such as designated nonattainment areas. Instead, we applied benefit-per-ton estimates, which reflect specific geographic patterns of emissions reductions and specific air quality and benefits modeling assumptions for each sector (U.S. EPA, 2013). For example, these estimates 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 PM precursors. Use of these $/ton values to estimate benefits 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 emissions reductions occurring in any specific location, as these reflect on national or regional emission changes and therefore represent average benefits-per-ton over the entire United States (U.S. EPA, 2013). The benefits-per-ton for emission reductions in specific locations may be very different than the estimates presented here, and the approach above did not yield benefit per-ton estimates at a sub-national level for this sector. To the extent that the geographic distributions of the emissions reductions for this rule are different than the modeled emissions, the benefits may be underestimated or overestimated. In general, there is inherently more uncertainty for new sources, which may not be included in the emissions inventory, than existing sources. For more information, see the TSD describing the calculation of these benefit-per-ton estimates (U.S. EPA, 2013).

Our estimate of the total benefits is based on EPA's interpretation of the best available scientific literature and methods and supported by the SAB-HES and the NAS (NRC, 2002). Below are key assumptions underlying the estimates for premature mortality which accounts for 98% of the total monetized $PM_{2.5}$ benefits:

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

2. We assume that the health impact function for fine particles is log-linear without a threshold in this analysis. Thus, the estimates include health benefits from reducing fine particles in areas with varied concentrations of $PM_{2.5}$, including both areas that do not meet the fine particle standard and those areas that are in attainment, down to the lowest modeled concentrations.

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

In general, we are more confident in the magnitude of the risks we estimate from simulated $PM_{2.5}$ concentrations that coincide with the bulk of the observed PM concentrations in the epidemiological studies that are used to estimate the benefits. Likewise, we are less confident in the risk we estimate from simulated $PM_{2.5}$ concentrations that fall below the bulk of the observed data in these studies. Concentration benchmark analyses (e.g., lowest measured level [LML] or one standard deviation below the mean of the air quality data in the study) allow readers to determine the portion of population exposed to annual mean $PM_{2.5}$ levels at or above different concentrations, which provides some insight into the level of uncertainty in the estimated $PM_{2.5}$ mortality benefits. There are uncertainties inherent in identifying any particular point at which our confidence in reported associations becomes appreciably less, and the scientific evidence provides no clear dividing line. However, the EPA does not view these concentration benchmarks as a concentration threshold below which we would not quantify health benefits of air quality improvements.[15] Rather, the benefits estimates reported in this RIA are the best estimates because they reflect the full range of air quality concentrations associated with the emission reduction strategies and because the current body of scientific literature indicates that a no-threshold model provides the best estimate of PM-related long-term mortality. In other words, although we may have less confidence in the magnitude of the risk at concentrations below these benchmarks, we still have high confidence that $PM_{2.5}$ is causally associated with risk at those lower air quality concentrations.

For this analysis, policy-specific air quality data is not available due to time or resource limitations. For this rule, we are unable to estimate the percentage of premature mortality associated with this specific rule's emission reductions at each $PM_{2.5}$ level. However, we believe that it is still important to characterize the distribution of exposure to baseline air quality levels. As a surrogate measure of mortality impacts, we provide the percentage of the population exposed at each $PM_{2.5}$ level in the baseline of the source apportionment modeling used to calculate the benefit-per-ton estimates for this sector. It is important to note that baseline exposure is only one parameter in the health impact function, along with baseline incidence rates population, and change in air quality. In other words, the percentage of the population exposed to air pollution below the LML is not the same as the percentage of the population experiencing health impacts as a result of a specific emission reduction policy. The most important aspect, which we are unable to quantify for rules without rule-specific air quality modeling, is the shift in exposure associated with this specific rule. Therefore, caution is warranted when interpreting the LML assessment for this rule because these results are not consistent with results from rules that had air quality modeling.

[15]For a summary of the scientific review statements regarding the lack of a threshold in the $PM_{2.5}$-mortality relationship, see the Technical Support Document (TSD) entitled *Summary of Expert Opinions on the Existence of a Threshold in the Concentration-Response Function for $PM_{2.5}$-related Mortality* (U.S. EPA, 2010b).

Table 4-5 provides the percentage of the population exposed above and below two concentration benchmarks (i.e., LML and 1 standard deviation below the mean) in the modeled baseline. Figure 4-2 shows a bar chart of the percentage of the population exposed to various air quality levels in the baseline, and Figure 4-3 shows a cumulative distribution function of the same data. Both figures identify the LML for each of the major cohort studies.

**Table 4-5. Population Exposure in the Baseline Above and Below Various Concentration Benchmarks in the Underlying Epidemiology Studies[a]**

| Epidemiology Study | Below 1 Std. Dev. Below AQ Mean | At or Above 1 Std. Dev. Below AQ Mean | Below LML | At or Above LML |
|---|---|---|---|---|
| Krewski et al. (2009) | 89% | 11% | 7% | 93% |
| Lepeule et al. (2012) | N/A | N/A | 23% | 67% |

[a] One standard deviation below the mean is equivalent to the middle of the range between the $10^{th}$ and $25^{th}$ percentile. For Krewski, the LML is 5.8 µg/$m^3$ and one standard deviation below the mean is 11.0 µg/$m^3$. For Lepeule et al., the LML is 8 µg/$m^3$ and we do not have the data for one standard deviation below the mean. It is important to emphasize that although we have lower levels of confidence in levels below the LML for each study, the scientific evidence does not support the existence of a level below which health effects from exposure to $PM_{2.5}$ do not occur.

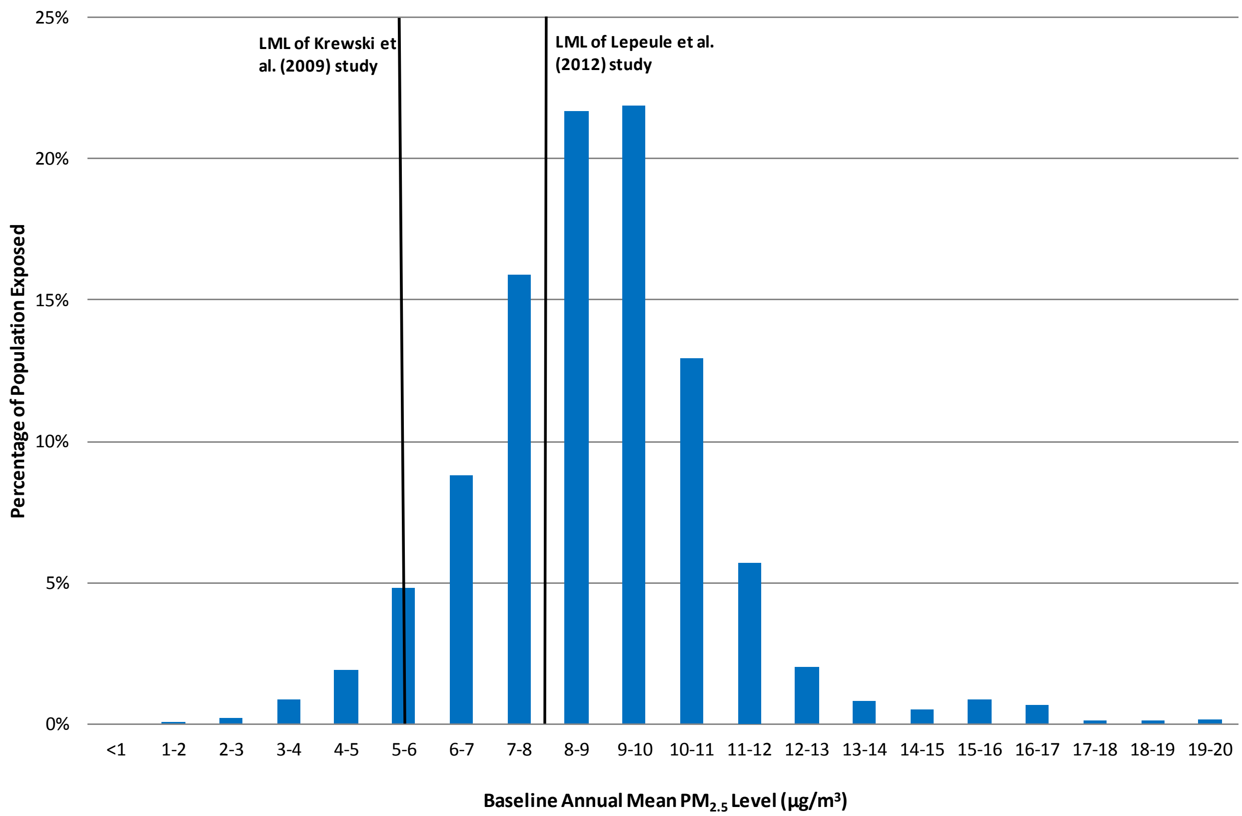


**Figure 4-2. Percentage of Adult Population by Annual Mean $PM_{2.5}$ Exposure in the Baseline**

**Among the populations exposed to $PM_{2.5}$ in the baseline:**

93% are exposed to $PM_{2.5}$ levels at or above the LML of the Krewski et al. (2009) study

67% are exposed to $PM_{2.5}$ levels at or above the LML of the Lepeule et al. (2012) study

## 4.2 Energy Disbenefits

In this section, we provide an estimate of the energy disbenefits associated with the increased emissions from additional energy usage. We estimate that electricity usage associated with operation of the control devices would increase. This electricity usage is anticipated to increase emissions of pollutants from electric utility boilers (EGU boilers) that supply electricity to these facilities. In the calculation of health benefits presented above, we have already subtracted the PM, $SO_2$, and NOx emission increases associated with increased electricity usage from the emission reductions associated with the regulatory requirements. Table 4-6 provides the estimated emission increases for each of the regulatory options analyzed in this RIA.

**Table 4-6. Emission Increases Associated with Secondary Energy Disbenefits (short tons per year)[a]**

| Option | Energy Impacts, MMBtu/yr | $PM_{2.5}$ | NOx | $SO_2$ | $CO_2$ |
|---|---|---|---|---|---|
| 1 | 419,022 | 1 | 41 | 121 | 25,337 |
| 2 | 461,329 | 1 | 46 | 133 | 27,896 |
| 3 | 783,978 | 2 | 78 | 226 | 47,406 |

[a] Emission increases for $PM_{2.5}$, NOx, and $SO_2$ have already been reflected in the monetized $PM_{2.5}$ co-benefits above.

### *4.2.1 Social Cost of Carbon and Greenhouse Gas Disbenefits*

We estimate the global social dis-benefits of $CO_2$ emission increases expected from the final rulemaking using the SC-$CO_2$ estimates presented in the *Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866 (May 2013, Revised July 2015)* ("current TSD").[16] We refer to these estimates, which were developed by the U.S. government, as "SC-$CO_2$ estimates." The SC-$CO_2$ is a metric that estimates the monetary value of impacts associated with marginal changes in $CO_2$ emissions in a given year. It includes a wide range of anticipated climate impacts, such as net changes in agricultural productivity and human health, property damage from increased flood risk, and changes in energy system costs, such as reduced costs for heating and increased costs for air conditioning. It is typically used to assess the avoided damages as a result of regulatory actions (i.e., benefits of rulemakings that lead to an incremental reduction in cumulative global $CO_2$ emissions) but is also used to assess increases in damages expected to result from rulemakings leading to an incremental increase in cumulative global $CO_2$ emissions.

The SC-$CO_2$ estimates used in this analysis were developed over many years, using the best science available, and with input from the public. Specifically, an interagency working group (IWG) that included the EPA and other executive branch agencies and offices used three integrated assessment models (IAMs) to develop the SC-$CO_2$ estimates and recommended four

[16] Docket ID EPA-HQ-OAR-2013-0495, Technical Support Document: *Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866*, Interagency Working Group on Social Cost of Carbon, with participation by Council of Economic Advisers, Council on Environmental Quality, Department of Agriculture, Department of Commerce, Department of Energy, Department of Transportation, Environmental Protection Agency, National Economic Council, Office of Energy and Climate Change, Office of Management and Budget, Office of Science and Technology Policy, and Department of Treasury (May 2013, Revised July 2015). Available at: <https://www.whitehouse.gov/sites/default/files/omb/inforeg/scc-tsd-final-july-2015.pdf> Accessed 7/11/2015.

global values for use in regulatory analyses. The SC-$CO_2$ estimates were first released in February 2010 and updated in 2013 using new versions of each IAM. As discussed further below, the IWG published two minor corrections to the SC-$CO_2$ estimates in July 2015.

The SC-$CO_2$ estimates were developed using an ensemble of the three most widely cited integrated assessment models in the economics literature with the ability to estimate the SC-$CO_2$. A key objective of the IWG was to draw from the insights of the three models while respecting the different approaches to linking GHG emissions and monetized damages taken by modelers in the published literature. After conducting an extensive literature review, the interagency group selected three sets of input parameters (climate sensitivity, socioeconomic and emissions trajectories, and discount rates) to use consistently in each model. All other model features were left unchanged, relying on the model developers' best estimates and judgments, as informed by the literature. Specifically, a common probability distribution for the equilibrium climate sensitivity parameter, which informs the strength of climate's response to atmospheric GHG concentrations, was used across all three models. In addition, a common range of scenarios for the socioeconomic parameters and emissions forecasts were used in all three models. Finally, the marginal damage estimates from the three models were estimated using a consistent range of discount rates, 2.5, 3.0, and 5.0%. See the 2010 TSD for a complete discussion of the methods used to develop the estimates and the key uncertainties, and the current TSD for the latest estimates.[17]

The 2010 TSD noted a number of limitations to the SC-$CO_2$ analysis, including the incomplete way in which the integrated assessment models capture catastrophic and non-catastrophic impacts, their incomplete treatment of adaptation and technological change, uncertainty in the extrapolation of damages to high temperatures, and assumptions regarding risk aversion. Currently integrated assessment models do not assign value to all of the important physical, ecological, and economic impacts of climate change recognized in the climate change literature due to a lack of precise information on the nature of damages and because the science incorporated into these models understandably lags behind the most recent research.[18] The limited amount of research linking climate impacts to economic damages makes the modeling exercise even more difficult. These individual limitations do not all work in the same direction in terms of their influence on the SC-$CO_2$ estimates, though taken together they suggest that the

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[17] See https://www.whitehouse.gov/omb/oira/social-cost-of-carbon for both TSDs.

[18] Climate change impacts and SCC modeling is an area of active research. For example, see: (1) Howard, Peter, "Omitted Damages: What's Missing from the Social Cost of Carbon." March 13, 2014, http://costofcarbon.org/files/Omitted_Damages_Whats_Missing_From_the_Social_Cost_of_Carbon.pdf; and (2) Electric Power Research Institute, "Understanding the Social Cost of carbon: A Technical Assessment," October 2014, www.epri.com.

$SC\text{-}CO_2$ estimates are likely conservative. In particular, the IPCC Fourth Assessment Report (2007), which was the most current IPCC assessment available at the time of the IWG's 2009-2010 review, concluded that "It is very likely that [$SC\text{-}CO_2$ estimates] underestimate the damage costs because they cannot include many non-quantifiable impacts." Since then, the peer-reviewed literature has continued to support this conclusion. For example, the IPCC Fifth Assessment report observed that $SC\text{-}CO_2$ estimates continue to omit various impacts that would likely increase damages. The 95th percentile estimate was included in the recommended range for regulatory impact analysis to address these concerns.

Accordingly, EPA and other agencies continue to engage in research on modeling and valuation of climate impacts with the goal to improve these estimates. The EPA and other agencies also continue to consider feedback on the $SC\text{-}CO_2$ estimates from stakeholders through a range of channels, including public comments on Agency rulemakings that use the $SC\text{-}CO_2$ in supporting analyses and through regular interactions with stakeholders and research analysts implementing the $SC\text{-}CO_2$ methodology used by the interagency working group. In addition, OMB's Office of Information and Regulatory Affairs sought public comment on the approach used to develop the $SC\text{-}CO_2$ estimates through a separate comment period that ended on February 26, 2014.[19]

After careful evaluation of the full range of comments, the interagency working group continues to recommend the use of the $SC\text{-}CO_2$ estimates in regulatory impact analysis.[20] With the release of the response to comments, the interagency working group announced plans to obtain expert independent advice from the National Academies of Sciences, Engineering, and Medicine to ensure that the $SC\text{-}CO_2$ estimates continue to reflect the best available scientific and economic information on climate change. The Academies review will be informed by the public comments received and focus on the technical merits and challenges of potential approaches to improving the $SC\text{-}CO_2$ estimates in future updates.

Concurrent with OMB's publication of the response to comments on $SC\text{-}CO_2$ and announcement of the Academies process, OMB posted a revised TSD that includes two minor technical corrections to the current estimates.[21] One technical correction addressed an inadvertent omission of climate change damages in the last year of analysis (2300) in one model and the second addressed a minor indexing error in another model. On average the revised $SC\text{-}CO_2$

[19] See https://www.federalregister.gov/articles/2013/11/26/2013-28242/technical-support-document-technical-update-of-the-social-cost-of-carbon-for-regulatory-impact

[20] See https://www.whitehouse.gov/blog/2015/07/02/estimating-benefits-carbon-dioxide-emissions-reductions

[21] See https://www.whitehouse.gov/omb/oira/social-cost-of-carbon for the response to comments, the blog post announcing the Academies' process, and the current TSD.

estimates are one dollar less than the mean SC-$CO_2$ estimates reported in the November 2013 TSD. The change in the estimates associated with the 95th percentile estimates when using a 3% discount rate is slightly larger, as those estimates are heavily influenced by the results from the model that was affected by the indexing error.

The four SC-$CO_2$ estimates are: $13, $43, $64, and $120 per metric ton of $CO_2$ emissions in the year 2018 (2011 dollars).[22] The first three values are based on the average SC-$CO_2$ from the three IAMs, at discount rates of 5, 3, and 2.5%, respectively. Estimates of the SC-$CO_2$ for several discount rates are included because the literature shows that the SC-$CO_2$ is sensitive to assumptions about the discount rate, and because no consensus exists on the appropriate rate to use in an intergenerational context (where costs and benefits are incurred by different generations). The fourth value is the 95$^{th}$ percentile of the SC-$CO_2$ across all three models at a 3% discount rate. It is included to represent higher-than-expected impacts from temperature change further out in the tails of the SC-$CO_2$ distribution. The SC-$CO_2$ increases over time because future emissions are expected to produce larger incremental damages as economies grow and physical and economic systems become more stressed in response to greater climate change.

**Table 4-7. Estimated Global Disbenefits of $CO_2$ Increases in 2018 (million 2011$)**

| | | Discount Rate and Statistic | | | |
|---|---|---|---|---|---|
| **Option** | **Metric Tonnes of $CO_2$ Reduced** | **5% (average)** | **3% (average)** | **2.5% (average)** | **3% (95$^{th}$ percentile)** |
| 1 | 22,985 | $0.29 | $1.0 | $1.5 | $2.8 |
| 2 | 25,307 | $0.32 | $1.1 | $1.6 | $3.1 |
| 3 | 43,006 | $0.55 | $1.8 | $2.7 | $5.3 |

After incorporating the $CO_2$ electricity disbenefits, the total monetized benefits of the final rule (Option 2) are $83 to $190 million at a 3% discount rate.

### 4.3 Unquantified Benefits

The monetized benefits estimated in this RIA only reflect a subset of benefits attributable to the health effect reductions associated with ambient fine particles. Data, time, and resource limitations prevented EPA from quantifying the impacts to, or monetizing the benefits from several important benefit categories, including benefits associated with the potential exposure to

[22] The TSDs present SC-CO2 in $2007. The estimates were adjusted to 2012$ using the GDP Implicit Price Deflator. Also available at: http://www.gpo.gov/fdsys/pkg/ECONI-2013-02/pdf/ECONI-2013-02-Pg3.pdf. The SC-$CO_2$ values have been rounded to two significant digits. Unrounded numbers from the 2013 SCC TSD were adjusted to 2012$ and used to calculate the $CO_2$ benefits.

HAP, ecosystem effects, and visibility impairment due to the absence of air quality modeling data for these pollutants in this analysis. This does not imply that there are no benefits associated with these emission reductions. In this section, we provide a qualitative description of these benefits. Below is a detailed qualitative assessment of health benefits related to multiple HAPs that have been reduced among including HAPs metals (i.e. antimony, arsenic, beryllium, cadmium, chromium, cobalt, lead, manganese, mercury, nickel, and selenium).

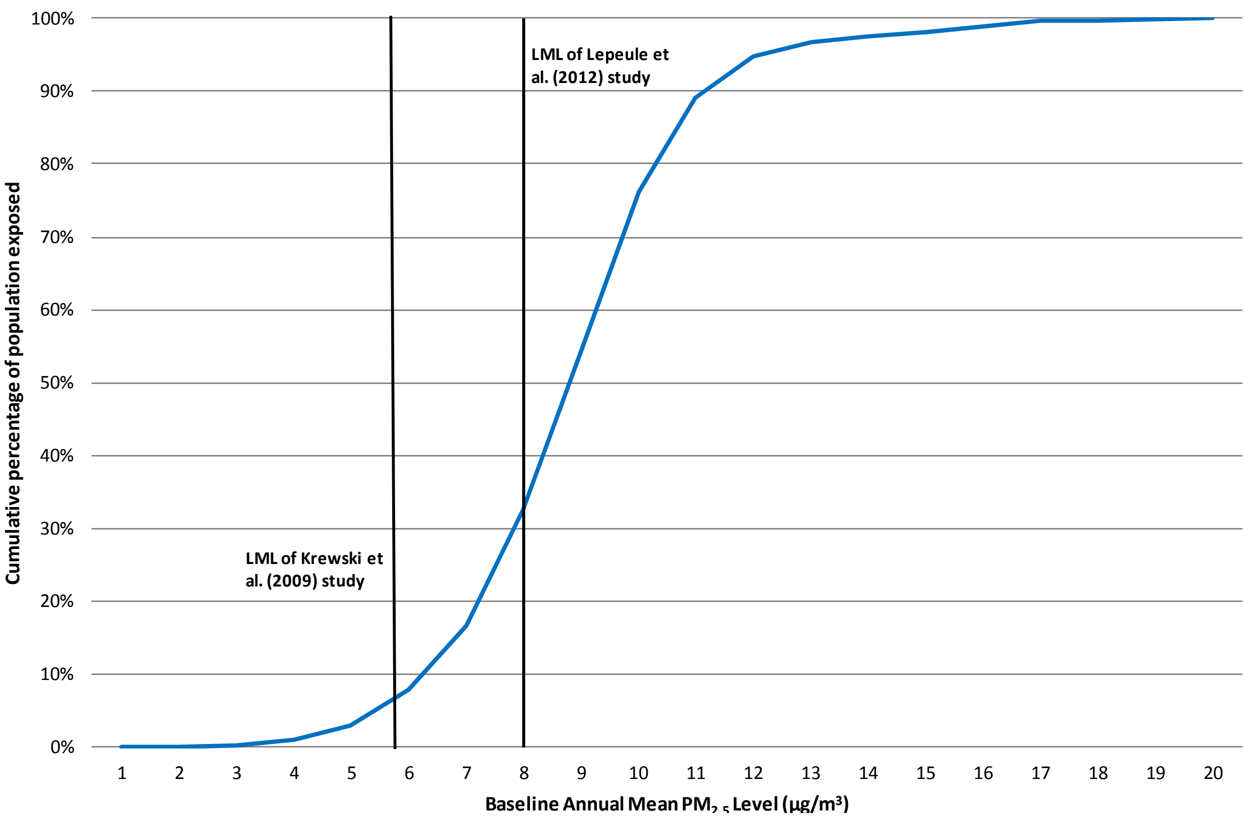


**Figure 4-3. Cumulative Distribution of Adult Population by Annual Mean $PM_{2.5}$ Exposure in the Baseline**

**Among the populations exposed to $PM_{2.5}$ in the baseline:**

93% are exposed to $PM_{2.5}$ levels at or above the LML of the Krewski et al. (2009) study

67% are exposed to $PM_{2.5}$ levels at or above the LML of the Lepeule et al. (2012) study

### *4.3.1 HAP Benefits*

Even though emissions of air toxics from all sources in the U.S. declined by approximately 42% since 1990, the 2005 National-Scale Air Toxics Assessment (NATA)[23]

[23] The NATA modeling framework has a number of limitations that prevent its use as the sole basis for setting regulatory standards. These limitations and uncertainties are discussed on the 2005 NATA website. Even so, this modeling framework is very useful in identifying air toxic pollutants and sources of greatest concern, setting

predicts that most Americans are exposed to ambient concentrations of air toxics at levels that have the potential to cause adverse health effects (U.S. EPA, 2011c).[24] The levels of air toxics to which people are exposed vary depending on where people live and work and the kinds of activities in which they engage. NATA includes four steps:

1. Compiling a national emissions inventory of air toxics emissions from outdoor sources

2. Estimating ambient and exposure concentrations of air toxics across the United States utilizing dispersion models

3. Estimating population exposures across the United States utilizing exposure models

4. Characterizing potential public health risk due to inhalation of air toxics including both cancer and noncancer effects

Based on the 2005 NATA, EPA estimates that about 5% of census tracts nationwide have increased cancer risks greater than 100 in a million. The average national cancer risk is about 50 in a million. Nationwide, the key pollutants that contribute most to the overall cancer risks are formaldehyde and benzene.[25] Secondary formation (e.g., formaldehyde forming from other emitted pollutants) was the largest contributor to cancer risks, while stationary, mobile and background sources contribute almost equal portions of the remaining cancer risk.

Noncancer health effects can result from chronic,[26] subchronic,[27] or acute[28] inhalation exposures to air toxics, and include neurological, cardiovascular, liver, kidney, and respiratory effects as well as effects on the immune and reproductive systems. According to the 2005 NATA, about three-fourths of the U.S. population was exposed to an average chronic concentration of air toxics that has the potential for adverse noncancer respiratory health effects.

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regulatory priorities, and informing the decision making process. U.S. EPA (2011). 2005 National-Scale Air Toxics Assessment. http://www.epa.gov/ttn/atw/nata2005/

[24]The 2005 NATA is available on the Internet at http://www.epa.gov/ttn/atw/nata2005/.

[25]Details about the overall confidence of certainty ranking of the individual pieces of NATA assessments including both quantitative (e.g., model-to-monitor ratios) and qualitative (e.g., quality of data, review of emission inventories) judgments can be found at http://www.epa.gov/ttn/atw/nata/roy/page16.html.

[26]Chronic exposure is defined in the glossary of the Integrated Risk Information (IRIS) database (http://www.epa.gov/iris) as repeated exposure by the oral, dermal, or inhalation route for more than approximately 10% of the life span in humans (more than approximately 90 days to 2 years in typically used laboratory animal species).

[27]Defined in the IRIS database as repeated exposure by the oral, dermal, or inhalation route for more than 30 days, up to approximately 10% of the life span in humans (more than 30 days up to approximately 90 days in typically used laboratory animal species).

[28]Defined in the IRIS database as exposure by the oral, dermal, or inhalation route for 24 hours or less.

Results from the 2005 NATA indicate that acrolein is the primary driver for noncancer respiratory risk.

Figures 4-4 and 4-5 depict the 2005 NATA estimated census tract-level carcinogenic risk and noncancer respiratory hazard from the assessment. It is important to note that large reductions in HAP emissions may not necessarily translate into significant reductions in health risk because toxicity varies by pollutant, and exposures may or may not exceed levels of concern. Thus, it is important to account for the toxicity and exposure, as well as the mass of the targeted emissions.

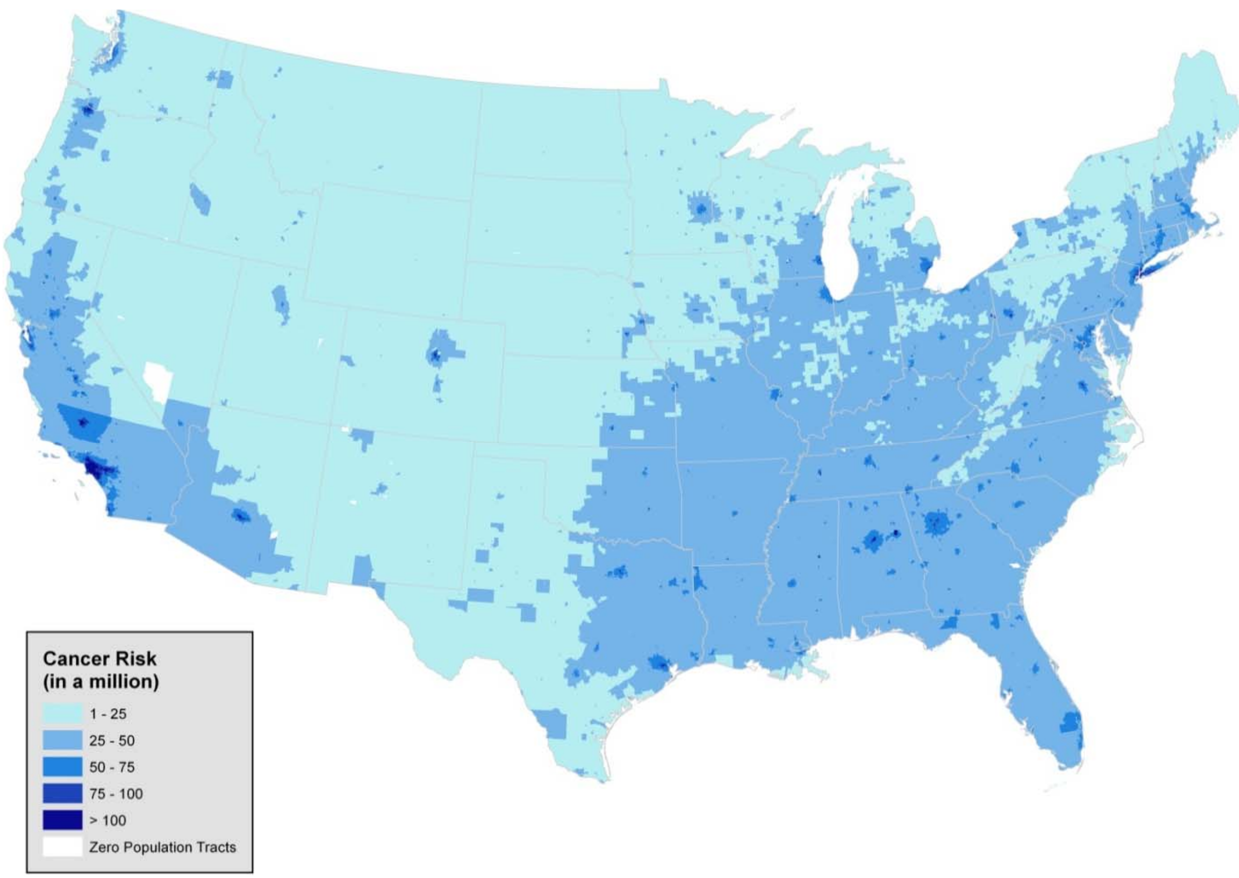


**Figure 4-4. 2005 NATA Model Estimated Census Tract Carcinogenic Risk from HAP Exposure from Emissions of All Outdoor Sources (inclusive of other nonpoint sources) based on the 2005 National Toxic Inventory**

Because of 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. In a few previous analyses of the benefits of reductions in HAP, EPA has quantified the benefits of potential reductions in the incidences of cancer and non-cancer risk (e.g., U.S. EPA, 1995). In those analyses, EPA relied on unit risk factors (URF) and reference concentrations (RfC) developed through risk assessment procedures. The URF is a quantitative estimate of the carcinogenic potency of a pollutant, often expressed as the probability of contracting cancer from a 70-year lifetime continuous exposure to a concentration of one µg/m3 of a pollutant. These URFs are designed to be conservative, and as such, are more likely to represent the high end of the distribution of risk rather than a best or most likely estimate of risk.

An RfC is an estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious non-cancer health effects during a lifetime.

As the purpose of a benefit analysis is to describe the benefits most likely to occur from a reduction in pollution, use of high-end, conservative risk estimates would overestimate the benefits of the regulation. While we used high-end risk estimates in past analyses, advice from the EPA's Science Advisory Board (SAB) recommended that we avoid using high-end estimates in benefit analyses (U.S. EPA-SAB, 2002). Since this time, EPA has continued to develop better methods for analyzing the benefits of reductions in HAP.

As part of the second prospective analysis of the benefits and costs of the Clean Air Act (U.S. EPA, 2011a), EPA conducted a case study analysis of the health effects associated with reducing exposure to benzene in Houston from implementation of the Clean Air Act (IEc, 2009). While reviewing the draft report, EPA's Advisory Council on Clean Air Compliance Analysis concluded that "the challenges for assessing progress in health improvement as a result of reductions in emissions of hazardous air pollutants (HAPs) are daunting ... due to a lack of exposure-response functions, uncertainties in emissions inventories and background levels, the difficulty of extrapolating risk estimates to low doses and the challenges of tracking health progress for diseases, such as cancer, that have long latency periods" (U.S. EPA-SAB, 2008).

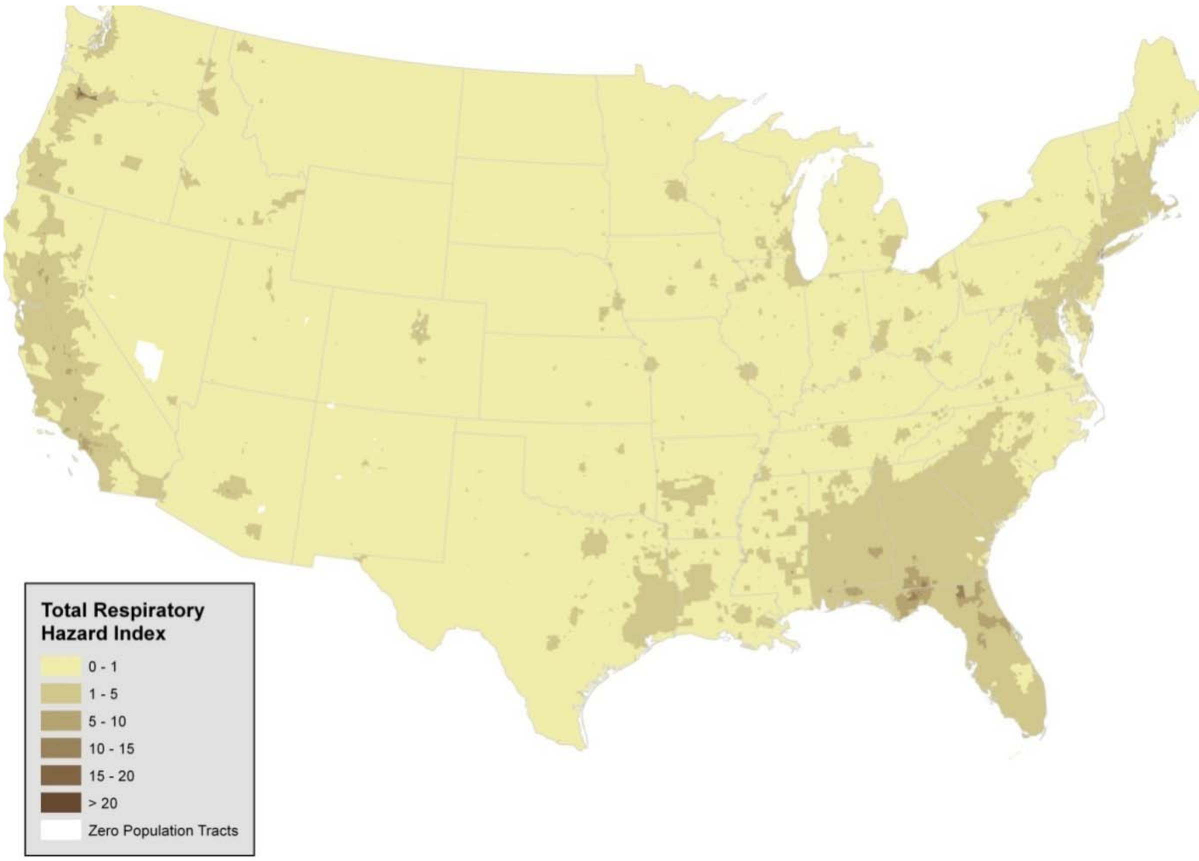


**Figure 4-5. 2005 NATA Model Estimated Census Tract Noncancer Risk from HAP Exposure from Emissions of All Outdoor Sources (inclusive of other nonpoint sources) based on the 2005 National Toxic Inventory**

In 2009, EPA convened a workshop to address the inherent complexities, limitations, and uncertainties in current methods to quantify the benefits of reducing HAP. Recommendations from this workshop included identifying research priorities, focusing on susceptible and vulnerable populations, and improving dose-response relationships (Gwinn et al., 2011).

In summary, monetization of the benefits of reductions in cancer incidences requires several important inputs, including central estimates of cancer risks, estimates of exposure to carcinogenic HAP, and estimates of the value of an avoided case of cancer (fatal and non-fatal). Due to methodology and time limitations under the court-ordered schedule, we did not attempt to monetize the health benefits of reductions in HAP in this analysis. Instead, we provide a qualitative analysis of the health effects associated with the HAP anticipated to be reduced by these rules. EPA remains committed to improving methods for estimating HAP benefits by continuing to explore additional concepts of benefits, including changes in the distribution of risk.

Below we describe the health effects associated with the HAP that would be reduced by this rulemaking, including 2 tons of chlorine, 22 tons of hydrogen chloride, 344 tons of hydrogen fluoride, 147 pounds of mercury, and 7 tons of other metal HAP (e.g., arsenic, cadmium, chromium, lead, manganese, nickel, and selenium).

#### *4.3.1.1 Arsenic*

Arsenic, a naturally occurring element, is found throughout the environment and is considered toxic through the oral, inhalation and dermal routes. Acute (short-term) high-level inhalation exposure to As dust or fumes has resulted in gastrointestinal effects (nausea, diarrhea, abdominal pain, and gastrointestinal hemorrhage); central and peripheral nervous system disorders have occurred in workers acutely exposed to inorganic As. Chronic (long-term) inhalation exposure to inorganic As in humans is associated with irritation of the skin and mucous membranes. Chronic inhalation can also lead to conjunctivitis, irritation of the throat and respiratory tract and perforation of the nasal septum.[29] Chronic oral exposure has resulted in gastrointestinal effects, anemia, peripheral neuropathy, skin lesions, hyperpigmentation, and liver or kidney damage in humans. Inorganic As exposure in humans, by the inhalation route, has been shown to be strongly associated with lung cancer, while ingestion of inorganic As in humans has been linked to a form of skin cancer and also to bladder, liver, and lung cancer. EPA has classified inorganic As a Group A, human carcinogen.[30]

#### *4.3.1.2 Cadmium (Cd)*[31]

Breathing air with lower levels of Cd over long periods of time (for years) results in a build-up of Cd in the kidney, and if sufficiently high, may result in kidney disease. Lung cancer has been found in some studies of workers exposed to Cd in the air and studies of rats that inhaled Cd. The U.S. DHHS has determined that Cd and Cd compounds are known human carcinogens. The IARC has determined that Cd is carcinogenic to humans. EPA has determined that Cd is a probable human carcinogen.

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[29] Agency for Toxic Substances and Disease Registry (ATSDR). Medical Management Guidelines for Arsenic. Atlanta, GA: U.S. Department of Health and Human Services. Available on the Internet at < http://www.atsdr.cdc.gov/mhmi/mmg168.html#bookmark02>

[30] U.S. Environmental Protection Agency (U.S. EPA). 1998. Integrated Risk Information System File for Arsenic. Research and Development, National Center for Environmental Assessment, Washington, DC. This material is available electronically at: http://www.epa.gov/iris/subst/0278.htm.

[31] 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>.

*4.3.1.3 Chlorine ($Cl_2$)*

The acute (short term) toxic effects of $Cl_2$ are primarily due to its corrosive properties. Chlorine is a strong oxidant that upon contact with water moist tissue (e.g., eyes, skin, and upper respiratory tract) can produce major tissue damage.[32] Chronic inhalation exposure to low concentrations of $Cl_2$ (1 to 10 parts per million, ppm) may cause eye and nasal irritation, sore throat, and coughing. Chronic exposure to $Cl_2$, usually in the workplace, has been reported to cause corrosion of the teeth. Inhalation of higher concentrations of $Cl_2$ gas (greater than 15 ppm) can rapidly lead to respiratory distress with airway constriction and accumulation of fluid in the lungs (pulmonary edema). Exposed individuals may have immediate onset of rapid breathing, blue discoloration of the skin, wheezing, Rales, or hemoptysis (coughing up blood or blood-stain sputum). Intoxication with high concentrations of $Cl_2$ may induce lung collapse. Exposure to $Cl_2$ can lead to reactive airways dysfunction syndrome (RADS), a chemical irritant-induced type of asthma. Dermal exposure to $Cl_2$ may cause irritation, burns, inflammation and blisters. EPA has not classified $Cl_2$ with respect to carcinogenicity.

*4.3.1.4 Chromium (Cr)*[33]

Chromium may be emitted in two forms, trivalent Cr (Cr+3) or hexavalent Cr (Cr+6). The respiratory tract is the major target organ for $Cr^{+6}$ toxicity, for acute and chronic inhalation exposures. Shortness of breath, coughing, and wheezing have been reported from acute exposure to $Cr^{+6}$, while perforations and ulcerations of the septum, bronchitis, decreased pulmonary function, pneumonia, and other respiratory effects have been noted from chronic exposures. Limited human studies suggest that $Cr^{+6}$ inhalation exposure may be associated with complications during pregnancy and childbirth, but there are no supporting data from animal studies reporting reproductive effects from inhalation exposure to $Cr^{+6}$. Human and animal studies have clearly established the carcinogenic potential of $Cr^{+6}$ by the inhalation route, resulting in an increased risk of lung cancer. EPA has classified $Cr^{+6}$ as a Group A, human carcinogen. Trivalent Cr is less toxic than $Cr^{+6}$. The respiratory tract is also the major target organ for $Cr^{+3}$ toxicity, similar to $Cr^{+6}$. EPA has not classified $Cr^{+3}$ with respect to carcinogenicity.

[32] Agency for Toxic Substances and Disease Registry (ATSDR). Medical Management Guidelines for Chlorine. Atlanta, GA: U.S. Department of Health and Human Services. http://www.atsdr.cdc.gov/mmg/mmg.asp?id=198&tid=36.

[33] U.S. Environmental Protection Agency. Integrated Risk Information System (IRIS) on Chromium VI. National Center for Environmental Assessment, Office of Research and Development, Washington, DC. 1999.

#### *4.3.1.5 Hydrogen Chloride (HCl)*

Hydrogen chloride is a corrosive gas that can cause irritation of 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.[34] 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. Exposure to HCl can lead to 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.[35]

#### *4.3.1.6 Hydrogen Cyanide (HCN)*[36]

Hydrogen cyanide is highly toxic by all routes of exposure and may cause abrupt onset of profound central nervous system, cardiovascular, and respiratory effects, leading to death within minutes. Exposure to lower concentrations of hydrogen cyanide may produce eye irritation, headache, confusion, nausea, and vomiting followed in some cases by coma and death. Hydrogen cyanide acts as a cellular asphyxiant. By binding to mitochondrial cytochrome oxidase, it prevents the utilization of oxygen in cellular metabolism. The central nervous system and myocardium are particularly sensitive to the toxic effects of cyanide.

#### *4.3.1.7 Hydrogen Fluoride (HF)*[37]

Acute (short-term) inhalation exposure to gaseous HF can cause severe respiratory damage in humans, including severe irritation and pulmonary edema. Chronic (long-term) oral

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[34] Agency for Toxic Substances and Disease Registry (ATSDR). Medical Management Guidelines for Hydrogen Chloride. Atlanta, GA: U.S. Department of Health and Human Services. Available online at http://www.atsdr.cdc.gov/mmg/mmg.asp?id=758&tid=147#bookmark02.

[35] U.S. Environmental Protection Agency (U.S. EPA). 1995. Integrated Risk Information System File of Hydrogen Chloride. Research and Development, National Center for Environmental Assessment, Washington, DC. This material is available electronically at .http://www.epa.gov/iris/subst/0396.htm.

[36] All health effects language for this section came from: Agency for Toxic Substances and Disease Registry (ATSDR). 2007. Medical Management Guidelines for Hydrogen Cyanide (HCN) (CAS#: 7782-50-5). Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service. Available on the Internet at http://www.atsdr.cdc.gov/Mhmi/mmg8.html#bookmark02.

[37] U.S. Environmental Protection Agency. Health Issue Assessment: Summary Review of Health Effects Associated with Hydrogen Fluoride and Related Compounds. EPA/600/8-89/002F. Environmental Criteria and Assessment Office, Office of Health and Environmental Assessment, Office of Research and Development, Cincinnati, OH. 1989.

exposure to fluoride at low levels has a beneficial effect of dental cavity prevention and may also be useful for the treatment of osteoporosis. Exposure to higher levels of fluoride may cause dental fluorosis. One study reported menstrual irregularities in women occupationally exposed to fluoride via inhalation. The EPA has not classified HF for carcinogenicity.

#### *4.3.1.8 Lead (Pb)*[38]

The main target for Pb toxicity is the nervous system, both in adults and children. Long-term exposure of adults to Pb 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.

Children are more sensitive to the health effects of Pb than adults. No safe blood Pb level in children has been determined. At lower levels of exposure, Pb can affect a child's mental and physical growth. Fetuses exposed to Pb in the womb may be born prematurely and have lower weights at birth. Exposure in the womb, in infancy, or in early childhood also may slow mental development and cause lower intelligence later in childhood. There is evidence that these effects may persist beyond childhood.

There are insufficient data from epidemiologic studies alone to conclude that Pb causes cancer (is carcinogenic) in humans. The DHHS has determined that Pb and Pb 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 Pb is a probable human carcinogen.

#### *4.3.1.9 Manganese (Mn)*[39]

Health effects in humans have been associated with both deficiencies and excess intakes of Mn. Chronic exposure to high levels of Mn by inhalation in humans results primarily in central nervous system effects. Visual reaction time, hand steadiness, and eye-hand coordination were affected in chronically-exposed workers. Manganism, characterized by feelings of weakness and lethargy, tremors, a masklike face, and psychological disturbances, may result from chronic exposure to higher levels. Impotence and loss of libido have been noted in male

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[38]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>.

[39]U.S. Environmental Protection Agency. Integrated Risk Information System (IRIS) on Manganese. National Center for Environmental Assessment, Office of Research and Development, Washington, DC. 1999.

workers afflicted with Manganism attributed to inhalation exposures. The EPA has classified Mn in Group D, not classifiable as to carcinogenicity in humans.

#### *4.3.1.10 Mercury (Hg)*

Mercury in the environment is transformed into a more toxic form, methylmercury (MeHg). Because Hg is a persistent pollutant, MeHg accumulates in the food chain, especially the tissue of fish. When people consume these fish, they consume MeHg. In 2000, the NAS Study was issued which provides a thorough review of the effects of MeHg on human health.[40] Many of the peer-reviewed articles cited in this section are publications originally cited in the MeHg Study. In addition, the EPA has conducted literature searches to obtain other related and more recent publications to complement the material summarized by the NRC in 2000.

In its review of the literature, the NAS found neurodevelopmental effects to be the most sensitive and best documented endpoints and appropriate for establishing an RfD;[39] in particular NAS supported the use of results from neurobehavioral or neuropsychological tests. The NAS report noted that studies in animals reported sensory effects as well as effects on brain development and memory functions and support the conclusions based on epidemiology studies. The NAS noted that their recommended endpoints for an RfD are associated with the ability of children to learn and to succeed in school. They concluded the following: "The population at highest risk is the children of women who consumed large amounts of fish and seafood during pregnancy. The committee concludes that the risk to that population is likely to be sufficient to result in an increase in the number of children who have to struggle to keep up in school."

The NAS summarized data on cardiovascular effects available up to 2000. Based on these and other studies, the NRC concluded that "Although the data base is not as extensive for cardiovascular effects as it is for other end points (i.e. neurologic effects) the cardiovascular system appears to be a target for MeHg toxicity in humans and animals." The NRC also stated that "additional studies are needed to better characterize the effect of methylmercury exposure on blood pressure and cardiovascular function at various stages of life."

Additional cardiovascular studies have been published since 2000. The EPA did not to develop a quantitative dose-response assessment for cardiovascular effects associated with MeHg exposures, as there is no consensus among scientists on the dose-response functions for these effects. In addition, there is inconsistency among available studies as to the association between MeHg exposure and various cardiovascular system effects. The pharmacokinetics of

[40]National Research Council (NRC). 2000. *Toxicological Effects of Methylmercury*. Washington, DC: National Academies Press.

some of the exposure measures (such as toenail Hg levels) are not well understood. The studies have not yet received the review and scrutiny of the more well-established neurotoxicity data base.

The Mercury Study[41] noted that MeHg is not a potent mutagen but is capable of causing chromosomal damage in a number of experimental systems. The NAS concluded that evidence that human exposure to MeHg caused genetic damage is inconclusive; they note that some earlier studies showing chromosomal damage in lymphocytes may not have controlled sufficiently for potential confounders. One study of adults living in the Tapajós River region in Brazil reported a direct relationship between MeHg concentration in hair and DNA damage in lymphocytes; as well as effects on chromosomes.[42] Long-term MeHg exposures in this population were believed to occur through consumption of fish, suggesting that genotoxic effects (largely chromosomal aberrations) may result from dietary, chronic MeHg exposures similar to and above those seen in the Faroes and Seychelles populations.

Although exposure to some forms of Hg can result in a decrease in immune activity or an autoimmune response,[43] evidence for immunotoxic effects of MeHg is limited.[39]

Based on limited human and animal data, MeHg is classified as a "possible" human carcinogen by the International Agency for Research on Cancer[44] and in IRIS.[45] The existing evidence supporting the possibility of carcinogenic effects in humans from low-dose chronic exposures is tenuous. Multiple human epidemiological studies have found no significant association between Hg exposure and overall cancer incidence, although a few studies have shown an association between Hg exposure and specific types of cancer incidence (e.g., acute leukemia and liver cancer).[39]

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[41]U.S. Environmental Protection Agency (U.S. EPA). 1997. *Mercury Study Report to Congress*, EPA–HQ–OAR–2009–0234–3054. December. Available on the Internet at <http://www.epa.gov/hg/report.htm>.

[42]Amorim, M.I.M., D. Mergler, M.O. Bahia, H. Dubeau, D. Miranda, J. Lebel, R.R. Burbano, and M. Lucotte. 2000. Cytogenetic damage related to low levels of methyl mercury contamination in the Brazilian Amazon. An. Acad. Bras. Ciênc. 72(4): 497-507.

[43]Agency for Toxic Substances and Disease Registry (ATSDR). 1999. Toxicological Profile for Mercury. U.S. Department of Health and Human Services, Public Health Service, Atlanta, GA.

[44]International Agency for Research on Cancer (IARC). 1994. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans and their Supplements: Beryllium, Cadmium, Mercury, and Exposures in the Glass Manufacturing Industry. Vol. 58. Jalili, H.A., and A.H. Abbasi. 1961. Poisoning by ethyl mercury toluene sulphonanilide. Br. J. Indust. Med. 18(Oct.):303-308 (as cited in NRC 2000).

[45]U.S. Environmental Protection Agency (EPA). 2002. Integrated Risk Information System (IRIS) on Methylmercury. National Center for Environmental Assessment. Office of Research and Development. Available online at http://www.epa.gov/iris/subst/0073.htm

There is also some evidence of reproductive and renal toxicity in humans from MeHg exposure. However, overall, human data regarding reproductive, renal, and hematological toxicity from MeHg are very limited and are based on either studies of the two high-dose poisoning episodes in Iraq and Japan or animal data, rather than epidemiological studies of chronic exposures at the levels of interest in this analysis.

#### *4.3.1.11 Nickel (Ni)[46]*

Respiratory effects have been reported in humans from inhalation exposure to Ni. No information is available regarding the reproductive or developmental effects of Ni in humans, but animal studies have reported such effects. Human and animal studies have reported an increased risk of lung and nasal cancers from exposure to Ni refinery dusts and nickel subsulfide. The EPA has classified nickel subsulfide as a human carcinogen and nickel carbonyl as a probable human carcinogen.[47,48] The IARC has classified Ni compounds as carcinogenic to humans.

#### *4.3.1.12 Selenium (Se)[49]*

Acute exposure to elemental Se, hydrogen selenide, and selenium dioxide ($SeO_2$) by inhalation results primarily in respiratory effects, such as irritation of the mucous membranes, pulmonary edema, severe bronchitis, and bronchial pneumonia. One Se compound, selenium sulfide, is carcinogenic in animals exposed orally. The EPA has classified elemental Se as a Group D, not classifiable as to human carcinogenicity, and selenium sulfide as a Group B2, probable human carcinogen.

### ***4.3.2 Additional $SO_2$ Health Co-benefits***

In addition to being a precursor to $PM_{2.5}$, $SO_2$ emissions are also associated with a variety of adverse health effects associated with direct exposure. Unfortunately, we were unable to estimate the health co-benefits associated with reduced $SO_2$ in this analysis because we do not have air quality modeling data available. Therefore, this analysis only quantifies and monetizes the $PM_{2.5}$ co-benefits associated with the reductions in $SO_2$ emissions.

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[46] Nickel (IARC Summary & Evaluation , Volume 49, 1990), Please check if there are relevant to this sectorhttp://www.inchem.org/documents/iarc/vol49/nickel.html

[47] U.S. Environmental Protection Agency. Integrated Risk Information System (IRIS) on Nickel Subsulfide. National Center for Environmental Assessment, Office of Research and Development, Washington, DC. 1999.

[48] U.S. Environmental Protection Agency. Integrated Risk Information System (IRIS) on Nickel Carbonyl. National Center for Environmental Assessment, Office of Research and Development, Washington, DC. 1999.

[49] U.S. Environmental Protection Agency. Integrated Risk Information System (IRIS) on Selenium and Compounds. National Center for Environmental Assessment, Office of Research and Development, Washington, DC. 1999.

Following an extensive evaluation of health evidence from epidemiologic and laboratory studies, the *Integrated Science Assessment for Oxides of Sulfur—Health Criteria* ($SO_2$ ISA) concluded that there is a causal relationship between respiratory health effects and short-term exposure to $SO_2$.[50] 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. We did not quantify these co-benefits due to data constraints.

### *4.3.3 Visibility Impairment Co-benefits*

Reducing secondary formation of $PM_{2.5}$ would improve levels visibility in the U.S. because suspended particles and gases degrade visibility by scattering and absorbing light (U.S. EPA, 2009). Fine particles with significant light-extinction efficiencies include sulfates, nitrates, organic carbon, elemental carbon, and soil.[51] Visibility has direct significance to people's enjoyment of daily activities and their overall sense of well-being. Good visibility increases the quality of life where individuals live and work, and where they engage in recreational activities. Particulate sulfate is the dominant source of regional haze in the eastern U.S. and particulate nitrate is an important contributor to light extinction in California and the upper Midwestern

[50] U.S. Environmental Protection Agency (U.S. EPA). 2008a. *Integrated Science Assessment for Sulfur Oxides—Health Criteria (Final Report)*. National Center for Environmental Assessment, Research Triangle Park, NC. September. Available at: <http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=198843>.

[51] Sisler, J.F. 1996. *Spatial and seasonal patterns and long-term variability of the composition of the haze in the United States: an analysis of data from the IMPROVE network*. CIRA Report, ISSN 0737-5352-32, Colorado State University.

U.S., particularly during winter (U.S. EPA, 2009). Previous analyses[52] show that visibility benefits can be a significant welfare benefit category. Without air quality modeling, we are not unable to estimate visibility related benefits, nor are we able to determine whether the emission reductions associated with this rule would be likely to have a significant impact on visibility in urban areas or Class I areas.

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# SECTION 5
# ECONOMIC IMPACT ANALYSIS

EPA prepares an EIA to provide decision makers with a measure of the social costs of using resources to comply with a regulation (EPA, 2010). The social costs can then be compared with estimated social benefits (as presented in Section 4). As noted in EPA's (2010) *Guidelines for Preparing Economic Analyses*, several tools are available to estimate social costs and range from simple direct compliance cost methods to the development of a more complex market analysis that estimates market changes (e.g., price and consumption) and economic welfare changes (e.g., changes in consumer and producer surplus).

The Office of Air Quality Planning and Standards (OAQPS) adopted a market-level analysis described in the Office's resource manual (EPA, 1999a). The market approach uses a single-period static partial-equilibrium model to compare pre-policy market baselines with expected post policy outcomes in these markets. Key measures in this analysis include

- market-level effects (market prices, changes in domestic production and consumption, and international trade) and
- social costs and their distribution between producers and consumers.

We also assessed the impacts on employment in the brick industry through a qualitative discussion and a quantitative analysis that is linked to the results of the market-level analysis. Finally, we assessed how the regulatory program may influence the profitability of large and small ultimate parent companies that own affected BSCP facilities. To do this, we used a screening analysis required to comply with the Regulatory Flexibility Act (RFA) as amended by the Small Business Regulatory Enforcement Fairness Act (SBREFA).

## 5.1 Market Analysis

The partial-equilibrium analysis includes a market model that simulates how stakeholders (consumers and firms) might respond to the additional regulatory program costs. EPA used a perfectly competitive regional market model that accounts for the fact that brick shipments are not likely to be shipped long distances because of weight and transportation costs. In regional markets, it is more likely that only a few firms offer similar brick products and other market structures may be applicable (i.e., oligopoly). If market power exists, the use of a perfectly competitive model may understate the social costs of the final rule. Appendix A provides additional details about the economic model equations and parameters.

### *5.1.1 Market-Level Results*

Market-level impacts include the price and production adjustments for bricks. As shown in Table 5-1, the average national price under the final standards increases by 1.8%, or $4.37 per 1,000 SBE, while overall domestic production falls by 1.5%, or 52 million bricks per year. These values are slightly higher than the Option 1 approach: the average national price increase for the Option 1 standards is 1.8%, or $4.27 per 1,000 SBE and U.S. brick production falls by about 50 million bricks. These values are lower than the Option 3 approach: the average national price increase for the Option 3 standards is 3.2% and U.S. brick production falls by about 90 million bricks.

Price increases are the highest in regions with high unit compliance costs. For example, the East North Central market price increase ($7.45 per 1,000 SBE) is associated with higher per-unit compliance costs ($16.56 per 1,000 SBE). Under the final standards, one region does not include any facilities with incremental compliance costs (New England). As a result, there are no market-level changes. For all of the census regions, the average regional price increases between 0% and 3.7%. Regional domestic production falls between 0% and 2.9% and 0 to 20 million bricks per year. Under the Option 1 standards, the average regional price increases between 0% and 3.8%. Regional domestic production falls between 0% and 3.0%, or 0 to 16 million bricks per year. Under the Option 3 standards, the average regional price increases between 0% and 5.8%. Regional domestic production falls between 0% and 4.6%, or 0 to 33 million bricks per year.

### *5.1.2 Social Cost Estimates*

Under the final standards, the economic model suggests that industries are able to pass on $15.1 million (2011$) of the rule's costs to U.S. households in the form of higher prices (Table 5-1). Existing U.S. industries' surplus falls by $12.1 million, and the total U.S. economic surplus loss is $27.2 million. Under the Option 1 standards, total U.S. economic surplus loss is $0.6 million lower ($26.6 million), and under the Option 3 standards, total U.S economic surplus loss is $21.4 million higher ($48.6 million). Because higher brick prices reduce consumption, the estimated compliance costs are lower than the engineering cost estimate that does not account for price responses. However, the differences are very small (i.e., less than 0.01%).

## Table 5-1. Estimated Market Impacts of Final BSCP NESHAP

| Census Region | Incremental Unit Compliance Costs ($/1,000 SBE) | Market Price Change | | U.S. Production Change | | Change in: | | |
|---|---|---|---|---|---|---|---|---|
| | | Absolute | Percent | Absolute | Percent | Consumer Surplus | Producer Surplus | Total Surplus |
| **Option 2: Final Rule** | | | | | | | | |
| New England | $0.00 | $0.00 | 0.0% | 0 | 0.0% | $0.0 | $0.0 | $0.0 |
| Middle Atlantic | $14.37 | $5.51 | 1.7% | −2,847 | −1.3% | −$1.2 | −$0.9 | −$2.1 |
| East North Central | $16.56 | $7.45 | 2.5% | −5,629 | −2.0% | −$2.1 | −$1.7 | −$3.8 |
| West North Central | $4.73 | $2.63 | 0.9% | −1,389 | −0.8% | −$0.5 | −$0.4 | −$0.9 |
| South Atlantic | $8.49 | $4.34 | 1.9% | −19,586 | −1.5% | −$5.6 | −$4.5 | −$10.1 |
| East South Central | $12.34 | $6.85 | 3.7% | −11,442 | −2.9% | −$2.6 | −$2.1 | −$4.7 |
| West South Central | $5.97 | $3.32 | 1.4% | −10,315 | −1.2% | −$2.9 | −$2.4 | −$5.3 |
| Mountain | $1.93 | $0.54 | 0.1% | −135 | −0.1% | −$0.1 | $0.0 | −$0.1 |
| Pacific | $3.51 | $1.66 | 0.3% | −179 | −0.2% | −$0.1 | −$0.1 | −$0.2 |
| ***U.S. Average/Total*** | ***$8.68*** | ***$4.37*** | ***1.8%*** | ***−51,521*** | ***−1.5%*** | ***−$15.1*** | ***−$12.1*** | ***−$27.2*** |

(continued)

## Table 5-1. Estimated Market Impacts of Final BSCP NESHAP (continued)

| Census Region | Incremental Unit Compliance Costs ($/1,000 SBE) | Market Price Change | | U.S. Production Change | | Change in: | | |
|---|---|---|---|---|---|---|---|---|
| | | Absolute | Percent | Absolute | Percent | Consumer Surplus | Producer Surplus | Total Surplus |
| **Option 1** | | | | | | | | |
| New England | $0.00 | $0.00 | 0.0% | 0 | 0.0% | $0.0 | $0.0 | $0.0 |
| Middle Atlantic | $11.28 | $4.33 | 1.3% | −2,236 | −1.0% | −$0.9 | −$0.7 | −$1.6 |
| East North Central | $16.56 | $7.45 | 2.5% | −5,628 | −2.0% | −$2.1 | −$1.7 | −$3.8 |
| West North Central | $4.73 | $2.63 | 0.9% | −1,389 | −0.8% | −$0.5 | −$0.4 | −$0.9 |
| South Atlantic | $7.09 | $3.62 | 1.6% | −16,347 | −1.3% | −$4.7 | −$3.8 | −$8.5 |
| East South Central | $12.67 | $7.04 | 3.8% | −11,755 | −3.0% | −$2.7 | −$2.2 | −$4.9 |
| West South Central | $7.16 | $3.98 | 1.7% | −12,382 | −1.4% | −$3.5 | −$2.8 | −$6.3 |
| Mountain | $8.16 | $2.27 | 0.6% | −572 | −0.5% | −$0.3 | −$0.2 | −$0.5 |
| Pacific | $3.51 | $1.66 | 0.3% | −179 | −0.2% | −$0.1 | −$0.1 | −$0.2 |
| ***U.S. Average/Total*** | ***$8.49*** | ***$4.27*** | ***1.8%*** | ***−50,487*** | ***−1.4%*** | ***−$14.8*** | ***−$11.8*** | ***−$26.6*** |

(continued)

## Table 5-1. Estimated Market Impacts of Final BSCP NESHAP (continued)

| Census Region | Incremental Unit Compliance Costs ($/1,000 SBE) | Market Price Change | | U.S. Production Change | | Change in: | | |
|---|---|---|---|---|---|---|---|---|
| | | Absolute | Percent | Absolute | Percent | Consumer Surplus | Producer Surplus | Total Surplus |
| **Option 3** | | | | | | | | |
| New England | $0.00 | $0.00 | 0.0% | 0 | 0.0% | $0.0 | $0.0 | $0.0 |
| Middle Atlantic | $16.04 | $6.15 | 1.9% | −3,179 | −1.5% | −$1.3 | −$1.0 | −$2.3 |
| East North Central | $28.31 | $12.74 | 4.2% | −9,623 | −3.4% | −$3.6 | −$2.8 | −$6.4 |
| West North Central | $19.12 | $10.62 | 3.8% | −5,613 | −3.1% | −$1.9 | −$1.5 | −$3.4 |
| South Atlantic | $14.15 | $7.23 | 3.1% | −32,635 | −2.5% | −$9.3 | −$7.4 | −$16.8 |
| East South Central | $19.48 | $10.82 | 5.8% | −18,072 | −4.6% | −$4.1 | −$3.3 | −$7.4 |
| West South Central | $10.37 | $5.76 | 2.5% | −17,926 | −2.0% | −$5.1 | −$4.1 | −$9.1 |
| Mountain | $14.39 | $4.00 | 1.1% | −1,008 | −0.9% | −$0.5 | −$0.4 | −$0.8 |
| Pacific | $37.17 | $17.55 | 3.2% | −1,899 | −2.5% | −$1.3 | −$1.0 | −$2.3 |
| ***U.S. Average/Total*** | ***$15.62*** | ***$7.86*** | ***3.2%*** | ***−89,954*** | ***−2.6%*** | ***−$27.1*** | ***−$21.5*** | ***−$48.6*** |

## 5.2 Employment Impacts of the Final Rule[53]

Executive Order 13563 directs federal agencies to consider the effect of regulations on job creation and employment. According to the Executive Order, “our regulatory system must protect public health, welfare, safety, and our environment while promoting economic growth, innovation, competitiveness, and job creation. It must be based on the best available science” (Executive Order 13563, 2011). Although standard benefit-cost analyses have not typically included a separate analysis of regulation-induced employment impacts,[54] during periods of sustained high unemployment, employment impacts are of particular concern and questions may arise about their existence and magnitude. This chapter provides a conceptual framework for considering the potential influence of environmental regulation on employment in the U.S. economy and discusses the limited empirical literature that is available. The chapter then discusses the potential employment impacts in the BSCP industry, as well as the environmental protection sector (e.g., for construction, manufacture, installation and operation of needed pollution control equipment). Section 5.2.1 describes the economic theory used for analyzing regulation-induced employment impacts, discussing how standard neoclassical theory alone does not point to a definitive net effect of regulation on labor demand for regulated firms. Section 5.2.2 presents an overview of the peer-reviewed literature relevant to evaluating the effect of environmental regulation on employment. Section 5.2.3 discusses macroeconomic net employment effects. EPA is currently in the process of seeking input from an independent expert panel on economy-wide impacts, including employment effects. Section 5.2.4 addresses the particular influence of this final rule on employment. Finally, Section 5.2.5 offers several conclusions.

### *5.2.1 Theory*

The effects of environmental regulation on employment are difficult to disentangle from other economic changes and business decisions that affect employment, over time and across regions and industries. Labor markets respond to regulation in complex ways. That response depends on the elasticities of demand and supply for labor and the degree of labor market imperfections (e.g., wage stickiness, long-term unemployment). The unit of measurement (e.g., number of jobs, types of job hours worked, or earnings) may affect observability of that response. Net employment impacts are composed of a mix of potential declines and gains in different areas of the economy (i.e., the directly regulated sector, upstream and downstream

[53] The employment analysis in this RIA is part of EPA’s ongoing effort to “conduct continuing evaluations of potential loss or shifts of employment which may result from the administration or enforcement of [the Act]” pursuant to CAA section 321(a).

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

sectors, and the pollution abatement sector) and over time. In light of these difficulties, economic theory provides a constructive framework for approaching these assessments and for better understanding the inherent complexities in such assessments. In this section, we briefly describe theory relevant to the impact of regulation on labor demand at the regulated firm, in the regulated industry, and in the environmental protection sector and highlight the importance of considering potential effects of regulation on labor supply, a topic addressed further in a subsequent section.

Neoclassical microeconomic theory describes how profit-maximizing firms adjust their use of productive inputs in response to changes in their economic conditions.[55] In this framework, labor is one of many inputs to production, along with capital, energy, and materials. In competitive output markets, profit-maximizing firms take prices as given and choose quantities of inputs and outputs to maximize profit. Factor demand at the firm, then, is determined by input and output prices.[56,57]

Berman and Bui (2001) and Morgenstern, Pizer, and Shih (2002) have specifically tailored one version of the standard neoclassical model to analyze how environmental regulations affect labor demand decisions.[58] Environmental regulation is modeled as effectively requiring certain factors of production, such as pollution abatement capital investment, that would not be freely chosen by profit-maximizing/cost-minimizing firms.

In Berman and Bui's (2001, p. 274–75) theoretical model, the change in a firm's labor demand arising from a change in regulation is decomposed into two main components: output and substitution effects.[59] For the output effect, by affecting the marginal cost of production, regulation affects the profit-maximizing quantity of output. The output effect describes how, if labor intensity of production is held constant, a decrease in output generally leads to a decrease in labor demand. However, as noted by Berman and Bui, although it is often assumed that regulation increases marginal cost, and thereby reduces output, it need not be the case. A regulation could induce a firm to upgrade to less polluting and more efficient equipment that

[55]See Layard and Walters (1978), a standard microeconomic theory textbook, for a discussion.
[56]See Hamermesh (1993), Chapter 2, for a derivation of the firm's labor demand function from cost-minimization.
[57]In this framework, labor demand is a function of quantity of output and prices (of both outputs and inputs).
[58]Berman and Bui (2001) and Morgenstern, Pizer, and Shih (2002) used a cost-minimization framework, which is a special case of profit-maximization with fixed output quantities.
[59]The authors also discuss a third component, the impact of regulation on factor prices but conclude that this effect is unlikely to be important for large competitive factor markets, such as labor and capital. Morgenstern, Pizer, and Shih (2002) used a very similar model, but they break the employment effect into three parts: 1) the demand effect, 2) the cost effect, and 3) the factor-shift effect.

lowers marginal production costs, for example. In such a case, output could theoretically increase.

The substitution effect describes how, holding output constant, regulation affects the labor intensity of production. Although increased environmental regulation generally results in higher utilization of production factors such as pollution control equipment and energy to operate that equipment, the resulting impact on labor demand is ambiguous. For example, equipment inspection requirements, specialized waste handling, or pollution technologies that alter the production process may affect the number of workers necessary to produce a unit of output. Berman and Bui (2001) modeled the substitution effect as the effect of regulation on "quasi-fixed" pollution control equipment and expenditures that are required by the regulation and the corresponding change in labor intensity of production. Within the production theory framework, when levels of a given set of inputs are fixed by external constraints such as regulatory requirements, rather than allowing the firm to freely choose all inputs under cost-minimization alone, these inputs are described as "quasi-fixed." For example, materials would be a "quasi-fixed" factor if there were specific requirements for landfill liner construction, but the footprint of the landfill was flexible. Brown and Christensen (1981) developed a partial static equilibrium model of production with quasi-fixed factors, which Berman and Bui (2001) extended to analyze environmental regulations with technology-based standards.

In summary, because the output and substitution effects may be both positive, both negative, or some combination, standard neoclassical theory alone does not point to a definitive net effect of regulation on labor demand at regulated firms. Operating within the bounds of standard neoclassical theory, however, rough estimation of net employment effects is possible with empirical study, specific to the regulated firms, when data and methods of sufficient detail and quality are available. The available literature illustrates some of the difficulties for empirical estimation: studies sometimes rely on confidential plant-level employment data from the U.S. Census Bureau, possibly combined with pollution abatement expenditure data that are too dated to be reliably informative. In addition, the most commonly used empirical methods in the literature do not permit the estimation of net effects. These studies will be discussed at greater length later in this chapter.

The above describes a conceptual framework for analyzing potential employment effects at a particular firm within a regulated industry. It is important to emphasize that employment impacts at a particular firm will not necessarily represent impacts for the overall industry; therefore, the theoretic approach requires some adjustment when applied at the industry level.

As stated, the responsiveness of industry labor demand depends on how the output and substitution effects interact.[60] At the industry level, labor demand will be more responsive when (1) the price elasticity of demand for the product is high, (2) other factors of production can be easily substituted for labor, (3) the supply of other factors is highly elastic, or (4) labor costs are a large share of the total costs of production.[61] So, for example, if all firms in the industry are faced with the same compliance costs of regulation and product demand is inelastic, then industry output may not change much at all, and output of individual firms may only be slightly changed.[62] In this case, the output effect may be small, while the substitution effect will still depend on the degree of substitutability or complementarity between factors of production. Continuing the example, if new pollution control equipment requires labor to install and operate, labor is more of a complement than a substitute. In this case, the substitution effect may be positive, and if the output effect is small or zero, the total effect may then be positive. As with the potential effects for an individual firm, theory alone is unable to determine the sign or magnitude of industry-level regulatory effects on labor. Determining these signs and magnitudes requires additional sector-specific empirical study. To conduct such targeted research would require estimates of product demand elasticity; production factor substitutability; supply elasticity of production factors; and the share of total costs contributed by wages, by industry, and perhaps even by facility. For environmental rules, many of these data items are not publicly available, would require significant time and resources to access confidential U.S. Census data for research, and also would not be necessary for other components of a typical RIA.

In addition to changes to labor demand in the regulated industry, net employment impacts encompass changes within the environmental protection sector and, potentially, in other related sectors, as well. Environmental regulations often create increased demand for pollution control equipment and services needed for compliance. This increased demand may increase revenue and employment in the environmental protection industry. At the same time, the regulated industry is purchasing the equipment, and these costs may affect labor demand at regulated firms. Therefore, it is important to consider the net effect of compliance actions on employment across multiple sectors or industries.

On the one hand, if the U.S. economy is at full employment, even a large-scale environmental regulation is unlikely to have a noticeable impact on aggregate net employment.[63]

[60]On Marshall's laws of derived demand, see Ehrenberg and Smith (2000), Chapter 4.
[61]See Ehrenberg and Smith (2000), p. 108.
[62]This discussion draws from Berman and Bui (2001), p. 293.
[63]Full employment is a conceptual target for the economy where everyone who wants to work and is available to do so at prevailing wages is actively employed.

Instead, labor would primarily be reallocated from one productive use to another (e.g., from producing electricity or steel to producing pollution abatement equipment). Theory supports the argument that, in the case of full employment, the net national employment effects from environmental regulation are likely to be small and transitory (e.g., as workers move from one job to another).[64] On the other hand, if the economy is operating at less than full employment, economic theory does not clearly indicate the direction or magnitude of the net impact of environmental regulation on employment; it could cause either a short-run net increase or short-run net decrease (Schmalansee and Stavins, 2011). An important fundamental research question is how to accommodate unemployment as a structural feature in economic models. This feature may be important in evaluating the impact of large-scale regulation on employment (Smith, 2012).

Affected sectors may experience transitory effects as workers change jobs. Some workers may need to retrain or relocate in anticipation of the new requirements or require time to search for new jobs, while shortages in some sectors or regions could bid up wages to attract workers. It is important to recognize that these adjustment costs can entail local labor disruptions, and although the net change in the national workforce is expected to be small, localized reductions in employment can still have negative impacts on individuals and communities just as localized increases can have positive impacts.

Although the current discussion focuses on labor demand effects, environmental regulation may also affect labor supply. In particular, pollution and other environmental risks may affect labor productivity[65] or employees' ability to work. Although there is an accompanying, and parallel, theoretical approach to examining impacts on labor supply, similar to labor demand, it is even more difficult and complex to study labor supply empirically. There is a small, nascent empirical literature using more detailed labor and environmental data and quasi-experimental techniques that is starting to find traction on this question. These are described in Section 5.2.6.

To summarize the discussion in this section, economic theory provides a framework for analyzing the impacts of environmental regulation on employment. The net employment effect incorporates expected employment changes (both positive and negative) in the regulated sector, the environmental protection sector, and other relevant sectors. Using economic theory, labor demand impacts for regulated firms, and also for the regulated industry, can be decomposed into

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[64]Arrow et al. (1996); see discussion on bottom of p. 8. In practice, distributional impacts on individual workers can be important, as discussed in later paragraphs of this section.
[65]For example, Graff Zivin and Neidell (2012).

output and substitution effects. With these potentially competing forces, under standard neoclassical theory estimation of net employment effects is possible with empirical study specific to the regulated firms and firms in the environmental protection sector and other relevant sectors when data and methods of sufficient detail and quality are available. Finally, economic theory suggests that labor supply effects are also possible. In the next section, we discuss the available empirical literature.

### *5.2.2 Current State of Knowledge Based on the Peer-Reviewed Literature*

In the labor economics literature, an extensive body of peer-reviewed empirical work analyzes various aspects of labor demand, relying on the above theoretical framework.[66] This work focuses primarily on the effects of employment policies, for example, labor taxes and minimum wage.[67] In contrast, the peer-reviewed empirical literature specifically estimating employment effects of environmental regulations is very limited. In this section, we present an overview of the latter. As discussed in the preceding section on theory, determining the direction of employment effects in regulated industries is challenging because of the complexity of the output and substitution effects. Complying with a new or more stringent regulation may require additional inputs, including labor, and may alter the relative proportions of labor and capital used by regulated firms (and firms in other relevant industries) in their production processes.

Several empirical studies, including Berman and Bui (2001) and Morgenstern et al. (2002), suggest that net employment impacts may be zero or slightly positive but small even in the regulated sector. Other research suggests that more highly regulated counties may generate fewer jobs than less regulated ones (Greenstone, 2002; Walker, 2011). However, because these latter studies compare more regulated to less regulated counties, they overstate the net national impact of regulation to the extent that regulation causes plants to locate in one area of the country rather than another. List et al. (2003) found some evidence that this type of geographic relocation may be occurring. Overall, the peer-reviewed literature does not contain evidence that environmental regulation has a large impact on net employment (either negative or positive) in the long run across the whole economy.

Environmental regulations seem likely to affect the environmental protection sector earlier than the regulated industry. Rules are usually announced well in advance of their effective dates and then typically provide a period of time for firms to invest in technologies and process changes to meet the new requirements. When a regulation is promulgated, the initial response of

[66]Again, see Hamermesh (1993) for a detailed treatment.
[67]See Ehrenberg and Smith (2000), Chapter 4: “Employment Effects: Empirical Estimates” for a concise overview.

firms is often to order pollution control equipment and services to enable compliance when the regulation becomes effective. This can produce a short-term increase in labor demand for specialized workers within the environmental protection sector, particularly workers involved in the design, construction, testing, installation, and operation of the new pollution control equipment required by the regulation (see Schmalansee and Stavins, 2011; Bezdek, Wendling, and Diperna, 2008). Estimates of short-term increases in demand for specialized labor within the environmental protection sector have been prepared for several EPA regulations in the past, including the Mercury and Air Toxics Standards (MATS) (U.S. EPA, 2011b).

### *5.2.3 Regulated Sector*

Determining the direction of net employment effects of regulation on industry is challenging. Two papers that present a formal theoretic model of the underlying profit-maximizing/cost-minimizing problem of the firm are Berman and Bui (2001) and Morgenstern, Pizer, and Shih (2002) mentioned above.

Berman and Bui (2001) developed an innovative approach to estimate the effect on employment of environmental regulations in California. Their model empirically examines how an increase in local air quality regulation affects manufacturing employment in the South Coast Air Quality Management District (SCAQMD), which incorporates Los Angeles and its suburbs. During the time frame of their study, 1979 to 1992, the SCAQMD enacted some of the country's most stringent air quality regulations. Using SCAQMD's local air quality regulations, Berman and Bui identified the effect of environmental regulations on net employment in the regulated industries.[68] In particular, they compared changes in employment in affected plants to those in other plants in the same 4-digit Standard Industrial Classification (SIC) industries but in regions not subject to the local regulations.[69] The authors found that "while regulations do impose large costs, they have a limited effect on employment" (Berman and Bui, 2001, p. 269). Their conclusion is that local air quality regulation "probably increased labor demand slightly" but that "the employment effects of both compliance and increased stringency are fairly precisely estimated zeros, even when exit and dissuaded entry effects are included" (Berman and Bui, 2001, p. 269).[70] In their view, the limited effects likely arose because 1) the regulations applied disproportionately to capital-intensive plants with relatively little employment, 2) the plants sold

[68]Note, like Morgenstern, Pizer, and Shih (2002), this study does not estimate the number of jobs created in the environmental protection sector.

[69]Berman and Bui include over 40 4-digit SIC industries in their sample.

[70]Including the employment effect of exiting plants and plants dissuaded from opening will increase the estimated impact of regulation on employment. This employment effect is not included in Morgenstern et al. (2002).

to local markets where competitors were subject to the same regulations (so that sales were relatively unaffected), and 3) abatement inputs served as complements to employment.

Morgenstern, Pizer, and Shih (2002) developed a similar structural approach to Berman and Bui's, but their empirical application used pollution abatement expenditures from 1979 to 1991 at the plant level, including air, water, and solid waste, to estimate net employment effects in four highly regulated sectors (pulp and paper, plastics, steel, and petroleum refining). Thus, in contrast to Berman and Bui (2001), this study identified employment effects by examining differences in abatement expenditures rather than geographical differences in stringency. They conclude that increased abatement expenditures generally have *not* caused a significant change in net employment in those sectors.

### *5.2.4 Environmental Protection Sector*

The long-term effects of a regulation on the environmental protection sector, which provides goods and services that help protect the environment to the regulated sector, are difficult to assess. Employment in the industry supplying pollution control equipment or services is likely to increase with the increased demand from the regulated industry for increased pollution control.[71]

A report by the U.S. International Trade Commission (2013) shows that domestic environmental services revenues grew by 41% between 2000 and 2010. According to U.S. Department of Commerce (2010) data, by 2008, there were 119,000 environmental technology (ET) firms generating approximately $300 billion in revenues domestically, producing $43.8 billion in exports, and supporting nearly 1.7 million jobs in the United States. Air pollution control accounted for 18% of the domestic ET market and 16% of exports. Small and medium-size companies represent 99% of private ET firms, producing 20% of total revenue (OEEI, 2010).

### *5.2.5 Labor Supply Impacts*

As described above, the small empirical literature on employment effects of environmental regulations focuses primarily on labor demand impacts. However, there is a nascent literature focusing on regulation-induced effects on labor supply, though this literature remains very limited because of empirical challenges. This new research uses innovative methods and new data and indicates that there may be observable impacts of environmental regulation on labor supply, even at pollution levels below mandated regulatory thresholds. Many

[71]See Bezdek, Wendling, and Diperna (2008), for example, and U.S. Department of Commerce (2010).

researchers have found that work-loss days and sick days, as well as mortality, are reduced when air pollution is reduced (EPA, 2011a). EPA's study of the benefits and costs of implementing the clean air regulations used these studies to predict how increased labor availability would increase the labor supply and improve productivity and the economy (EPA, 2011a).Another literature estimates how worker productivity improves at the work site when pollution is reduced. Graff Zivin and Neidell (2013) reviewed this literature, focusing on how health and human capital may be affected by environmental quality, particularly air pollution. In previous research, Graff Zivin and Neidell (2012) used detailed worker-level productivity data from 2009 and 2010, paired with local ozone air quality monitoring data for one large California farm growing multiple crops, with a piece-rate payment structure. Their quasi-experimental structure identified an effect of daily variation in monitored ozone levels on productivity. They found "that ozone levels well below federal air quality standards have a significant impact on productivity: a 10 parts per billion (ppb) decrease in ozone concentrations increases worker productivity by 5.5 percent." (Graff Zivin and Neidell, 2012, p. 3654). Such studies are a compelling start to exploring this new area of research, considering the benefits of improved air quality on productivity, alongside the existing literature exploring the labor demand effects of environmental regulations.

### *5.2.6 Macroeconomic Net Employment Effects*

The preceding sections have outlined the challenges associated with estimating net employment effects in the regulated sector and in the environmental protection sector and labor supply impacts. These challenges make it very difficult to accurately produce net employment estimates for the whole economy that would appropriately capture the way in which costs, compliance spending, and environmental benefits propagate through the macro-economy. Quantitative estimates are further complicated by the fact that macroeconomic models often have very little sectoral detail and usually assume that the economy is at full employment. EPA is currently in the process of seeking input from an independent expert panel on modeling economy-wide impacts, including employment effects.

### *5.2.7 Information Specific to this Regulation*

In 2011, the ASM reported that 218 establishments (174 in NAICS 327121 and 44 in NAICS 327123) employed 8,000 people with a total annual payroll of about $300 million (U.S. Census Bureau, 2013a, b). Approximately 12 million production labor hours were used to produce BSCP in 2011.

For this analysis, EPA quantified a subset of possible types of employment effects associated with the regulation:

- additional labor requirements (full-time equivalents [FTEs]) associated with meeting the new regulation
- employment effect of facilities that may exit the BSCP industry

As shown in Table 5-2, EPA estimates that the regulation will require an additional 181,000 labor hours per year to operate control devices. This is equivalent to about 87 additional FTEs. The total estimated cost of these additional labor requirements to operate control devices is $4.24 million per year. For Option 2, the recordkeeping and reporting labor hours are approximately 49,000 hours (see section 6.3), or 23 additional FTE.

**Table 5-2. Estimated Additional Labor Requirements**

| | Total Annual Labor Cost ($ million) Required to Operate Control Devices | Total Annual Labor Hours Required to Operate Control Devices |
|---|---|---|
| Option 1 | $4.13 | 176,000 |
| Option 2 Final | $4.24 | 181,000[a] |
| Option 3 | 8.12 | 347,000 |

[a]Excludes record keeping and reporting labor hours (49,000) (see section 6.3).

In Section 5.3, EPA estimates that the regulation may lead to two to four affected facilities exiting the BSCP industry. According the U.S. Census Bureau (2013b), the average number of employees per facility in 2011 was 37 (8,000/218 = 37). As a result, we estimate 74 to 148 employees may need to retrain or relocate in anticipation of the new requirements or require time to search for new jobs.

### *5.2.8 Conclusion*

Although EPA has quantified two types of employment effects in this RIA, deriving estimates of how this regulation will affect *net* employment is a difficult task, requiring consideration of labor demand in both the regulated and environmental protection sectors. Economic theory predicts that the total effect of an environmental regulation on labor demand in regulated sectors is not necessarily positive or negative. Peer-reviewed econometric studies that use a structural approach, applicable to overall net effects in the regulated sectors, converge on the finding that such effects, whether positive or negative, have been small and have not affected employment in the national economy in a significant way. Effects on labor demand in the environmental protection sector seem likely to be positive. Finally, new evidence suggests that environmental regulation may improve labor supply and productivity.

## 5.3 Impacts on Small Entities

As mentioned above, EPA was particularly concerned about the final rule's potential impacts to small entities, because 36 of 44 firms owning BSCP facilities have fewer than 750 employees and thus meet the Small Business Administration's (SBA's) criterion for a small business in this industry. EPA thus conducted a screening analysis of the potential impacts by computing the ratio of control costs to firm sales revenues (i.e., a sales test). Based on the results of the screening analysis, EPA concluded that it is not able to certify that the rule will not have a Significant Impact on a Substantial Number of Small Entities (SISNOSE). As a result, EPA initiated a Small Business Advisory Review panel and undertook an Initial Regulatory Flexibility Analysis (IRFA).

### *5.3.1 Small Business Impact Screening Analysis*

As discussed in Section 2, EPA has identified 44 ultimate parent companies with facilities that will need new or modified control devices to meet new emission standards. Affected parent companies fall under the Clay Building Material and Refractories Manufacturing (NAICS 327120) industry and the SBA (2013) defines a small business as having fewer than 750 employees. There are 36 parent companies that are small businesses.

EPA assessed how the regulatory program may influence the profitability of ultimate parent companies by comparing pollution control costs to total sales (i.e., a "sales" test or cost-to-sales ratios [CSR]). To do this, we divided an ultimate parent company's (i) total annualized compliance costs by its reported revenue:

$$\text{Sales Test}_i = \frac{Total\ Annualized\ Compliance\ Cost_i}{Total\ Revenue_i} \quad (5.1)$$

As shown in Table 5-3, 40 of the 44 ultimate parent companies had sales data available that enabled EPA to compute a sales test. The table shows that 58% of all businesses and 59% of small businesses affected by the final standards have CSRs of under 1%.

EPA estimated the range of the number of ultimate parent companies that may close rather than comply with the regulation. The lower and upper bounds of the range were determined as follows:

- Lower bound: All ultimate parent companies with CSR > 10%.
- Upper bound: All ultimate parent companies with CSR > 10%, 50% of ultimate parent companies with CSRs between 5% and 10%, and 25% of ultimate parent companies with CSRs between 3% and 5%.

## Table 5-3. Small Business Impact Screening Assessment Results and Closure Estimates

| | Capital Cost (Million $) | Annual Cost (Million $) | Ultimate Parent Companies with Cost-to-Sales Ratios (CSRs)[a] Less than 1% | 1% to 3% | 3% to 5% | 5% to 10% | Greater than 10% | Estimated[b] Closures | Estimated Number of Facilities Closed |
|---|---|---|---|---|---|---|---|---|---|
| **All Businesses (n=40)** | | | | | | | | | |
| Option 1 | $64 | $27 | 53% | 30% | 10% | 5% | 3% | 3–8 | 1–3 |
| Option 2 Final | $65 | $27 | 58% | 28% | 3% | 8% | 5% | 5–9 | 2–4 |
| Option 3 | $131 | $49 | 35% | 15% | 13% | 15% | 23% | 23–33 | 9–13 |
| **Small Businesses (n=32)** | | | | | | | | | |
| Option 1 | $16 | $7 | 53% | 31% | 9% | 3% | 3% | 3–7 | 1–2 |
| Option 2 Final Rule | $14 | $7 | 59% | 28% | 3% | 3% | 6% | 6–9 | 2–3 |
| Option 3 | $50 | $19 | 34% | 9% | 16% | 13% | 28% | 28–38 | 9–12 |

[a] The screening assessment was conducted for 40 of the 44 ultimate parent companies with annual sales data available. For small businesses, 32 of the 36 small entities had annual sales data available.

[b] EPA estimated a lower and upper bound as follows: Lower bound: All ultimate parent companies with CSR > 10%.; Upper bound: All ultimate parent companies with CSR > 10%, 50% of ultimate parent companies with CSRs between 5% and 10%, and 25% of ultimate parent companies with CSRs between 3% and 5%.

Under the final standards, EPA estimated that two to four brick manufacturing facilities are at significant risk of closure. Under the Option 1 standards, one to three brick manufacturing facilities are at significant risk of closure, and under the Option 3 standards, nine to thirteen brick manufacturing facilities are at significant risk of closure.

As shown in Table 5-3, 32 of the 36 small ultimate parent companies had sales data available that enabled EPA to compute a sales test. Under the final standards, EPA estimated that two to three small brick manufacturing facilities are at significant risk of closure. Under the Option 1 standards, one to two small brick manufacturing facilities, and under Option 3 standards, nine to twelve small brick manufacturing facilities are at significant risk of closure. All of the facilities at risk of closure were one-facility companies.

EPA has been informed that firms may have difficulty obtaining longer-term financing needed to buy the control equipment and make process changes needed to comply with the final standards. Firms may not have cash on hand or the ability to convert assets into cash in order to make these purchases; as a result, firms would have to consider other long-term financing options. Affected firms are less likely to be publicly traded and thus would be more likely to consider debt versus equity options. The additional liabilities can put firms at additional risk of closure if market conditions do not improve during the period when the rule is adopted. In addition, if creditors are concerned about existing or future market conditions in the brick industry, they may be less willing to enter a loan contract or may require higher rates of interest than the 7% interest rate used to annualize the capital costs associated with the rule. EPA estimates of the range of the number of ultimate parent companies that may close rather than comply with the regulation may be an underestimate because of the difficulty in obtaining financing at a 7% interest rate. The estimates might be an overestimate if the industry has become more robust by 2018 when the control must be in place. The closure estimate did not include net effects on revenue due to price increases or reductions in sales attributable to the regulation.

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# SECTION 6
# STATUTORY AND EXECUTIVE ORDER REVIEWS

## 6.1 Synopsis

This chapter summarizes the Statutory and Executive Order (EO) impact analyses relevant for the final NESHAP for Bricks and Structural Clay Products. For each EO and Statutory requirement, we describe both the requirements and the way in which our analysis addresses these requirements.

## 6.2 Executive Order 12866: Regulatory Planning and Review and Executive Order 13563: Improving Regulation and Regulatory Review

This action is an economically significant regulatory action that was submitted to the Office of Management and Budget (OMB) for review. Any changes made in response to OMB recommendations have been documented in the dockets for this action. The EPA prepared an analysis of the potential costs and benefits associated with this action.

The EPA's study estimates that affected BSCP facilities will incur total annualized costs of $24.6 million (2011 dollars) under the BSCP Manufacturing NESHAP, including costs of emission controls, testing and monitoring, along with recordkeeping and reporting costs for facilities that have testing and monitoring. The EPA gathered information on firm sales and overall industry profitability for firms owning affected BSCP facilities. The EPA estimated that two to four BSCP manufacturing facilities are at significant risk of closure under the final standards.

The EPA also conducted an assessment of the benefits of the final rule, as described in section VI of this preamble. These estimates reflect the monetized human health benefits of reducing cases of morbidity and premature mortality among populations exposed to PM2.5 reduced by this rule. Data, resource and methodological limitations prevented the EPA from monetizing the benefits from several important benefit categories, including benefits from reducing exposure to 375 tons of HAP each year for the promulgated standards, as well as ecosystem effects and visibility impairment. In addition to reducing emissions of PM precursors such as SO2, this rule will reduce several non-Hg HAP metals emissions (i.e., arsenic, cadmium, chromium, lead, manganese, nickel, and selenium) each year. The EPA estimates the total monetized co-benefits to be $83 million to $190 million (2011 dollars) at a 3-percent discount rate and $75 million to $170 million (2011 dollars) at a 7-percent discount rate on a yearly average in 2018 for the promulgated standards.

Based on the EPA's examination of costs and benefits of the final BSCP Manufacturing NESHAP, the EPA believes that the benefits of the BSCP Manufacturing NESHAP will exceed the costs.

### 6.3 Paperwork Reduction Act (PRA)

The information collection activities in the BSCP Manufacturing NESHAP and Clay Ceramics Manufacturing NESHAP have been submitted for approval to OMB under the PRA. The ICR document that the EPA prepared for the BSCP Manufacturing NESHAP has been assigned EPA ICR number 2509.01. You can find a copy of the ICRs in the dockets for the BSCP Manufacturing NESHAP and they are briefly summarized here. The information collection requirements are not enforceable until OMB approves them.

The information collected from respondents will be used by EPA enforcement personnel to: (1) identify new, modified, reconstructed and existing sources subject to the standards; (2) ensure that MACT is being properly applied; and (3) ensure that the APCD are being properly operated and maintained on a continuous basis. In addition, records and reports are necessary to enable the EPA to identify facilities that may not be in compliance with the standards. Based on the reported information, the EPA can decide which facilities should be inspected and what records or processes should be inspected at these facilities. The records that facilities maintain will indicate to the EPA whether the owners and operators are in compliance with the emission limitations (including emission limits, operating limits) and work practice standards. Much of the information the EPA would need to determine compliance would be recorded and retained onsite at the facility. Such information would be reviewed by enforcement personnel during an inspection and would not need to be routinely reported to the EPA.

All information submitted to the EPA for which a claim of confidentiality is made will be safeguarded according to EPA policies set forth in title 40, chapter 1, part 2, subpart B - Confidentiality of Business Information. (See 40 CFR 2; 41 FR 36902, September 1, 1976; amended by 43 FR 39999, September 28, 1978; 43 FR 42251, September 28, 1978; and 44 FR 17674, March 23, 1979.)

Potential respondents to the information collection requirements in the BSCP Manufacturing NESHAP are owners and operators of new and existing sources at BSCP manufacturing facilities. A BSCP facility manufactures brick, including face brick, structural brick, brick pavers, or other brick and/or structural clay products including clay pipe; roof tile; extruded floor and wall tile; or other extruded, dimensional clay products. The BSCP facilities typically form, dry and fire bricks and shapes that are composed primarily of clay and shale.

Kilns are used to fire BSCP. The rule applies to all new and existing tunnel and periodic kilns at BSCP facilities.

The information requirements are based on notification, recordkeeping and reporting requirements in the NESHAP General Provisions (40 CFR part 63, subpart A), which are mandatory for all operators subject to national emissions standards. These recordkeeping and reporting requirements are specifically authorized by CAA section 114 (42 U.S.C. 7414). All information submitted to the EPA pursuant to the recordkeeping and reporting requirements for which a claim of confidentiality is made is safeguarded according to the EPA policies set forth in 40 CFR part 2, subpart B.

In addition to the notification, recordkeeping and reporting requirements in the NESHAP General Provisions, the final rule includes paperwork requirements associated with initial and 5-year repeat testing for selected process equipment, electronic reporting of performance test results, parameter monitoring, preparation of an OM&M plan, maintenance and inspection of process and control equipment, compliance with work practice standards and periods of malfunction.

Collection of data will begin after the effective date of the final BSCP Manufacturing NESHAP. The compliance date for existing sources is 3 years after the effective date. The compliance date for new or reconstructed sources is the effective date if the source startup date is before the effective date, or upon startup if the startup date is on or after the effective date. The schedule for notifications and reports required by the rule is summarized below.

For BSCP facilities with existing affected sources, the initial notification stating that the facility is subject to the rule must be submitted no later than 120 calendar days after the effective date of the rule. Facilities with new or reconstructed affected sources for which startup occurs on or after the effective date must submit the initial notification no later than 120 calendar days after the source becomes subject to the rule (although we are projecting no new affected sources in the short term). Facilities may choose to submit a request to use the routine control device maintenance alternative standard no later than 120 calendar days prior to the compliance date. Facilities required to conduct a performance test must submit a notification of intent to conduct a performance test at least 60 calendar days before the performance test is scheduled to begin. For each initial compliance demonstration that includes a performance test, facilities must submit an initial notification of compliance status no later than 60 calendar days following the completion of the performance test. For each initial compliance demonstration that does not involve a performance test, facilities must submit an initial notification within 30 calendar days of completing the initial compliance demonstration. Records necessary to determine compliance with the emission limitations and work practice standards must be compiled on a daily basis, and compliance reports must be submitted to the Administrator on a semiannual basis. Repeat performance tests are to be conducted every 5 years to ensure ongoing compliance.

There are 90 BSCP facilities that are currently major sources of HAP, 84 of which have at least one tunnel kiln. An estimated 21 of these facilities are projected to become synthetic area sources by promulgation rather than comply with the BSCP standards. The remaining 69 facilities (63 of which have a tunnel kiln) are expected to be subject to the BSCP Manufacturing NESHAP. For these 69 facilities, the annual recordkeeping and reporting burden associated with the BSCP standards (averaged over the first 3 years after the effective date of the standards) is estimated to be 20,963 labor hours per year, at a cost of $1,113,105 per year (yr). Burden is defined at 5 CFR 1320.3(b).

No capital costs associated with monitoring, testing, recordkeeping or reporting are expected to be incurred during this period. The annual operation and maintenance costs are estimated to be $682/yr.

The total burden for the federal government (averaged over the first 3 years after the effective date of the standards) is estimated to be 71 labor hours per year, at a total labor cost of $3,698/yr. (All costs are in 2011 dollars.)

Because BSCP facilities are not required to come into full compliance with the standards until 3 years after promulgation, much of the respondent burden (e.g., performance tests, inspections, notification of compliance status, compliance reports, records of compliance data and malfunctions) does not occur until the fourth year following promulgation.

For the BSCP Manufacturing NESHAP, we estimate an average annual recordkeeping and reporting burden of 48,674 labor hours per year, at a cost of $2,702,447/yr, for years 4 through 6. We also estimate annualized capital costs of $606,760/yr and annual operating and maintenance costs of $206,872/yr over this period, for a total annualized cost of $813,632/yr. The average annual burden for the federal government for years 4 through 6 is estimated to be 3,891 labor hours per year, at a total labor cost of $204,550/yr. (All costs are in 2011 dollars.)

An agency may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid OMB control number. The OMB control numbers for the EPA's regulations in 40 CFR are listed in 40 CFR part 9. When OMB approves this ICR, the agency will announce that approval in the Federal Register and publish a technical amendment to 40 CFR part 9 to display the OMB control number for the approved information collection activities contained in this final rule.

## 6.4 Regulatory Flexibility Act (RFA)

Pursuant to sections 603 and 609(b) of the RFA, the EPA prepared an IRFA that examines the impact of the proposed rule on small entities along with regulatory alternatives that could minimize that impact. The complete IRFA is available for review in the docket and is summarized here. We convened a SBAR Panel to obtain advice and recommendations from small entity representatives that potentially would be subject to the rule's requirements. Summaries of the IRFA and Panel recommendations are included at 79 FR 75669-75671.

As required by section 604 of the RFA, the EPA prepared a final regulatory flexibility analysis (FRFA) for this action. The FRFA addresses the issues raised by public comments on the IRFA for the proposed rule.

### *6.4.1 Need for the Rule*

The EPA is required under CAA section 112(d) to establish emission standards for each category or subcategory of major and area sources of HAP listed for regulation in section 112(b). These standards are applicable to new or existing sources of HAP and shall require the maximum degree of emission reduction. In the Administrator's judgment, the pollutants emitted from BSCP manufacturing facilities cause or contribute significantly to air pollution that may reasonably be anticipated to endanger public health. Consequently, NESHAP for the BSCP source category are being finalized.

### *6.4.2 Objectives and Legal Basis for the Rule*

Section 112(d) of the CAA requires the EPA to set emissions standards for HAP emitted by major stationary sources based on the performance of the MACT. The MACT standards for existing sources must be at least as stringent as the average emissions limitation achieved by the best performing 12 percent of existing sources (for which the Administrator has emissions information) or the best performing five sources for source categories with less than 30 sources (CAA section 112(d)(3)(A) and (B)). For new sources, MACT standards must be at least as stringent as the control level achieved in practice by the best controlled similar source (CAA section 112(d)(3)). The EPA also must consider more stringent "beyond-the-floor" control options. When considering beyond-the-floor options, the EPA must consider not only the maximum degree of reduction in emissions of HAP, but must take into account costs, energy and non-air environmental impacts when doing so. This rule is being proposed to comply with CAA section 112(d).

### *6.4.3 Significant Issues Raised*

The EPA received comments on the proposed standards and requests for comment that were included based on SBAR Panel recommendations. See section V of this preamble and "National Emission Standards for Hazardous Air Pollutants for Brick and Structural Clay Products Manufacturing: Background Information for Final Rule - Summary of Public Comments and Responses" in Docket ID No. EPA-HQ-OAR-2013-0291 for more detailed comment summaries and responses.

Work practices for dioxin/furan: One commenter stated that work practices for dioxin/furan emissions from BSCP tunnel kilns are not lawful under the CAA, and, even if they were, the work practices proposed are not sufficient to minimize dioxin/furan emissions. Other commenters supported the proposed work practices for dioxin/furan.

Response: The EPA is finalizing work practices for dioxin/furan as proposed. The EPA's response to the legal arguments made against work practice standards is presented in "National Emission Standards for Hazardous Air Pollutants for Brick and Structural Clay Products Manufacturing: Background Information for Final Rule - Summary of Public Comments and Responses" found in the docket (Docket ID No. EPA-HQ-OAR-2013-0291).

Work practices for Hg and other metals: Several commenters responded to the EPA's request for comment on work practices for Hg and non-Hg HAP metals. Numerous commenters stated that the EPA should finalize work practices instead of numeric limits and provided support for their assertion that the numeric limits are technically and economically impracticable to enforce. Commenters also noted that the emissions reduced by these numeric standards are not justified by the high cost that would be incurred to meet the standards.

Response: Emissions of Hg and non-Hg HAP metals were detected using standard EPA test methods; therefore, the Hg and non-Hg HAP metals data sets do not meet the criteria for setting work practice standards under CAA section 112(h). The EPA is finalizing numeric standards for Hg and non-Hg HAP metals under CAA section rather than work practices. The final numeric standards have been revised since the proposal to account for new data from the industry (including data on the Hg content of raw materials), removal of test data found not to meet the requirements of the applicable data, and changes in the EPA's approach to selecting the MACT floor pools (see section V.B.1 of this preamble for additional details).

Health-based standard for acid gases: Several commenters asserted that the EPA may not legally set CAA section 112(d)(4) health-based standards for acid gases for BSCP facilities.

Other commenters supported the EPA's decision to propose health-based standards for acid gases but noted that the EPA's approach was overly conservative and requested that the EPA consider setting multiple limits based on site characteristics.

Response: The EPA is finalizing the health-based standards for acid gases as proposed. The EPA's response to the legal arguments made against health-based standards is presented in section V.A of this preamble. The EPA is not changing the HBEL from proposal, as the proposed HBEL provides low potential for both chronic and acute health effects.

Size subcategories for MACT floors: Several commenters requested that the EPA subcategorize by size for the non-Hg HAP metal/PM MACT floor limits, as was proposed for Hg.

Response: As part of recalculating the MACT floor limits based on the final data set, the EPA is finalizing separate limits for small and large kilns for non-Hg HAP metals/PM as well as Hg. The EPA is also finalizing limits in three different formats for both pollutants to provide additional flexibility for small tunnel kilns and tunnel kilns with a low metals content in the PM emissions.

Sawdust dryers: Several commenters requested that the EPA finalize a subcategory of sawdust-fired kilns venting to sawdust dryers. Commenters provided general descriptions of how the operation of these kilns is different than tunnel kilns and stated that there are only two operating that would be subject to the BSCP Manufacturing NESHAP.

Response: Although one commenter noted that stack testing of a sawdust dryer is being considered, commenters did not provide test data to demonstrate that emissions from sawdust dryers are different than other tunnel kilns. Therefore, the EPA is not finalizing a subcategory of sawdust-fired kilns venting to sawdust dryers.

Periods of startup and shutdown: One commenter stated that work practices for periods of startup and shutdown of BSCP tunnel kilns are not lawful under the CAA. Other commenters supported the proposal to provide work practices for periods of startup and shutdown, but suggested improvements to the standards to make them feasible for all tunnel kilns.

Response: The EPA evaluated the comments and is finalizing work practice standards for periods of startup and shutdown that reflect best practices for minimizing emissions during these periods (see section V.B.2 of this preamble for additional information).

MACT floor pool: Several commenters supported the EPA's proposal to calculate MACT floor standards for PM based on the top 12 percent of the kilns in the industry (i.e., the best-performing sources with a FF-based APCD). One commenter asserted that the EPA's proposal is unlawful and the EPA must consider other factors than the APCD type when setting MACT standards.

Response: The EPA reviewed all the data used for the MACT floor for PM as a surrogate for non-Hg HAP metals and found that some of the test data did not meet the requirements of EPA Method 5. When these data were removed, the EPA could no longer confirm that the data available to the agency represented all the best-performing sources. Therefore, the final PM and non-Hg HAP metals are based on the top 12 percent of sources for which we had test data, regardless of APCD type (see section V.B.1 of this preamble for additional details).

### *6.4.4 Small Business Administration Comments*

The SBA's Office of Advocacy supported the EPA's proposals to set work practice standards and health-based emission standards in all instances allowed by statute and suggested other areas of improvement. The comments on areas of improvement and the EPA's responses are summarized below:

Hg standards: The EPA should pursue subcategorization by input (raw material) type and delay promulgation of a Hg standard to gather more information if needed. Standards may need to be combined with a significantly longer averaging time to allow for continuous compliance.

Response: The EPA maintains that a delay in promulgation of an Hg standard is not appropriate for two reasons.  First, under CAA section 112(e), the EPA was scheduled to complete standards for all source categories by 2000. The EPA's 2003 BSCP Manufacturing NESHAP was vacated, and that vacatur re-created the EPA's obligation to set standards for the BSCP source category. Sierra Club v. EPA, 850 F.Supp.2d 300, 303-304 (D.D.C. 2012). Under the consent decree in that case, as amended in August 2014, the EPA was obligated to sign a notice of final rulemaking to set standards for the BSCP source category by September 24, 2015.

Second, the EPA notes that following proposal, it received additional information on the Hg content of raw materials from facilities in the BSCP industry. This information did not provide the EPA with the information needed to establish subcategories based on the class or type of raw materials. However, the EPA has concluded that it has sufficient information to allow it to finalize Hg standards that account for the variability of Hg content in raw materials.

Thus, the EPA's conclusion is that there is no basis to delay promulgation of the Hg standards in order to gather more information.

Economic analysis: The economic impact of the proposed rule on small entities is significantly underestimated. Specifically, the EPA should not annualize costs at 7 percent over 20 years because that does not reflect the financing options available to small entities, the EPA underestimated the cost for a facility to become a synthetic area source, and the EPA has underestimated the cost to comply with the Hg standards given the limited information the agency has on the performance of Hg controls in this industry.

Response: The EPA standard engineering cost practice is to annualize over the expected life of the control equipment at 7 percent. The EPA does not have the data available to model the way a firm pays for an APCD because each firm has a different set of potential options for financing including debt financing, equity financing, and financing through retained earnings. The EPA acknowledges that some firms may not be able to borrow the money and some may close. The EPA's closure analysis is quite uncertain, but we do not have the detailed firm-specific information necessary to refine the analysis. The EPA agrees that the costs to become a synthetic area source at proposal were underestimated, and the final rule impacts include testing costs for all facilities, as potential synthetic area sources would have to demonstrate that their emissions qualify them to apply for synthetic area status. Finally, the EPA must use the best information available to the agency to estimate the impact of the standards on all entities. The final Hg standards incorporate variability in the Hg content of raw materials, which is expected to ease the burdens on some small entities.

### *6.4.5 Affected Small Entities*

Of 44 parent companies owning BSCP facilities, 36 parent companies are small businesses. The EPA computed the ratio of estimated compliance costs to company sales (cost-to-sales ratio) to measure the magnitude of potential impacts on small companies. Under the final standards, the EPA estimated that two to three small BSCP manufacturing facilities (two to four BSCP manufacturing facilities overall) are at significant risk of closure.

### *6.4.6 Reporting, Recordkeeping, and Other Compliance Requirements*

Respondents would be required to provide one-time and periodic notifications, including initial notification, notification of performance tests, and notification of compliance status. Respondents would also be required to submit semiannual reports documenting compliance with the rule and detailing any compliance issues, and they would be required to submit the results of performance tests to the EPA's ERT. Respondents would be required to keep documentation supporting information included in these notifications and reports, as well as records of the operation and maintenance of affected sources and APCD at the facility.

### *6.4.7 Significant Alternatives*

The EPA considered three major options for this final rule. Finalizing the proposed changes without revision is expected to have similar cost and emission reduction impacts to the standards the EPA is finalizing, with a similar number of closures (one to two small BSCP manufacturing facilities rather than two to three). However, for the various legal and technical reasons outlined in this preamble and “National Emission Standards for Hazardous Air Pollutants for Brick and Structural Clay Products Manufacturing: Background Information for Final Rule - Summary of Public Comments and Responses” in Docket ID No. EPA-HQ-OAR-2013-0291, the EPA determined that the PM/non-Hg HAP metals and Hg standards should not be finalized as proposed. The other alternative considered included the same standards for acid gases and Hg that are being finalized but only provided one set of limits PM/non-Hg HAP metals (i.e., did not provide separate sets of limits for small and large tunnel kilns). This alternative is expected to have significantly higher cost impacts than the standards the EPA is finalizing, along with a significantly higher number of closures (five to 10 small BSCP manufacturing facilities rather than two to three small BSCP manufacturing facilities). Therefore, the EPA determined that it is necessary to exercise its discretion to subcategorize by kiln size to minimize the significant economic impact on small entities.

In addition, the EPA is preparing a Small Entity Compliance Guide to help small entities comply with this rule. The guide will be available on the World Wide Web approximately 1 year after promulgation of the rule, at http://www.epa.gov/ttn/atw/brick/brickpg.html.

## 6.5 Unfunded Mandates Reform Act

This action does not contain an unfunded mandate of $100 million or more as described in the UMRA, 2 U.S.C. 1531-1538, and does not significantly or uniquely affect small governments. This action imposes no enforceable duty on any state, local, or tribal governments or the private sector.

## 6.6 Executive Order 13132: Federalism

This action does not have federalism implications. It will not have substantial direct effects on the states, on the relationship between the national government and the states, or on the distribution of power and responsibilities among the various levels of government.

### 6.7 Executive Order 13175: Consultation and Coordination with Indian Tribal Governments

This action does not have tribal implications, as specified in Executive Order 13175. It will not have substantial direct effects on tribal governments, on the relationship between the federal government and Indian tribes, or on the distribution of power and responsibilities between the federal government and Indian tribes, as specified in Executive Order 13175. The action imposes requirements on owners and operators of BSCP and clay ceramics manufacturing facilities and not tribal governments. Thus, Executive Order 13175 does not apply to this action.

### 6.8 Executive Order 13045: Protection of Children from Environmental Health Risks and Safety Risks

This action is not subject to Executive Order 13045 because the EPA does not believe the environmental health risks or safety risks addressed by this action present a disproportionate risk to children. This action's health and risk assessments are contained in the memoranda "Risk Assessment to Determine a Health-Based Emission Limitation for Acid Gases for the Brick and Structural Clay Products Manufacturing Source Category," Docket Item No. EPA-HQ-OAR-2013-0291-0132.

### 6.9 Executive Order 13211: Actions Concerning Regulations That Significantly Affect Energy Supply, Distribution or Use

This action is not a "significant energy action" because it is not likely to have a significant adverse effect on the supply, distribution, or use of energy. This action will not adversely directly affect productivity, competition, or prices in the energy sector.

### 6.10 National Technology Transfer and Advancement Act (NTTAA) and 1 CFR part 51

This action involves technical standards. The EPA has decided to use the following four voluntary consensus standards as acceptable alternatives to the EPA test methods for the purpose of this rule.

The EPA has decided to use ANSI/ASME PTC 19.10-1981, "Flue and Exhaust Gas Analyses," for its manual methods of measuring the oxygen or carbon dioxide content of the exhaust gas. This standard is acceptable as an alternative to Method 3A and 3B and is available from the American Society of Mechanical Engineers (ASME) at http://www.asme.org; by mail at Three Park Avenue, New York, NY 10016-5990; or by telephone at (800) 843-2763.

The EPA has also decided to use ASTM D6735-01 (Reapproved 2009), "Standard Test Method for Measurement of Gaseous Chlorides and Fluorides from Mineral Calcining Exhaust

Sources—Impinger Method," for its measurement of the concentration of gaseous HCl and HF and other gaseous chlorides and fluorides. This standard is acceptable as an alternative to Methods 26 and 26A.

In addition, the EPA has decided to use ASTM D6784-02 (Reapproved 2008), "Standard Test Method for Elemental, Oxidized, Particle-Bound and Total Mercury Gas Generated from Coal-Fired Stationary Sources (Ontario Hydro Method)," for its determination of elemental, oxidized, particle-bound, and total Hg emissions. This standard is acceptable as an alternative to Method 29 (portion for Hg only).

Finally, the EPA has decided to use ASTM D6348-03 (Reapproved 2010), "Standard Test Method for Determination of Gaseous Compounds by Extractive Direct Interface Fourier Transform Infrared (FTIR) Spectroscopy," for its use of an extractive sampling system to direct stationary source effluent to an FTIR spectrometer for the identification and quantification of gaseous compounds. This standard is acceptable as an alternative to Method 320 with the following conditions: (1) the test plan preparation and implementation in the Annexes to ASTM D 6348-03, Sections A1 through A8 are mandatory; and (2) in ASTM D6348-03 Annex A5 (Analyte Spiking Technique), the percent recovery (%R) must be determined for each target analyte (Equation A5.5). In order for the test data to be acceptable for a compound, %R must be greater than or equal to 70 percent and less than or equal to 130 percent. If the %R value does not meet this criterion for a target compound, the test data are not acceptable for that compound and the test must be repeated for that analyte (i.e., the sampling and/or analytical procedure should be adjusted before a retest). The %R value for each compound must be reported in the test report and all field measurements must be corrected with the calculated %R value for that compound by using the following equation: Reported Result = (Measured Concentration in the Stack x 100)/%R.

The standards ASTM D6735-01, ASTM D6784-02, and ASTM D6348-03 are available from the American Society of Testing and Materials (ASTM) at http://www.astm.org; by mail at 100 Barr Harbor Drive, Post Office Box C700, West Conshohocken, PA 19428-2959; or by telephone at (610) 832-9585.

While the EPA identified ASTM D7520–13, "Standard Test Method for Determining the Opacity in a Plume in an Outdoor Ambient Atmosphere" as being potentially applicable as an alternative to Method 9 for measuring opacity from BSCP tunnel kilns, the agency decided not to use it. The use of this voluntary consensus standard would be impractical. The five provisions for the use of this standard appear to be based on the assumption that the optical camera will be used on a daily basis. However, this rulemaking does not include daily Method 9 tests. The rule requirements are such that a Method 9 observation would need to be made unexpectedly and only when the Method 22 test failed. It would be unreasonable to expect that a source would be making daily calibrations of the camera when its use would be so infrequent. Given that, it is unlikely that the camera could be made ready in the time specified for the Method 9 readings. Therefore, this standard is not usable based on the current requirements in this rulemaking.

### 6.11 Executive Order 12898: Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations

The EPA believes the human health or environmental risk addressed by this action will not have potential disproportionately high and adverse human health or environmental effects on minority, low-income, or indigenous populations because it does not affect the level of protection provided to human health or the environment. As explained in the December 2014 proposal (79 FR 75672), the EPA determined that this final rule will not have disproportionately high and adverse human health or environmental effects on minority or low-income populations, because it increases the level of environmental protection for all affected populations without having any disproportionately high and adverse human health or environmental effects on any population, including any minority or low-income population. Additionally, the agency has conducted a proximity analysis for this rulemaking, which is located in the docket. (See “EJ Screening Report for Brick and Structural Clay,” Docket Item No. EPA-HQ-OAR-2013-0291-0102).

### 6.12 Congressional Review Act (CRA)

This action is subject to the CRA, and the EPA will submit a rule report to each house of the Congress and to the Comptroller General of the United States. This action is a “major rule” as defined by 5 U.S.C. 804(2).

# SECTION 7
# COMPARISON OF BENEFITS AND COSTS

## 7.1 Introduction

The EPA compared the monetized human health benefits of reducing cases of morbidity and premature mortality among populations exposed to PM2.5 (Section 4) with the estimated annualized social costs (Section 5) and found that the benefits of the final rule outweigh the costs. The net benefits are likely higher since EPA was not able to monetize other environmental benefits from reducing exposure to 375 tons of HAPs each year and ecosystem effects and visibility impairment associated with PM emissions.

## 7.2 Net Benefits of the Final Standards

Using a 3% discount rate, we estimate the total monetized benefits of the final standards to be $83 million to $190 million (Table 7-1). Using a 7% discount rate, we estimate the total monetized benefits to be $75 million to $170 million. The annualized costs are $27 million at a 7% interest rate. The net benefits are $56 million to $160 million at a 3% discount rate for the benefits and $48 million to $150 million at a 7% discount rate.

**Table 7-1. Summary of the Monetized Benefits, Social Costs, and Net Benefits (million 2011$)**

| | Total (3% Discount Rate) | Total (7% Discount Rate) |
|---|---|---|
| **Final Standards** | | |
| Total Monetized Benefits | $83 to $190 | $75 to $170 |
| Total Social Costs[a] | $27 | |
| Net Benefits | $56 to $160 | $48 to $150 |

[a] The methodology uses the estimate social costs from the baseline year of economic model. As a result, the same value of social costs is used for both discount rates. All estimates are independently rounded to two significant figures, so estimates may not appear to sum in this table.

# APPENDIX A
# ECONOMIC MODEL

## A.1 Baseline Data for Economic Model

### Table A-1. Affected Production Statistics by Census Region

| Census Region | 1,000 S.B.E Shipped in 2010 | Estimated Affected Production Share within Region[a] |
|---|---|---|
| East North Central | 285,508 | 81% |
| East South Central | 388,685 | 100% |
| Mid-Atlantic | 213,583 | 69% |
| Mountain | 114,154 | 50% |
| New England | 37,034 | 0% |
| Pacific | 74,563 | 85% |
| South Atlantic | 1,307,601 | 92% |
| West North Central | 183,247 | 100% |
| West South Central | 891,232 | 100% |
| **United States** | **3,495,657** | **90%** |

[a] To approximate the affected shares, EPA estimated affected production from kiln capacity and operating hours of major sources.

Source: U.S. Census Bureau, 2011 and U.S. EPA calculations.

**Table A-2. Average Prices of Brick, Building or Common and Facing: 2010**

| Census Region | $ per 1,000 S.B.E. Expressed in 2010 dollars | $ per 1,000 S.B.E. Expressed in 2011 dollars |
|---|---|---|
| New England | $379 | $387 |
| Middle Atlantic | $324 | $331 |
| East North Central | $297 | $302 |
| West North Central | $272 | $277 |
| South Atlantic | $227 | $232 |
| East South Central | $183 | $186 |
| West South Central | $225 | $229 |
| Mountain | $355 | $362 |
| Pacific | $541 | $551 |
| **United States** | **$248** | **$253** |

Sources: U.S. Census Bureau, 2011. Prices adjusted using the Implicit Price Deflator for Gross Domestic Product (GDP).

## A.2 Model Equations

Given the weight of bricks, transportation costs are high relative to value. For this reason, bricks are more likely to be bought and sold within regions because of the cost of transportation across long distances. We found that international trade represented only a small fraction of economic activity (see Section 2.5), and the latest Census data show that a majority of nonmetallic mineral products were shipped less than 100 miles (U.S. Department of Transportation, 2010).[72] Approximately 75% of the total tons shipped are shipped in NAICS is less than 50 miles. A comparison of Census region average prices for bricks shows substantial differences between regions in the average price of brick products shipped. To the extent these price differences persist over time, these differences may be consistent with regional markets for brick. As a result, we use a perfectly competitive partial equilibrium model with nine regional brick markets (defined by census region).

The market demand (D) in region (r) with regulation is:

$$Q'_{Dr} = Q_{Dr} \times \left[1 + \left(\frac{P'}{p} - 1\right) \times \eta\right] \quad \text{(A.1)}$$

The affected market supply (SA) in region (r) with regulation is:

[72]The data include other products such as cement, so it is unclear from this data whether brick and structural clay products face the same transportation and shipment patterns as cement products.

$$Q'_{SAr} = Q_{SAr} \times \left[1 + \left(\frac{(P' - unit\ cost\ increase)}{p} - 1\right) \times \varepsilon\right] \quad \text{(A.2)}$$

The unaffected market supply (SU) in region (r) with regulation is:

$$Q'_{SUr} = Q_{SUr} \times \left[1 + \left(\frac{P'}{p} - 1\right) \times \varepsilon\right] \quad \text{(A.3)}$$

At the new with-regulation market-clearing price, quantities in A.1, A.2, and A.3 satisfy the following market equilibrium condition for each region (r):

$$Q'_{Dr} = Q'_{SAr} + Q'_{SUr} \quad \text{(A.3)}$$

As reported in Section 2, a single parent company accounts for a majority of estimated census region production. As a result, the price-taking model of firm decisions may not describe business decisions as well as other economic models of pricing behavior (i.e., oligopoly). If market power exists, the use of a perfectly competitive model may understate the social costs of the final rule.

## A.3 Model Parameters

### *A.3.1 Demand*

All other things equal, consumers will likely buy fewer brick and structural clay products (BSCP) when the price of the product rises. The price elasticity of demand measures the size of the price response.[73] Several factors influence how sensitive consumers are to price changes. If consumers can easily switch from one product to another because there are many close substitutes, demand tends to be more elastic. This is particularly true for more narrow market definitions (king versus modular brick) and over longer time horizons for the consumption decision (months versus years).

Currently, EPA has not identified statistically estimated price elasticities for BSCP. However, economy-wide simulation models have suggested the nonmetallic mineral industry demand elasticity is approximately −0.8. As are result, a 1% change in price results in a 0.8% decline in the quantity demanded (Ho, Morgenstern, and Shih, 2008). Because the market definition for the product is broad, the price response for BSCP is likely more elastic than this value.

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[73]The measure is computed as the percentage change in quantity demanded divided by the percentage change in price.

### *A.3.2 Supply*

All other things equal, brick manufacturers will likely offer to sell more bricks when the price of bricks rises. The price elasticity of supply measures how much the quantity of bricks supplied responds to changes in the brick price.[74] If manufacturers have a significant amount of flexibility to change the amount of bricks they produce when the price rises, the supply of bricks is elastic. In contrast, if the quantity of brick produced and supplied only changes by small amounts when the price rises, the supply of bricks is inelastic.

A key determinant of the price elasticity of supply is the length of the time period over which the product choices can be made. During shorter periods, it is more difficult for the firm to adjust inputs and increase production. Put another way, the firm typically has some fixed factors of production that limit its ability to respond to price changes. Rutherford (2002) developed an equation that can be used to derive a benchmark price elasticity of supply that considers the fixed factor value as a share of total product value. In our example, consider the case of two production inputs, one input that is fixed during a short time period[75] and the other input that varies with production.

$$\text{Supply Elasticity} = \text{elasticity of substitution} \times \frac{1 - \text{fixed factor value share}}{\text{fixed factor value share}} \quad \text{(A.4)}$$

To illustrate the approach, consider the value share of the fixed factor to be 50% to approximately match the nonlabor value added reported in the U.S. Census data above. In cases where we lack data to estimate the elasticity of substitution, it is common to assume the elasticity is 1 (a Cobb-Douglas production function). This means that a 1% change in the ratio of factor prices would result in a 1% change in the ratio of factor shares. If we assume the elasticity of substitution between the fixed and variable input is one, the formula is

$$\text{Supply Elasticity} = 1 \times \frac{1 - 0.5}{0.5} = 1 \quad \text{(A.5)}$$

Using these values for the fixed factor's value share and elasticity of substitution, the supply elasticity is approximately one. This means if the price of brick rose by 1%, brick manufacturers would plan to sell 1% more bricks to the market. Given the current low capacity utilization rates and excess capacity available in the industry, this value may underestimate how

[74]The measure is computed as the percentage change in quantity supplied divided by the percentage change in price.
[75]The fixed factor generally includes plant and capital equipment; factors that vary with production could include materials or labor.

responsive the brick industry would be to changes in the market price. As a result, the actual supply elasticity value may be elastic with a value higher than one.

### A.4 Partial Equilibrium Measures of Social Cost: Changes Consumer and Producer Surplus

In partial equilibrium analysis, the social costs are estimated by measuring the changes in consumer and producer surplus. These values can be approximated using the market supply and demand model (Figure A-1).

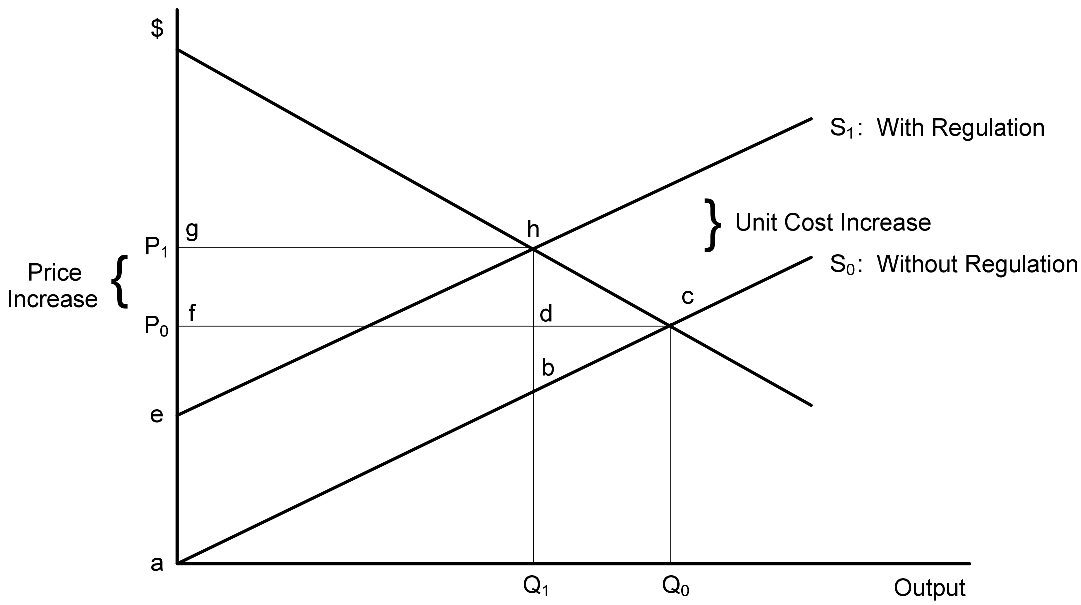


**Figure A-1. Partial Equilibrium Measures of Social Cost: Changes Consumer and Producer Surplus**

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

The change in consumer surplus is measured as follows:

$$\Delta CS = -[\Delta Q_1 \times \Delta p] + [0.5 \times \Delta Q \times \Delta p]. \quad (A.6)$$

Higher market prices and lower quantities lead to consumer welfare losses.

For affected supply, the change in producer surplus is measured as follows:

$$\Delta PS = [Q_1 \times \Delta p] - [Q_1 \times \text{unit cost increase}] - [0.5 \times \Delta Q \times (\Delta p - \text{unit cost increase})]. \quad (A.7)$$

Higher unit costs and lower production level reduce producer surplus. The losses are offset to some degree because market prices tend to rise. In contrast, for unaffected supply, the change in producer surplus is:

$$\Delta PS = [Q_0 \times \Delta p] + [0.5 \times \Delta Q \times \Delta p]. \quad (A.8)$$

Higher prices increase producer surplus for unaffected producers in the U.S. and other countries.