RESEARCH TRIANGLE INSTITUTE

Economic Analysis of Air Pollution Regulations: Portland Cement

Final Report

Submitted to

Thomas G. Walton III
U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Air Quality Strategies and Standards Division
Innovative Strategies and Economics Group
Research Triangle Park, NC 27711

Prepared by

Tyler J. Fox
Craig D. Randall
Center for Economics Research
Research Triangle Institute
Research Triangle Park, NC 27709

RTI Project Number 6443-23 DR

July 1996

RTI Project Number
6443-23 DR

Economic Analysis of Air Pollution Regulations: Portland Cement

Final Report

July 1996

Submitted to

Thomas G. Walton III
U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Air Quality Strategies and Standards Division
Innovative Strategies and Economics Group
Research Triangle Park, NC 27711

Prepared by

Tyler J. Fox
Craig D. Randall
Center for Economics Research
Research Triangle Institute
Research Triangle Park, NC 27709

CONTENTS

CONTENTS (continued)

LIST OF FIGURES

LIST OF TABLES

LIST OF TABLES

EXECUTIVE SUMMARY

The product that most Americans know simply as cement is technically referred to as Portland cement. This product received its name because it resembled the well-known building stone quarried on the Isle of Portland in the English Channel in color and texture. Production of Portland cement results in the emission of hazardous air pollutants (HAPs). Currently, the U.S. Environmental Protection Agency's (EPA's) Office of Air and Radiation is preparing a National Emission Standard for Hazardous Air Pollutants (NESHAP) for the Portland cement manufacturing industry under the authority of Section 112 of the Clean Air Act. This reports evaluates the economic impacts of additional pollution control requirements for the Portland cement industry that are designed to control releases of HAPs to the atmosphere.

ES.1 INDUSTRY PROFILE

The manufacture of Portland cement involves quarrying of clay and limestone and the crushing, drying and blending of these raw materials into the proper chemical ratio. Two distinct methods of blending the raw mixture are used: the wet process and the dry process. In the dry process, materials are dried and pulverized into a powder. In the wet process, water is added to the materials to create a slurry. The raw material mixture is then heated in kilns to 2,800° Fahrenheit at which time chemical reactions occur forming a new compound called clinker. After the addition of a small amount of gypsum (roughly 5 percent by weight), the clinker is ground into a very fine powder, which is known as Portland cement.

In 1993, production of Portland cement occurred at 201 cement kilns operating at 105 plants across the U.S. During that year, the U.S. produced 79.5 million short tons of Portland cement, while U.S. producers shipped 78.4 million short tons. The total value of Portland cement shipments in 1993 was $3.9 billion with an average value of $50.33 per short ton shipped. Portland cement is primarily used as the key ingredient in making concrete. Concrete and reinforced concrete are used extensively in almost all construction applications including homes, public buildings, roads, industrial plants, dams, bridges, and many other structures. Therefore, the demand for Portland cement is a derived demand and the rate of growth in demand for Portland cement is largely dependent on the rate of growth in construction activities.

The U.S. Portland cement industry is fragmented into regional markets rather than a single national market. Because of its low value-to-weight ratio, the relative cost of transporting cement is high and limits the geographic area in which each producer can supply its product economically. Since Portland cement is a homogeneous product, buyers are unable to distinguish between the product of sellers in the market so that the geographic bounds of each market are solely determined by the costs of transporting the Portland cement. Generally, cement sales are made within a radius of 300 miles of each plant with access to river transport allowing one to expand beyond that radius. Although some large firms compete in many regional markets by operating numerous plants, no single cement company has a distribution of plants extensive enough to serve all markets.

ES.2 REGULATORY CONTROL OPTIONS AND COSTS

The EPA's engineering analysis has determined the technology basis for the national emission standards on major and area sources. Model plants were developed to evaluate the effects of various control options on the Portland cement industry. Selection of control options was based on the application of presently available control equipment and technologies and varying levels of capture consistent with different levels of overall control. Table ES-1 presents a summary of the control options that define the MACT Floor and Beyond-the-Floor (BTF) regulatory alternatives for existing major and area sources.*

As shown in Table ES-1, sources of HAP emissions in Portland cement production include the cement kiln, clinker cooler, raw and finish mills, and materials handling facilities. The proposed MACT standards to control HAPs from cement kilns will potentially affect only non-hazardous waste burning kilns. However, the proposed controls for clinker coolers, raw and finish mills, and materials handling facilities will potentially affect all cement plants, i.e., those with hazardous waste burning kilns and those that do not have hazardous waste burning kilns. Furthermore, the proposed MACT standards are evaluated as applicable to both major and area sources within the industry.

In regard to the applicability of controls, the engineering analysis has estimated national applicability percentages for each control option shown in Table ES-1 under the MACT Floor and BTF options. However, due to the uncertainty in determining the actual kilns that will be subject to each control option and the independent nature of the control options, the economic analysis randomly determines

*The proposed control options and associated costs for new sources under the MACT Floor and BTF regulatory alternatives are presented in Section 3 of this report. However, because the estimated control costs for new sources are, on average, less than those projected for existing sources, the Agency does not anticipate any differential impact on these sources. Thus, the economic impact analysis described in Section 4 focuses on the regulatory effects on existing sources only.

TABLE ES-1. SUMMARY OF MACT FLOOR AND BEYOND-THE-FLOOR CONTROL OPTIONS ON EXISTING MAJOR AND AREA SOURCES

Emission point/HAP	Emission limit	Control Option Requirement	Monitoring Requirement
MACT Floor Control Options			
Kiln PM	0.3 lb/ton dry feed and opacity level at performance test + 5%, no greater than 20%	Upgrade FF or ESP	COM and initial M5 performance test
Kiln dioxin/furan	0.2 TEQ ng/dscm or 400° F	Water injection for gas temp. control	Initial M23 performance test
Clinker cooler PM	0.1 lb/ton dry feed and opacity limit at 10%	Upgrade FF	COM and initial M5 performance test
Raw & finish mills[a]	10% opacity	None	1 COM per raw mill and 1 COM per finish mill
Materials handling facilities	10% opacity	None	One-time M9 readings
BTF Control Option 1			
Kiln D/F and mercury	0.2 ng/dscm TEQ D/F and 30 ug/dscm Hg	Carbon injection (assuming water injection already used for gas temp. control)	Initial M29 performance test for mercury
BTF Control Option 2			
Kiln D/F and mercury	0.2 ng/dscm TEQ D/F and 50 ug/dscm Hg	Carbon injection (assuming water injection already used for gas temp. control)	Initial M29 performance test for mercury

[a] Assumes one raw mill and one finish mill per kiln.
Note: COM equals continuous opacity monitor.

Source: Memorandum from Jim Crowder, EPA, to Ron Evans, EPA. January 29, 1996. "Additional Engineering Inputs for Economic Impacts Analysis for the Portland Cement Industry NESHAP."

the applicability of the control options and associated costs to each kiln. Thus, the economic analysis will perform multiple simulations of the economic impact model to provide national-level impacts based on the engineering estimates of the national applicability percentages for each control option.

ES.3 ECONOMIC IMPACT ANALYSIS

The proposed NESHAP to control HAPs from cement kilns will directly (through imposition of control costs) and indirectly (through changes in market prices) affect each of the 201 kilns operating in the Portland cement industry as of 1993. Implementation of the proposed regulations increase the costs of producing Portland cement. The compliance costs will vary across the different kilns in the industry depending on their physical characteristics and existing level of control. The response to these additional costs will determine the economic impacts of the regulations. Specifically, the cost of the regulations may induce some owners to close their operations or to change their current operating rates. These choices affect, and in turn are affected by, the market price for Portland cement.

Because of the low value and high transport cost of Portland cement, the U.S. cement industry is divided into 20 independent regional markets as shown in Table ES-2. For each of these markets, the analysis characterizes domestic and foreign producers and consumers of Portland cement and their behavioral responses to each regulatory scenario. Given the compliance costs for directly affected kilns, each market model determines a new equilibrium solution in a comparative static approach to determine the policy outcomes of the regulatory action. Because Portland cement plants operate under conditions of high fixed costs and substantial returns to scale with a limited number of competitors, the analysis

TABLE ES-2. SUMMARY DATA FOR PORTLAND CEMENT MARKETS: 1993

Market	Number of: Operating plants	Number of: Operating kilns	F.O.B. price ($/ton)	Production (million tons): U.S.	Production (million tons): Canadian	Production (million tons): Rest of world	Production (million tons): Total	Top 2-plant concentration ratio
Atlanta	8	19	$51.99	5.69	--	0.50	6.19	34.1%
Baltimore/Philadelphia	10	24	$51.51	7.18	--	0.01	7.18	27.2%
Birmingham	6	7	$50.84	4.29	--	0.26	4.54	48.0%
Chicago	6	10	$53.57	3.50	0.15	--	3.66	44.8%
Cincinnati	4	7	$53.73	2.88	--	--	2.88	58.0%
Dallas	6	15	$48.25	5.19	--	--	5.19	43.4%
Denver	5	9	$63.72	2.69	--	--	2.69	54.0%
Detroit	4	10	$56.73	4.76	1.13	--	5.89	58.1%
Florida	4	8	$59.71	3.08	--	1.42	4.50	66.4%
Kansas City	7	18	$53.79	3.86	--	--	3.86	40.9%
Los Angeles	7	15	$61.86	6.72	--	0.46	7.18	42.3%
Minneapolis	2	3	$60.85	1.44	0.18	--	1.62	100.0%
New York/Boston	5	6	$59.18	3.53	0.41	0.25	4.19	60.6%
Phoenix	4	10	$64.88	2.69	--	--	2.69	64.8%
Pittsburgh	4	8	$63.44	1.85	1.04	--	2.88	63.8%
Salt Lake City	5	7	$76.41	1.53	0.31	--	1.84	49.7%
San Antonio	7	11	$46.16	5.11	--	0.17	5.27	36.6%
San Francisco	4	5	$51.18	3.08	--	0.31	3.40	68.5%
Seattle	2	2	$62.27	1.13	0.74	0.41	2.27	100.4%
St. Louis	5	7	$49.75	5.04	--	--	5.04	45.9%
U.S. total/average	105	201	$55.49	75.2	4.0	3.8	83.0	--

employs an oligopolistic market structure to compute the new equilibrium prices and quantities associated with imposition of the regulatory option(s). As opposed to the models of perfect and monopolistic competition, the general model oligopolistic competition stresses the strategic interaction between producers in that each must take into account the output choices of others in determining its own output choice.

Table ES-3 provides a summary of the national-level economic impact results, which reflect the sum of the mean impact measures across each of the 20 regional models. As shown, imposition of the MACT Floor results in a national increase of roughly 1 percent in the market price of Portland cement and a reduction in domestic production between 1.6 and 1.9 percent depending on the potentially affected population. The projected price increase is just over half of the 1.7 percent change in Portland cement prices from 1992 to 1993, while the projected reduction in domestic production is almost 40 percent of the increase observed during that time period. The economic analysis also projects that as many as 3 kilns will close as a result of imposition of the MACT Floor.

For the BTF options, the economic analysis projects a national price increase between 2.3 and 2.9 percent and a reduction in domestic production between 3.6 and 4.5 percent depending on the potentially affected population. The projected price increase is 1.5 times the percent change in Portland cement prices from 1992 to 1993, while the projected reduction in domestic production is very close to the change during that time period. The economic analysis also projects that between 5 and 10 kilns will close as a result of imposition of the BTF options depending on the potentially affected population.

TABLE ES-3. SUMMARY OF NATIONAL LEVEL ECONOMIC IMPACTS RESULTS BY REGULATORY ALTERNATIVE

	Market Impacts (%)		Industry Impacts			
Regulatory Alternative	Change in Price	Change in Dom. Prod.	Post-Reg. Control Costs ($\$10^6$)	Kiln Closures	Emp. Losses	Social Costs ($\$10^6$)
Major and area sources						
MACT Floor	1.1	-1.9	\$31.3	3	250	\$37.3
BTF Option 1	2.8	-4.5	\$81.2	6	560	\$103.6
BTF Option 2	2.6	-4.0	\$55.4	9	485	\$73.6
Major sources only						
MACT Floor	1.0	-1.6	\$28.6	2	220	\$33.9
BTF Option 1	2.9	-4.5	\$59.4	10	540	\$81.1
BTF Option 2	2.3	-3.6	\$48.0	8	449	\$64.2
Major sources and D/F and Hg controls on area sources						
MACT Floor	1.1	-1.7	\$28.8	2	227	\$34.5
BTF Option 1	2.5	-3.9	\$73.6	5	509	\$93.1
BTF Option 2	2.5	-3.9	\$50.0	9	459	\$67.5

Furthermore, the market adjustments in price and quantity allow calculation of the economic welfare impacts (i.e., changes in the aggregate economic welfare as measured by consumer and producer surplus changes). These estimates represent the social cost of the regulation. For the MACT Floor, the estimated social cost of the regulation varies from $34 million as applied to major sources only to $37 million as applied to both major and area sources. This indicates that the impacts on major sources are driving the results at the MACT Floor level. For the BTF options, the estimated social cost of the regulation varies by potentially affected population from $64 million for BTF option 2 on major sources only to $104 million for BTF option 1 on major and area sources. These results indicate that the impacts on domestic producers do vary with the potentially affected population as the significant differences in BTF control costs across kilns causes greater distributional impacts within the industry.

ES.4 SMALL BUSINESS IMPACTS

The small business analysis focuses on the economic impact of the proposed regulatory options on the 9 cement plants and 22 cement kilns operating during 1993 that are owned by the 9 small companies identified in Section 2.4.2. Small companies are defined according to the SBA size standard for SIC 3241--hydraulic cement as those companies that own Portland cement plants and have less than 750 total employees. Given the small number of cement plants and kilns owned by small businesses relative to the industry as a whole (8.5 percent of all plants and 10.9 percent of all kilns), it is important to point out that the random determination of applicability of the regulatory controls and associated costs will introduce some uncertainties regarding the impacts projected for particular plants or kilns more so than the aggregate estimates. The measures of economic impact provided by this analysis include the changes in revenue, costs, and pre-tax earnings; the post-regulatory compliance costs; cement plant and kiln closures; the change in employment attributable to the change in output at these plants; and the engineering control cost share of baseline revenues.

A summary measure of small business impacts is the share of control cost to baseline revenues at cement plants owned by small businesses. For this calculation, control costs are defined as the engineering control costs imposed on these plants and, thus, do not reflect the individual plant or kiln production responses to the imposition of these costs and the resulting market adjustments. For the MACT Floor options, the control cost share of revenue is less than 1 percent for each potentially affected population of cement plants and kilns. Alternatively, for the BTF options, the control cost share exceeds 2 percent under BTF option 1, which affects 30 percent of non-hazardous waste burning kilns, and is in the neighborhood of 2 percent under BTF option 2, which affects 20 percent of non-hazardous waste burning kilns.

SECTION 1
INTRODUCTION

The Environmental Protection Agency (EPA or the Agency) is developing an air pollution regulation for reducing emissions generated by the Portland cement industry. A National Emission Standard for Hazardous Air Pollutants (NESHAP) has been developed for each category of major and area sources under the authority of section 112(d) of the Clean Air Act as amended in 1990. The Innovative Strategies and Economics Group (ISEG) of EPA contributes to this effort by providing analyses and supporting documents that describe the likely economic impacts of the proposed standards on directly and indirectly affected entities.

1.1 SCOPE AND PURPOSE

This report evaluates the economic impacts of additional pollution control requirements for the Portland cement industry that are designed to control releases of hazardous air pollutants to the atmosphere. The Clean Air Act's purpose is "to protect and enhance the quality of the Nation's air resources: (Section 101(b)). Section 112 of the Clean Air Act as amended in 1990 establishes the authority to set national emission standards for 189 hazardous air pollutants. The 189 pollutants that are designated as HAP are listed in section 112(b).

A major source is defined as a stationary source or group of stationary sources located within a contiguous area and under common control that emits, or has the potential to emit considering control, 10 tons or more of any one HAP or 25 tons or more of any combination of HAP. An area source is any stationary source that is not a major source. For hazardous air pollutants, the Agency establishes Maximum Achievable Control Technology (MACT) standards. The term "MACT floor" refers to the minimum control technology on which MACT can be based. For existing major sources, the MACT floor is the average emissions limitation achieved by the best performing 12 percent of sources (if there are 30 or more sources in the category or subcategory), or best performing 5 sources (if there are fewer than 30 sources in the category or subcategory). MACT can be more stringent than the floor considering costs, non-air quality health and environmental impacts, and energy requirements. The statute gives discretion to the Agency when setting standards under section 112(d) for area sources. Standards for area sources may either be based on MACT, as for major sources, or on generally available control technology (GACT).

1.2 ORGANIZATION OF THE REPORT

The remainder of this report is divided into three sections that support and provide details on the methodology and results of this analysis. The sections include the following:

- Section 2 provides a summary profile of the Portland cement industry. It provides an overview of the Portland cement industry with data presented on products and markets, cement plants and kilns, and the companies that own and operate these plants.
- Section 3 reviews the regulatory control options and associated costs of compliance. This section is based on the EPA's engineering analysis conducted in support of the national emission standards for the Portland cement industry.

- Section 4 details the methodology for assessing the economic impacts of the proposed regulations and the analysis results, which include market, industry, and small business impacts as well as social cost estimates.

SECTION 2
INDUSTRY PROFILE

The product that most Americans know simply as cement is technically referred to as Portland cement. This product received its name because it resembled the well-known building stone quarried on the Isle of Portland in the English Channel in color and texture. Production of Portland cement results in the emission of hazardous air pollutants (HAPs). Currently, the U.S. Environmental Protection Agency's (EPA's) Office of Air and Radiation is preparing a National Emission Standard for Hazardous Air Pollutants (NESHAP) for the Portland cement manufacturing industry under the authority of Section 112 of the Clean Air Act.

In 1993, the U.S. produced 79.5 million short tons of Portland cement, while U.S. producers shipped 78.4 million short tons. The total value of Portland cement shipments in 1993 was $3.9 billion with an average value of $50.33 per short ton shipped.[1] Portland cement is used predominantly in the production of concrete. Concrete and reinforced concrete are used extensively in almost all construction applications including homes, public buildings, roads, industrial plants, dams, bridges, and many other structures. Therefore, the demand for Portland cement is a derived demand and the rate of growth in demand for Portland cement is largely dependent on the rate of growth in construction activities.

The remainder of this section provides a brief introduction to the Portland cement industry. The purpose is to give the reader a general understanding of the technical and economic aspects of the industry that must be addressed in the economic impact analysis. Section 2.1 provides an overview of the production processes. Section 2.2 presents historical data on the Portland cement industry, including the U.S. production and consumption and foreign trade. Lastly, Section 2.3 summarizes the organization of the Portland cement industry, including a description of the markets for Portland cement, the U.S. manufacturing plants and the firms that own these plants.

2.1 PRODUCTION PROCESS

As shown in Figure 2-1, the Portland cement manufacturing process consists of:

- quarrying and crushing the raw materials,
- grinding the carefully proportioned materials to a high degree of fineness,
- firing the raw materials mixture in a rotary kiln to produce clinker, and
- grinding the resulting clinker to a fine powder and mixing with gypsum to produce cement.

There are basically two distinct methods of blending the raw mixture: the wet process and the dry process. In the wet process, water is added to the materials to create a slurry that is fed into the kiln. The water eventually is evaporated in the kiln where the raw materials are converted into clinker. The wet process consumes much more fuel that the dry process to evaporate the water in the slurry, therefore requiring more energy.

In the dry process, all grinding and blending are done with dry materials that are fed directly into the kiln to be calcined into clinker. Newer plants employing the dry process are equipped with innovations such as suspension preheaters and precalciners to increase the overall energy efficiency of

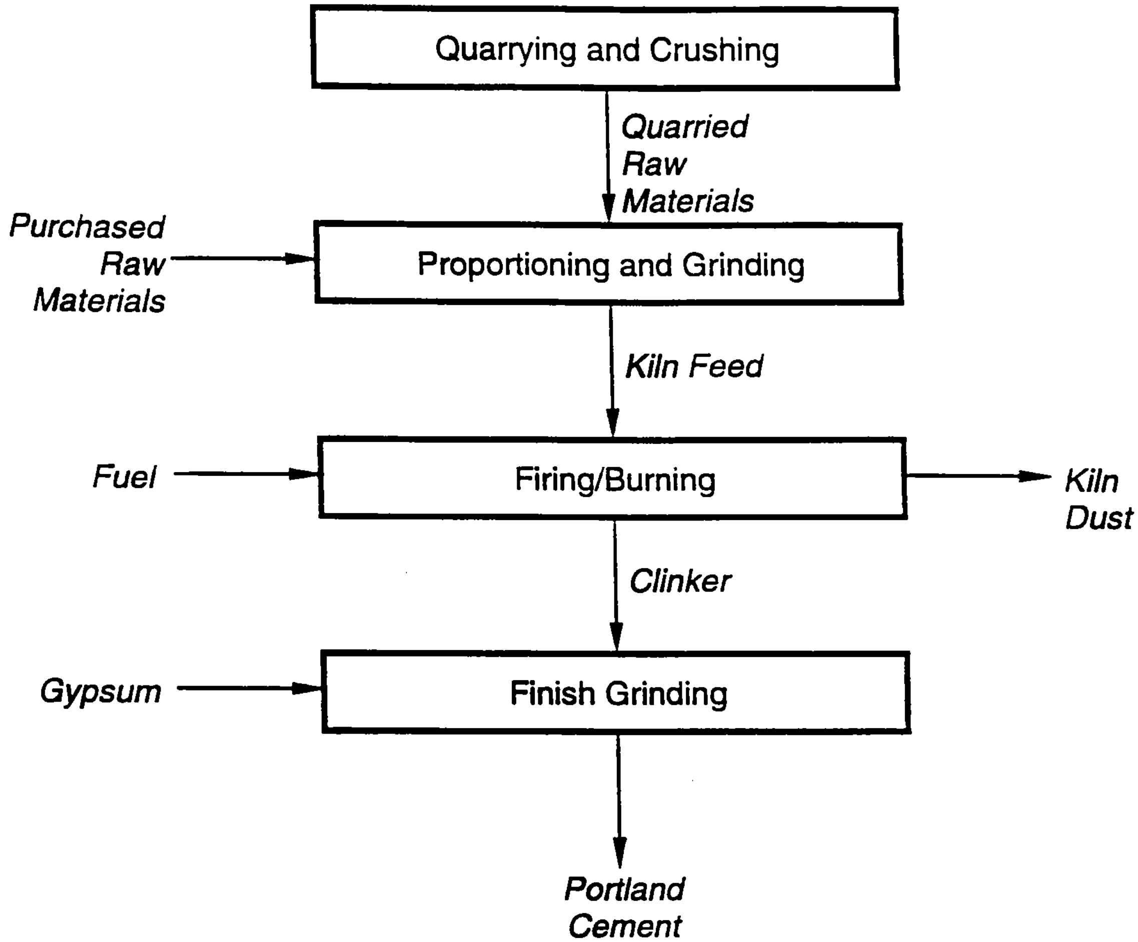

Figure 2-1. Basic flow diagram of the Portland cement manufacturing process.

the cement plant. This improvement is the only major technological change in Portland cement production that has occurred over the last three decades. A cyclone preheater system typically achieves 40 to 50 percent calcination of the feed before it enters the rotary cement kiln, whereas a precalciner system uses an additional firing system to achieve almost 95 percent calcination of feed before it enters the kiln.[2] The advantage of using preheaters and precalciners is that they can further increase fuel efficiency and reduce production costs.

In 1993, clinker capacity at wet process kilns was 24 tpy and capacity at dry process kilns was 58.2 tpy. Within the dry process category facilities equipped with preheater technology had capacity totaling 15.4 tpy (28 percent) and facilities equipped with a precalciner system had capacity totaling 24.2 tpy (41.2 percent).

Clinker is ground into cement by adding roughly 5 percent gypsum and other materials that retard the absorption of water and allow for easier handling. The final grinding step and the materials added are very important in determining the specifications and type of finished cement.

2.2 TYPES OF PORTLAND CEMENT

The five basic types of Portland cement produced in the United States are described below. In addition, different varieties are prepared by using various blending formulations

Type I: Regular Portland cements are the usual products used in general concrete construction, most commonly known as gray cement because of its color. Type I is provided as a concrete without special properties. In contrast, white cement typically contains less ferric oxide and is used for special applications. Other types of regular cements include oil-well cement, quick-setting cement, and others for special uses.

Type II: Moderate heat-of -hardening and sulfate resisting Portland cements are intended for use when moderate heat of hydration is required or for general concrete construction exposed to moderate sulfate action.

Type III: High early strength cements are made from raw materials with a lime to silica ratio higher than that of Type I cement and are ground finer than Type I cements. They contain a higher proportion of tricalcium silicate than regular Portland cements.

Type IV: Low heat Portland cements contain a lower percentage of tricalcium silicate and tricalcium aluminate than Type I, thus lowering the heat evolution. Consequently, the percentage of tetracalcium aluminoferrite is increased. Type IV cements are produced to attain a low heat of hydration.

Type V: Sulfate resisting Portland cements are those that, by their composition or processing, resist sulfates better than the other four types.

The use of additives, or admixtures, allows producers to alter or enhance the attributes of the cement product and, thus, the ultimate concrete product. Admixtures affect factors such as durability, appearance, versatility, and cost-effectiveness by altering the hydration of Portland cement in some way, by changing the speed of reaction, or by dispersing the cement particles more thoroughly throughout the concrete mix.

As shown in Table 2-1, 91 percent of total Portland cement production in 1990 comprised Types I and II cement, while almost 4 percent was Type III.[3] Type V accounted for 2 percent and oil-well cements accounted for 1 percent. The remaining production in 1990 included white, expansive, Portland slag and pozzolan, and other miscellaneous cements. Furthermore, as illustrated in Table 2-1, the average value per ton varied greatly across each type of cement in 1990. The average value per ton ranged from a high of $156.40 per ton of white cement to a low of $45.97 per ton of oil-well cement. The value per ton for the most common types of Portland cement (Types I through V) does not vary as greatly--

ranging from a high of $58.45 per ton of Type V to a low of $48.60 per ton of Types I and II.

TABLE 2-1. PORTLAND CEMENT SHIPPED FROM PLANTS IN THE UNITED STATES BY TYPE: 1990[a]

Type	Quantity (10^3 short tons)	Value[b] ($\$10^3$)	Average per ton ($)
General use and moderate heat (Types I and II)	77,342	3,758,475	48.60
High-early-strength (Type III)	3,152	159,311	50.55
Sulfate-resisting (Type V)	957	55,927	58.45
Oil well	963	44,286	45.97
White	415	64,980	156.40
Portland slag and Portland pozzolan	436	23,651	54.30
Expansive	45	4,405	98.48
Miscellaneous[c]	1,060	62,727	59.19
Total or average[d,e]	84,370	4,173,762	49.47

[a] Includes Puerto Rico.
[b] This value reflects the actual value of sales to customer, free on board (f.o.b.) plant, less all discounts and allowances, less all freight charges to customer, less all freight charges from producing plant to distribution terminal if any, less total cost of operating terminal if any, less cost of paper bags and pallets.
[c] Includes waterproof, low-heat (Type IV), and regulated fast-setting cement.
[d] Data may not add to totals shown because of rounding.
[e] Does not include cement consumed at plant.

Source: Johnson, W. Cement: Annual Report 1990. U.S. Department of the Interior, Bureau of Mines. 1992. Table 16.

2.3 HISTORICAL INDUSTRY DATA

Portland cement is produced and consumed domestically as well as traded internationally. Therefore, domestic producers export some Portland cement to other countries, and foreign producers supply their Portland cement to U.S. markets. This section includes tables and figures on value, quantity, and price trends over the past decade for Portland cement, where statistics are available. Otherwise data were aggregated for hydraulic cement, which includes Portland and masonry cement.

2.3.1 Domestic Production

Domestic quantity and value shipped for Portland cement from 1982 to 1993 are shown in Table 2-2.[4, 5, 6, 7] In 1993, the domestic shipments of Portland cement were valued at $3.9 billion, reflecting a 20.9 percent increase from 1982, and more recently, a 6.63 percent increase from 1992. As shown in Table 2-2, quantity shipped increased 22.3 percent from 1982 to 1993, increasing to 78.4 million tons in 1993. Average value per ton was $50.33 in 1993, which reflects a decline of 1.2 percent from 1982 but a 1.7 percent increase from 1992.

2.3.2 Foreign Trade

Table 2-3 shows the quantity imported and total value of imports to the U.S. between 1982 and 1993.[8], [9], [10] Cement imports became a significant share of domestic consumption in the 1980s, but the share has declined in recent years. Many distribution terminals for imports were built during the 1980s, while closed plants were converted into terminals. From 1982 to 1987, foreign imports of cement to the U.S. increased fivefold from 2.9 million tons to 17.5 million tons, respectively. Since 1987, the absolute level of foreign imports has declined. In 1993, foreign imports totaled only 7.7 million tons, reflecting a dramatic decline of over 55.6 percent from 1987. Major importing countries include Canada (36 percent of total foreign imports to the U.S. in 1991), Colombia (14 percent), and Mexico (12 percent). Florida and California led all other states in the amount of imports received, accounting for 19 and 12 percent of the total, respectively.

TABLE 2-2. VALUE OF DOMESTIC SHIPMENTS, QUANTITY SHIPPED, AND AVERAGE VALUE PER TON: 1982-1993

Year	Value of Shipments ($103)	Quantity Shipped (10^3 short tons)	Avg. Value/Ton ($)
1982	3,263,522	64,066	50.94
1983	3,543,103	70,933	49.95
1984	4,152,598	80,166	51.80
1985	4,290,263	83,032	51.67
1986	4,407,722	87,592	50.32
1987	4,393,684	89,246	49.23
1988	4,370,463	89,460	48.85
1989	4,242,931	86,238	49.20
1990	4,173,762	84,370	49.47
1991	3,606,714	74,032	48.72
1992	3,699,611	74,782	49.47
1993	3,944,796	78,378	50.33

Sources: Soloman, Cheryl. Cement: Annual Report 1991. Washington, DC, U.S. Department of the Interior, Bureau of Mines. 1993.

Johnson, W. Cement: Annual Report 1990. Washington, DC, U.S. Department of the Interior, Bureau of Mines. 1992.

U.S. Department of Interior, Bureau of Mines. Mineral Commodity Summaries 1987. Washington, DC, U.S. Government Printing Office. 1987.

Solomon, Cheryl. Cement: Annual Report 1993. Washington, DC, U.S. Department of the Interior, Bureau of Mines. 1995.

The observed decline in imports from 1987 through 1993 can be attributed to recent findings by the International Trade Commission (ITC) that imports from Mexico, Japan, and Venezuela were sold in the U.S. at less than fair value and the subsequent duties placed upon imports from these countries.[11] The recent findings against Mexico, Japan, and Venezuela have not only affected the level of imports but also the mix of supplying countries to the U.S. market.

TABLE 2-3. SUMMARY OF HYDRAULIC CEMENT IMPORTS TO THE U.S.: 1982-1993

Year	Value ($\$10^3$)	Quantity (10^3 short tons)	Value/Ton ($)
1982	N/A	2,911	N/A
1983	N/A	4,221	N/A
1984	N/A	8,689	N/A
1985	N/A	14,120	N/A
1986	N/A	16,091	N/A
1987	N/A	17,536	N/A
1988	616,107	17,488	35.23
1989	605,325	15,741	38.45
1990	553,047	13,273	41.66
1991	402,557	8,701	46.26
1992	297,174	6,797	43.72
1993	331,337	7,782	42.58

N/A = not available.

Sources: Soloman, Cheryl. Cement: Annual Report 1991. Washington, DC, U.S. Department of the Interior, Bureau of Mines. 1993.

Johnson, W. Cement: Annual Report 1990. Washington, DC, U.S. Department of the Interior, Bureau of Mines. 1992.

U.S. Department of Interior, Bureau of Mines. Mineral Commodity Summaries 1987. Washington, DC, U.S. Government Printing Office. 1987.

The penetration of foreign imports increased drastically over the period from 1982 to 1988 because of the gap between domestic production and demand for cement. Imports as a percentage of domestic consumption increased from 4.4 percent in 1982 to almost 19 percent in 1988. In 1990, foreign imports accounted for 14.8 percent of domestic consumption of Portland and masonry cement. In recent years, roughly 70 percent of all imports have been by firms that also produce cement in the U.S. The remaining 30 percent of foreign imports is shipped in by independent importers.[12] Soloman reports that 17 independent importers have constructed terminals to receive foreign cement for coastal markets.[13]

Table 2-4 provides the quantity exported and total value of exports from the U.S. of Portland and masonry cement between 1982 and 1993.[14, 15, 16] During the period from 1982 to 1987, U.S. exports declined by almost 75 percent from 201,000 tons to only 52,000 tons. Since that time, the level of U.S. exports has increased each year. In 1991, U.S. exports totaled 698,000 tons at a value of $45.8 million, which accounts for only 1.3 percent of the total U.S. value of shipments for 1991. The vast majority of U.S. exports of hydraulic cement goes to Canada: U.S. producers shipped a total of 531,000 tons to Canada in 1991, or 76 percent of total U.S. exports. The remaining fraction of U.S. exports in 1991 went to the Bahamas, Mexico, and 49 other countries around the world.[17]

2.4 INDUSTRY ORGANIZATION

Generally because of the low value of Portland cement and the high transportation costs, the Portland cement industry is characterized by regional markets. Current studies by Iwand and Rosenbaum analyzing the effects of capacity constraints on the pricing strategies of firms in the cement industry[18] and Rosenbaum and Reading on the relationship between domestic market structure and cement importation into the U.S.[19] have divided the U.S. market for Portland cement into a number of regional submarkets. Portland cement is generally regarded as a homogeneous product. This homogeneity prevents buyers from distinguishing between the product of sellers in the market so that the geographic boundaries of each market are solely determined by the costs of transporting the Portland cement, which are borne by the consumers.

TABLE 2-4. SUMMARY OF U.S. EXPORTS OF HYDRAULIC CEMENT: 1993

Year	Value ($$10^3$)	Quantity (10^3 short tons)	Value/Ton ($)
1982	N/A	201	N/A
1983	N/A	118	N/A
1984	N/A	80	N/A
1985	N/A	98	N/A
1986	N/A	59	N/A
1987	N/A	52	N/A
1988	8,907	101	88.18
1989	25,561	512	49.92
1990	38,306	554	69.14
1991	45,774	698	65.57
1992	48,720	822	59.27
1993	47,772	689	69.34

N/A = not available.

Sources: Soloman, Cheryl. Cement: Annual Report 1991. Washington, DC, U.S. Department of the Interior, Bureau of Mines. 1993.

Johnson, W. Cement: Annual Report 1990. Washington, DC, U.S. Department of the Interior, Bureau of Mines. 1992.

U.S. Department of Interior, Bureau of Mines. Mineral Commodity Summaries 1987. Washington, DC, U.S. Government Printing Office. 1987.

The Census of Transportation reported that 82.5 percent of all Portland cement shipments were within a radius of 200 miles and 99.8 percent were within a distance of 500 miles in 1977, the last year for which this information was collected.[20] These data support the idea that buyers and sellers of Portland cement are concentrated in localized markets. For each study mentioned above, the regional cement market consists of a major metropolitan area and all Portland cement plants located within 200 miles of the central city. Thus, geographical markets are delineated where only neighboring firms compete directly. Possible exceptions could occur at locations where plants or firms have access to inexpensive transportation such as waterways.

Table 2-5 provides times-series data from 1983 to 1993 on delivered prices of Portland cement for 20 cities as reported by the Engineering News-Record.[21] Delivered prices reflect the transport costs paid by the consumer and the "free on board" (f.o.b.) price received by the producer. The unweighted 20-city average price of Portland cement in 1993 was $63.22 per ton--a 1.3 percent increase from the previous year. The prices in 1993 ranged from a low of $49.93 in Dallas to a high of $79.65 in Cincinnati. The 20-city average in Portland cement price grew over the past decade by 1.75 percent, with price declining in 8 cities and increasing in the remaining 12 cities.

2.4.1 MANUFACTURING PLANTS

The number of Portland cement plants in the U.S. has slowly and consistently decreased since 1973. Figure 2-2 shows that 176 plants were in operation in 1973 compared to the 118 plants in operation in 1993, which consist of 107 gray cement plants, 3 white cement plants, and 8 grinding-only facilities.[22]

2.4.1.1 <u>Location</u>. Figure 2-3 identifies the location of U.S. cement producing facilities operating in 1993.[23] According to the survey conducted by the Portland Cement Association, one state agency and 44 companies operated 118 Portland cement manufacturing plants in 37 states across the U.S in 1993. California, Texas, Pennsylvania, Michigan, and Missouri are the top five states in order of capacity, together accounting for over 44 percent of U.S. clinker production.[24]

TABLE 2-5. AVERAGE PER TON VALUE OF PORTLAND CEMENT DELIVERED TO 20 U.S. CITIES: 1983 TO 1993

City	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Atlanta	$59.51	$59.79	$61.55	$61.96	$61.96	$60.23	$59.00	$59.75	$55.35	$53.63	$55.00
Baltimore	$58.83	$68.42	$72.63	$67.00	$64.50	$64.50	$66.50	$65.25	$64.50	$64.50	$67.42
Birmingham	$64.95	$64.13	$62.67	$64.25	$62.17	$61.00	$63.00	$59.83	$60.17	$59.33	$60.00
Boston	$57.41	$63.29	$74.20	$80.50	$75.00	$73.42	$67.00	$59.65	$55.65	$58.25	$60.50
Chicago	$57.00	$60.83	$65.33	$67.92	$68.00	$68.75	$68.33	$61.50	$62.50	$64.00	$64.00
Cincinnati	$58.60	$56.35	$59.02	$63.10	$67.17	$71.20	$72.20	$72.20	$78.45	$80.20	$79.65
Cleveland	$59.00	$60.00	$60.00	$61.33	$61.00	$61.50	$61.33	$63.17	$65.75	$59.68	$60.23
Dallas	$57.50	$60.08	$57.67	$56.00	$47.58	$45.67	$44.12	$45.08	$46.17	$47.83	$49.93
Denver	$78.72	$76.51	$75.77	$81.07	$77.27	$71.40	$56.60	$56.44	$62.40	$68.76	$71.21
Detroit	$56.22	$58.71	$64.63	$66.92	$71.71	$74.28	$74.49	$76.06	$80.81	$78.45	$68.83
Kansas City	$68.64	$69.79	$72.04	$73.07	$67.94	$67.47	$67.47	$67.47	$67.47	$64.79	$63.90
Los Angeles	$66.16	$62.39	$63.60	$63.91	$63.95	$65.95	$66.93	$66.60	$65.83	$63.38	$63.62
Minneapolis	$71.71	$73.19	$70.30	$63.05	$55.38	$56.49	$57.80	$61.00	$61.23	$62.83	$62.33
New Orleans	$57.00	$52.92	$55.00	$53.00	$52.00	$51.43	$48.71	$53.73	$51.92	$53.67	$56.00
New York	$59.33	$65.00	$67.75	$67.40	$70.50	$78.66	$76.75	$70.00	$63.33	$61.83	$64.92
Philadelphia	$54.50	$63.84	$70.28	$65.39	$65.50	$68.92	$73.00	$74.17	$76.00	$51.25	$57.50
Pittsburgh	$62.36	$64.03	$66.38	$66.36	$66.52	$60.58	$62.39	$61.86	$65.69	$68.69	$69.36
St. Louis	$54.03	$57.82	$56.61	$52.51	$46.71	$48.67	$47.00	$48.25	$52.75	$50.83	$53.33
San Francisco	$66.75	$64.79	$64.86	$65.01	$65.11	$65.96	$65.67	$66.14	$66.66	$64.24	$63.67
Seattle	$74.33	$58.00	$58.00	$58.00	$64.00	$71.50	$67.15	$65.17	$69.17	$72.00	$73.00
20 city average	$62.13	$62.99	$64.91	$64.89	$63.70	$64.38	$63.27	$62.67	$63.59	$62.41	$63.22

[a] Values reported are spot prices quoted from single source within the city. Quotes are delivered prices for Portland Cement.

Source: Engineering News Record. ENR Materials Prices. Annual Average 1983 through Annual Average 1993.

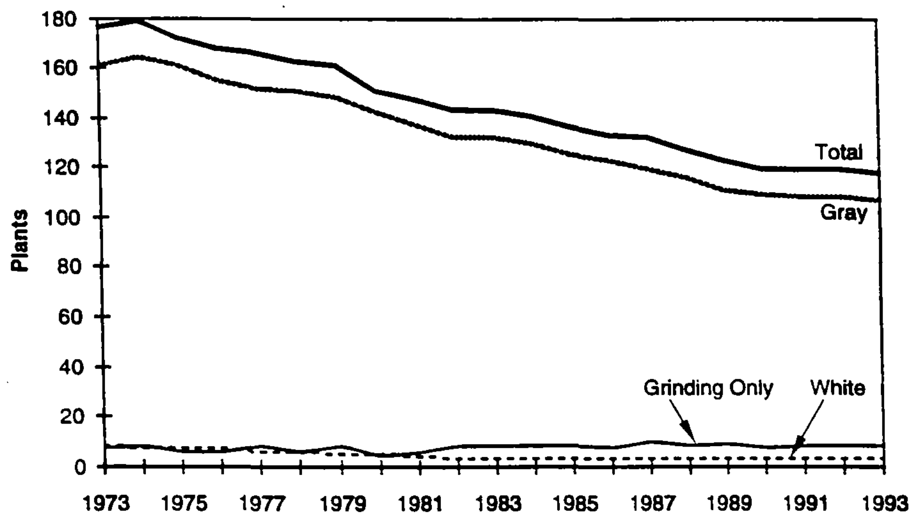

Figure 2-2. Number of U.S. cement plants by type of cement: 1973-1993.

Source: Portland Cement Association. U.S. and Canadian Portland Cement Industry: Plant Information Summary. Skokie, IL, Portland Cement Association. 1994.

Thirteen states and the District of Columbia had no clinker producing facilities in 1993: Alaska, Connecticut, Louisiana, New Hampshire, North Dakota, Wisconsin, Delaware, Massachusetts, New Jersey, Rhode Island, District of Columbia, Minnesota, North Carolina, and Vermont. Table 2-6 identifies cement production capacity by state.[25, 26] Thirteen of these areas (excluding Alaska) also have no cement producing facilities.

2.4.1.2 Kilns. Data collected by EPA under the authority of Section 114 of the Clean Air Act, combined with

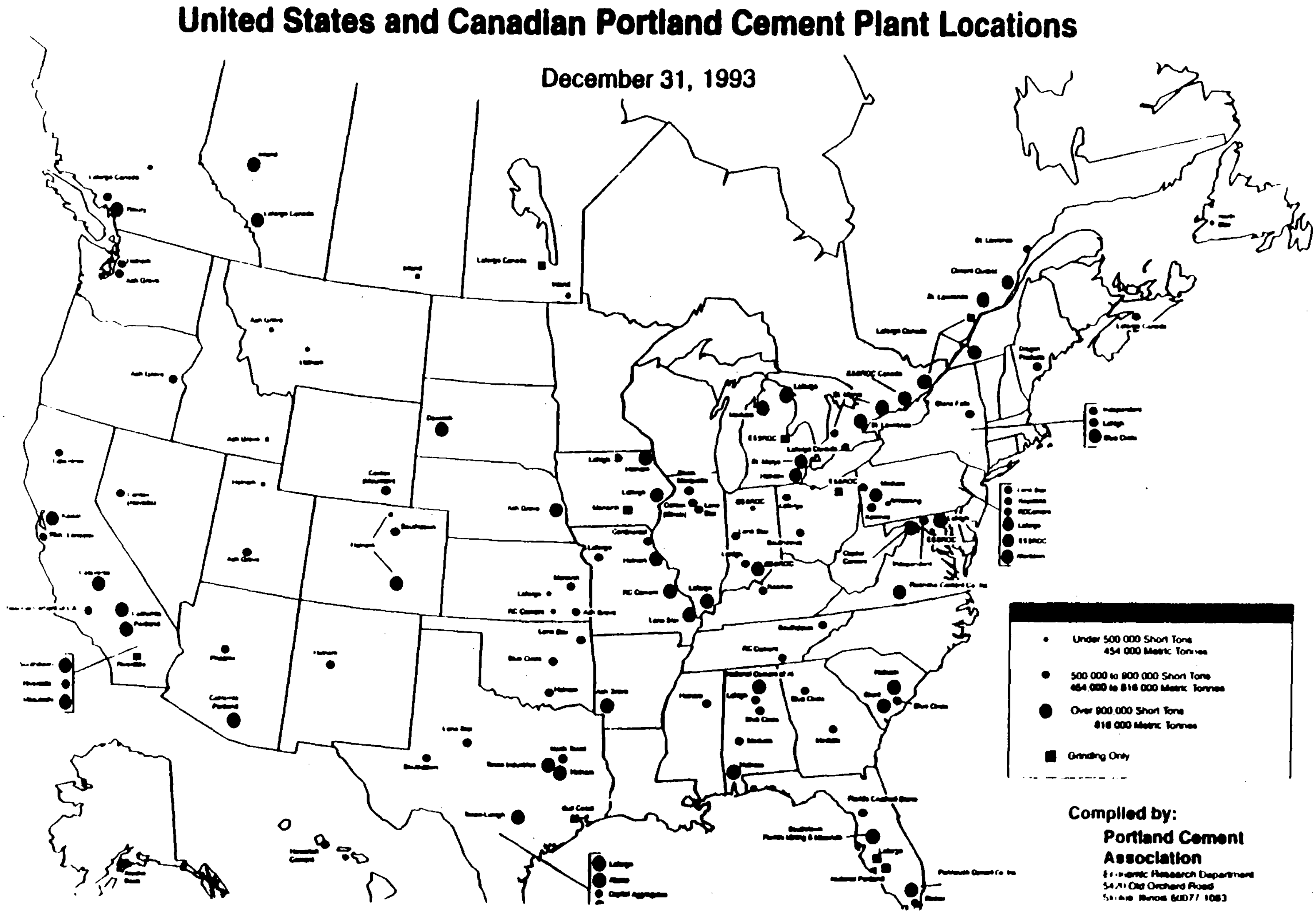

Figure 2-3. U.S. Portland cement plant locations, December 31, 1993.

Source: Portland Cement Association. U.S. and Canadian Portland Cement Industry: Plant Information the PCA survey, profile the industry on the basis of process technology used to manufacture cement (see Table 2-7).[27, 28] According to the EPA survey, in 1993, 210 kilns operated at 113 plants (including two plants in Puerto Rico not included in the PCA survey). On the basis of number of kilns, 35 percent used the wet process and 65 percent used the dry process. Breaking down the dry process kilns further, 18 percent of the kilns were using a preheater type of dry process, while 13 percent were using a precalciner type of dry process. The current trend in the industry is toward the dry process because of its lower fuel costs and generally higher efficiency levels.

Data also indicate that the newer kilns employ the dry process. Only 10 of the 71 kilns that have gone on-line since 1971 employ the wet process. The information in Table 2-8 also provides evidence that average kiln capacity, especially dry process kiln capacity, continues to increase because plants are using newer kilns. Data collected by EPA through the information collection request (ICR) indicate that the expected service life of kilns ranges between 25 and 50 years.[29]

Kilns can also be characterized by the type of fuel they use. Table 2-9 summarizes fuel use at U.S. cement plants operating in 1993. In 1993, most Portland cement kilns (accounting for about 82.2 percent of the clinker capacity) in the U.S. were fired with coal, coke, or a combination of the two. A small fraction reported using natural gas (2.2 percent of clinker capacity) or oil (0.1 percent) as the primary fuel. The remaining 15.5 percent of the clinker capacity was in plants that use combinations of fossil fuels plus waste fuels.[30] In 1993, operators of 43 plants reported that they were using wastes for part or all of their fuel requirements.[31]

TABLE 2-6. U.S. CLINKER CAPACITIES BY STATE: 1993[a]

Rank	Clinker (10^3 tons)	States
1	10,928	California
2	8,675	Texas
3	7,197	Pennsylvania
4	5,073	Michigan
5	4,773	Missouri
6	4,491	Alabama
7	3,368	New York
8	3,346	Florida
9	2,994	Indiana
10	2,766	Illinois
11	2,623	South Carolina
12	2,508	Iowa
13	1,980	Arizona
14	1,887	Oklahoma
15	1,885	Maryland
16	1,876	Kansas
17	1,704	Colorado
18	1,394	Georgia
19	1,142	Washington
20	1,082	Ohio
21	1,030	Tennessee
22	993	Virginia
23	976	Nebraska
24	956	West Virginia
25	945	Arkansas

(continued)

TABLE 2-6. U.S. CLINKER CAPACITIES BY STATE: 1993[a] (CONTINUED)

Rank	Clinker (10^3 tons)	States
26	918	Utah
27	752	South Dakota
28	700	Kentucky
29	602	Montana
30	500	Mississippi
31	494	Oregon
32	474	New Mexico
33	432	Maine
34	428	Nevada
35	428	Wyoming
36	250	Hawaii
37	220	Idaho
Total	82,790	

[a] Includes gray and white plants.

There are no clinker-producing plants in the following states:

Alaska	Connecticut	Delaware
District of Columbia	Louisiana	Massachusetts
Minnesota	New Hampshire	New Jersey
North Carolina	North Dakota	Rhode Island
Vermont	Wisconsin	

TABLE 2-7. PORTLAND CEMENT INDUSTRY PROFILE BY PROCESS TYPE: 1993

			No. of kilns			
ID	Corporate name	City, state	Wet	Dry	PH	PC
1	Ash Grove	Forman, AR	3			
2	Ash Grove	Chanute, KS	2			
3	Ash Grove	Nephi, UT				1
4	Ash Grove	Inkom, ID	2			
5	Dacotah Cement	Rapid City, SD	2		1	
6	Ash Grove	Louisville, NB			1	1
7	LaFarge Corporation	Fredonia, KS	2			
8	Medusa Cement Company	Demopolis, AL			1	
9	Ash Grove	Durkee, OR			1	
10	Blue Circle	Calera, AL		2		
11	Ash Grove	Montana City, MT	1			
12	Holnam Incorporated	La Porta, CO				1
13	Hawaiian Cement	Ewa Beach, HI			1	
14	National Cement	Ragland, AL				1
15	Monarch Cement	Humbolt, KS		1	2	
16	National Cement of Ca.	Lebec, CA		1		
17	Independent Cement	Hagerstown, MD		1		
18	Ash Grove	Seattle, WA				1
199	Centex	Laramie, WY			1	
201	Blue Circle	Harleyville, SC			1	
202	Blue Circle	Atlanta, GA		2		
203	Blue Circle	Ravena, NY	2			
204	Blue Circle	Tulsa, OK		2		
205	Allentown Cement	Blandon, PA		1	1	
206	LaFarge Corporation	Sugar Creek, MO		2		
207	Glens Falls Cement	Glens Falls, NY			1	
209	Signal Mountain Cement	Chattanooga, TN	2			

(continued)

TABLE 2-7. PORTLAND CEMENT INDUSTRY PROFILE BY PROCESS TYPE: 1993 (CONTINUED)

			No. of kilns			
ID	Corporate name	City, state	Wet	Dry	PH	PC
210	Texas Lehigh Cement	Buda, TX				1
211	Phoenix Cement	Clarksdale, AZ		1	2	
212	Armstrong Cement	Cabot, PA	2			
213	Florida Crushed Stone	Brooksville, FL			1	
214	LaFarge Corporation	New Braunfels, TX				1
301	Keystone Cement Group	Bath, PA	2			
302	Giant Group Limited	Harleyville, SC	4			
303	Rinker Materials	Miami, FL	2			
304	Riverside Cement	Oro Grande, Ca		7		
305	Riverside Cement	Riverside, CA		2		
306	River Cement	Festus, MO		2		
308	Holnam Incorporated	Artesia, MS	1			
309	Heartland Cement	Independence, KS		4		
310	Independent Cement	Catskill, NY	1			
311	LaFarge Corporation	Grand Chain, IL		1	1	
312	RMC Lonestar	Davenport, CA				1
313	Dragon Products	Thomaston, ME	1			
314	Holnam Incorporated	Clarksville, MO	1			
315	Holnam Incorporated	Morgan, UT	2			
316	Holnam Incorporated	Dundee, MI	2			
317	Holnam Incorporated	Saratoga, AR	2			
318	Holnam Incorporated	Florence, CO	3			
319	Holnam Incorporated	Seattle, WA	1			
320	Holnam Incorporated	Theodore, AL				1
321	Holnam Incorporated	Three Forks, MT	1			
322	Holnam Incorporated	Tijeras, NM			2	

(continued)

TABLE 2-7. PORTLAND CEMENT INDUSTRY PROFILE BY PROCESS TYPE: 1993 (CONTINUED)

			No. of kilns			
ID	Corporate name	City, state	Wet	Dry	PH	PC
401	Kaiser Cement	Permanente, CA				1
402	Hercules Cement	Stockertown, PA			1	1
403	Dixon-Marquette	Dixon, IL		1	3	
404	San Juan Cement	San Juan, PR				1
405	Mitsubishi Cement	Lucerne Valley, CA				1
406	LaFarge Corporation	Alpena, MI		5		
407	Centex	Fernley, NV		1	1	
408	LaFarge Corporation	Buffalo, IA				1
409	LaFarge Corporation	Paulding, OH	2			
410	LaFarge Corporation	Whitehall, PA			3	
411	Capitol Aggregates	San Antonio, TX	1			1
412	Puerto Rican Cement	Ponce, PR	2			1
413	Holnam, Inc.	Midlothian, TX				1
414	Centex	LaSalle, IL			1	
415	Texas Industries	Midlothian, TX	4			
416	Texas Industries	New Braunfels, TX				1
501	Calaveras Cement	Tehachapi, CA				1
502	Capitol Cement	Martinsburg, WV	3			
503	Medusa Cement	Clinchfield, GA			1	
504	Alamo Cement	San Antonio, TX				1
506	Essroc Materials	Nazareth, PA			1	
507	Medusa Cement	Charlevoix, MI				1
508	North Texas Cement	Midlothian, TX	3			
509	Southdown Incorporated	Knoxville, TN				1
510	Kosmos Cement	Kosmosdale, KY			1	

(continued)

TABLE 2-7. PORTLAND CEMENT INDUSTRY PROFILE BY PROCESS TYPE: 1993 (CONTINUED)

			No. of kilns			
ID	Corporate name	City, state	Wet	Dry	PH	PC
511	Southdown Incorporated	Fairborn, OH			1	
512	Southdown Incorporated	Lyons, CO				1
513	Southdown Incorporated	Odessa, TX		1	1	
514	Kosmos Cement	Pittsburgh, PA	1			
515	Southdown Incorporated	Victorville, CA		1		1
517	Holnam Incorporated	Holly Hill, SC	2			
518	Holnam Incorporated	Mason City, IA		2		
519	Holnam Incorporated	Ada, OK	2			
520	Southdown Incorporated	Brooksville, FL			2	
521	Essroc Materials	Speed, IN		1	1	
522	Roanoke Cement	Cloverdale, VA		4	1	
523	Essroc Materials	Bessemer, PA	2			
524	Medusa Cement	Wampum, PA		3		
601	Calaveras Cement	Redding, CA				1
602	California Portland	Rillito, AZ		3		1
603	California Portland	Mojave, CA				1
604	Pennsuco Cement Company	Medley, FL	3			
701	Continental Cement	Hannibal, MO	1			
702	California Portland	Colton, CA		2		
801	Lehigh Cement	Leeds, AL			1	
802	Lehigh Cement	Mitchell, IN		2	1	
803	Lehigh Cement	Union Bridge, MD		4		
804	Lehigh Cement	Mason City, IA				1

(continued)

TABLE 2-7. PORTLAND CEMENT INDUSTRY PROFILE BY PROCESS TYPE: 1993 (CONTINUED)

ID	Corporate name	City, state	No. of kilns			
			Wet	Dry	PH	PC
805	Lehigh Cement	Cementon, NY	1			
806	Lehigh Cement	York, PA	1			
807	Lehigh Cement	Waco, TX	1			
901	Lone Star	Olgesby, IL		1		
902	Lone Star	Greencastle, IN	1			
903	Lone Star	Cape Girardeau, MO				1
904	Lone Star	Pryor, OK		3		
905	Lone Star	Nazareth, PA		4		
906	Lone Star	Sweetwater, TX			3	
998	Essroc Materials	Logansport, IN	2			
999	Essroc Materials	Frederick, MD	2			
	St. Mary's Cement Corporation	Detroit, MI	1			
		Total:	73	67	40	27
	Total Plants: 113	Total Kilns: 210				

Source: U.S. Environmental Protection Agency. Information Collection Request.

Portland Cement Association. The U.S. Cement Industry: An Economic Report. Skokie, IL, Portland Cement Association. October 1994.

TABLE 2-8. NUMBER OF KILNS, CLINKER CAPACITY, AND AVERAGE CAPACITY PER KILN BY KILN AGE AND PROCESS: 1993

Age	No. kilns	Clinker capacity (10^3 tons)	Avg. capacity/kiln (10^3 tons)
Total			
0-10	20	16,458	822.9
11-15	23	15,387	669.0
16-20	28	12,701	453.6
21-25	20	8,777	438.9
26-30	40	14,385	359.6
31-35	45	10,446	232.1
36-40	12	2,106	175.5
41-45	11	1,631	148.3
46-50	0	0	0.0
51-55	0	0	0.0
56-60	0	0	0.0
60+	8	899	112.4
Total	207	82,790	400.0
Dry process			
0-10	20	16,458	822.9
11-15	23	15,387	669.0
16-20	18	8,109	450.5
21-25	7	3,244	463.4
26-30	20	7,040	352.0
31-35	27	5,651	209.3
36-40	9	1,506	167.3
41-45	6	868	144.7
46-50	0	0	0.0
51-55	0	0	0.0
56-60	0	0	0.0
60+	4	332	83.0
Total	134	58,595	437.3
Wet process			
0-10	0	0	0.0
11-15	0	0	0.0
16-20	10	4,592	459.2
21-25	13	5,533	425.6
26-30	20	7,345	367.3
31-35	18	4,795	266.4
36-40	3	600	200.0
41-45	5	63	152.6
46-50	0	0	0.0
51-55	0	0	0.0
56-60	0	0	0.0
60+	4	567	141.8
Total	73	24,195	331.4

Source: Portland Cement Association. U.S. and Canadian Portland Cement Industry: Plant Information Summary. Skokie, IL, Portland Cement Association. 1994. Table 6.

TABLE 2-9. FUEL USAGE SUMMARY FOR U.S. CEMENT PLANTS: 1993

Types of fuel	No. of plants	Clinker capacity (10^3 tons)	Percentage of total capacity
Primary fuel			
Coal	71	55,208	66.7
Coal, coke	10	9,468	11.4
Coal, waste	7	4,621	5.6
Coal, nat. gas	5	4,084	4.9
Nat. gas	5	1,784	2.2
Coke	5	3,366	4.1
Waste	2	828	1.0
Coal, coke, waste	2	2,366	2.9
Coal, nat. gas, coke	1	855	1.0
Oil	1	100	0.1
Oil, nat. gas	1	110	0.1
Totals:	110	82,790	100.0
Alternate fuel			
Nat. gas	25	16,973	20.5
Waste	17	11,694	14.1
Coke	8	5,177	6.3
Nat. gas, Coke	7	6,915	8.4
Nat. gas, coke	6	3,526	4.3
Oil	6	5,069	6.1
Coal	4	3,107	3.8
Coke, waste	3	2,273	2.7
Oil, waste	3	1,869	2.3
Coal, nat. gas	2	1,124	1.4
Oil, nat. gas	2	1,900	2.3
Nat. gas, oil, coke	2	2,699	3.3
Coal, nat. gas, waste	1	332	0.4
Coal, coke, waste	1	304	0.4
Totals:	88	63,422	76.6

Source: Portland Cement Association. U.S. and Canadian Portland Cement Industry: Plant Information Summary. Skokie, IL, Portland Cement Association. 1994. Table 7.

Kiln Capacity. The number of kilns in operation is declining; however, kiln capacity continues to grow, as demonstrated by Figure 2-4. According to the PCA survey, between 1973 and 1993 average kiln capacity increased from 191,000 tons per kiln to 400,000 tons per kiln.

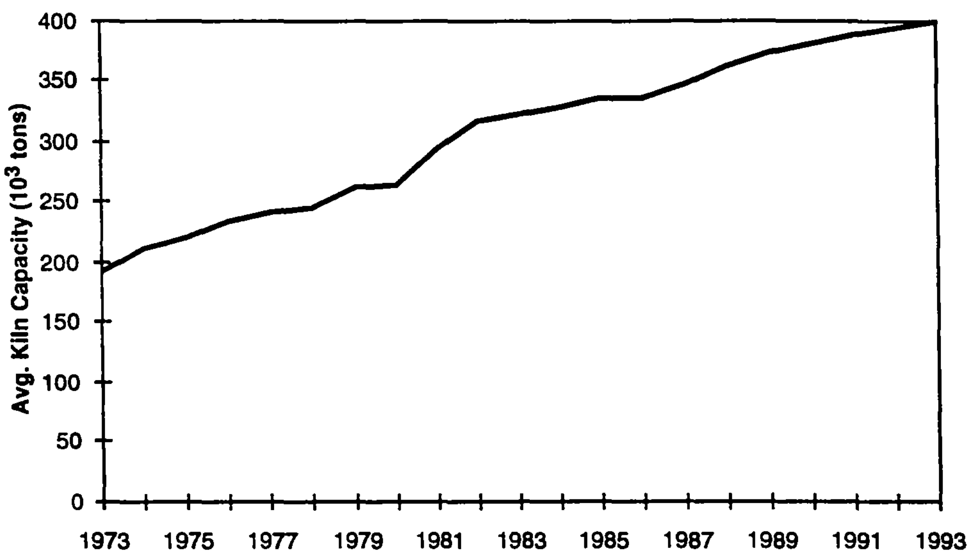

Figure 2-4. Average kilns capacity at U.S. cement plants: 1973-1993.

Figure 2-5 illustrates changes in total annual clinker capacity at U.S. plants from 1973 to 1993 by production process. This figure separates clinker capacity by production process to address the changes in capacity of the wet process compared to the dry process over the same time period. The trend revealed by the clinker capacity data is the increase in dry process clinker capacity from 35.6 million tons in 1973 to 58.6 million tons in 1993 paired with the decrease in wet process capacity from 49.6 million tons in 1973 to 24.2 million tons in 1993.[32] These statistics are consistent with

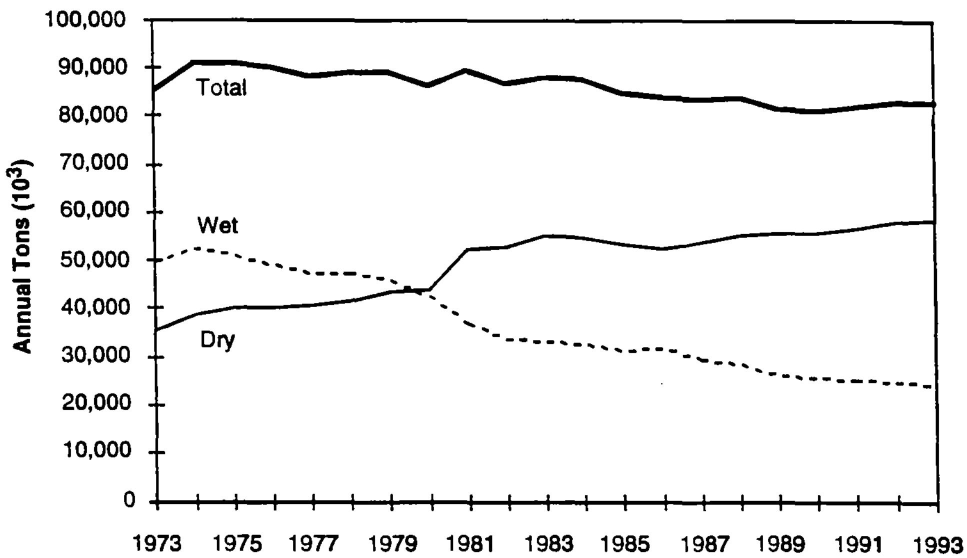

Figure 2-5. U.S. clinker capacity by type of process: 1973-1993.

others suggesting that the dry process is replacing the wet process because it is more efficient.

2.4.1.3 Employment. Table 2-10 provides regional average employment and labor productivity at U.S. cement plants.[33] In 1990, the national average was 135.4 employees per cement plant with a high of 169.3 employees in the East North Central region and a low of 96 employees in the West South Central region.[34] As shown in Table 2-10, the national average labor productivity for 1990 is reported at 2.52 tons of cement produced per man-hour with a high of 4.17 tons per man-hour in the West South Central region and a low of 1.63 tons per man-hour in the Mountain region. The labor productivity at cement plants varies across kiln size, technology, and age (higher for newer and larger kilns and those with dry process technologies), but the observed

TABLE 2-10. REGIONAL AVERAGE EMPLOYMENT AND LABOR PRODUCTIVITY AT CEMENT PLANTS: 1990

Region	Number of plant personnel[a]	Labor productivity (tons of cement per man-hour)
New England/North Atlantic	168.0	2.01
East North Central	169.3	2.02
West North Central	141.3	1.77
South Atlantic	141.0	3.11
East South Central	118.0	2.45
West South Central	96.0	4.17
Mountain	98.0	1.63
Pacific	151.6	3.02
National Average	135.4	2.52

[a] Number reflects average U.S. cement plant employment, including clerical staff but excluding sales and corporate management staff.

Source: Huhta, R.S. Operating Costs of U.S. Cement Plants. Rock Products. November. 1992. pp. 29-31.

production per man-hour for the West South Central and Mountain regions cannot be explained by differences in these kiln characteristics. While the author of this survey provides no further information to explain these observations, it is likely due to respondent error.

2.4.2 Firm Characteristics

A regulatory action to reduce pollutant discharges from facilities manufacturing Portland cement will potentially affect the business entities that own the regulated facilities. Facilities comprise a site of land with plant and equipment that combine inputs (raw materials, fuel, energy, and labor) to produce outputs (Portland cement). Companies that own these facilities are legal business entities that have the capacity to conduct business transactions and make business decisions that affect the facility. The terms facility, establishment, plant, and mill are synonymous in this analysis and refer to the physical location where products are manufactured. Likewise, the terms company and firm are synonymous and refer to the legal business entity that owns one or more facilities.

Potentially affected firms include entities that own plants manufacturing Portland cement. According to the PCA survey, one state agency and 44 companies operated 118 Portland cement manufacturing plants in 1993. Table 2-11 lists these U.S. Portland cement companies and their clinker capacity for 1993.[35]

2.4.2.1 Foreign Ownership. As of 1991, 70 percent of U.S. cement capacity was under foreign ownership. Seven of the ten largest U.S. cement producers were under foreign ownership.[36] As shown in Table 2-12, the percentage of U.S. cement capacity under foreign ownership has more than tripled over the past decade although the trend has slackened since 1989.[37]

2.4.2.2 Size Distribution. Firm size is likely to be a factor in the distribution of the regulatory action's financial impacts. Grouping the firms by size facilitates the analysis of small business impacts, as required by the Regulatory Flexibility Act (RFA) of 1982. In assessing these small business impacts, it is important to correctly identify the company or legal business entity that has the capacity to make business decisions that affect the Portland cement facility. The Agency has revised the PCA estimate of companies involved in this industry to better reflect the chain of ownership by accounting for subsidiaries, divisions, and joint ventures so as to appropriately group companies by size. Table 2-13 provides sales and employment data for the

TABLE 2-11. U.S. PORTLAND CEMENT COMPANY CAPACITIES: 1993[a]

Rank	Clinker (10^3 tons)	Percent industry	Company name
1	10,751	13.0	Holnam Inc.
2	7,258	8.8	Lafarge Corporation
3	4,964	6.0	Southdown Inc.
4	4,717	5.7	Ash Grove Cement Company
5	4,313	5.2	Lone Star Industries
6	4,233	5.1	Blue Circle Inc.
7	3,902	4.7	Lehigh Portland Cement
8	3,669	4.4	Medusa Cement Company
9	3,583	4.3	Essroc Materials
10	3,225	3.9	California Portland Cement
11	2,840	3.4	River Cement Company (RC Cement)
12	2,023	2.4	Texas Industries
13	1,706	2.1	Mitsubishi Cement Corp.
14	1,550	1.9	Kaiser Cement Corporation
15	1,382	1.7	Calaveras Cement Company
16	1,332	1.6	Centex
17	1,290	1.6	Riverside Cement
18	1,116	1.3	Independent Cement Corporation
19	1,086	1.3	Texas-Lehigh Cement Company
20	1,085	1.3	Kosmos Cement Co.
21	1,007	1.2	Pennsuco Cement Company
22	993	1.2	Roanoke Cement Company
23	956	1.2	Capitol Cement Corporation
24	930	1.1	Allentown Cement Company Inc.
25	897	1.1	North Texas Cement
26	894	1.1	National Cement Company of Alabama
27	870	1.1	Giant Cement Company

(continued)

TABLE 2-11. U.S. PORTLAND CEMENT COMPANY CAPACITIES: 1993[a] (CONTINUED)

Rank	Clinker (10^3 tons)	Percent industry	Company name
28	855	1.0	Capitol Aggregates, Inc.
29	800	1.0	RMC Lonestar
30	769	0.9	Alamo Cement Company
31	752	0.9	Dacotah Cement
32	705	0.9	Phoenix Cement Company
33	674	0.8	Monarch Cement Company
34	650	0.8	St. Mary's Cement Corporation
35	650	0.8	National Cement Company of California
36	602	0.7	Keystone Cement Company
37	599	0.7	Continental Cement Company, Inc.
38	571	0.7	Florida Crushed Stone
39	552	0.7	Rinker Portland Cement Corporation
40	524	0.6	Dixon-Marquette
41	507	0.6	Glens Falls Cement Company Inc.
42	432	0.5	Dragon Products Company
43	326	0.4	Armstrong Cement & Supply Corporation
44	250	0.3	Hawaiian Cement Company
Total	82,790		

[a] Includes gray and white plants.

Source: Portland Cement Association. U.S. and Canadian Portland Cement Industry: Plant Information Summary. Skokie, IL, Portland Cement Association. 1994.

TABLE 2-12. FOREIGN OWNERSHIP OF U.S. CEMENT CAPACITY

Year	Foreign ownership (%)
1981	22
1986	41
1988	60
1990	65
1991	70

Sources: U.S. Department of Commerce. U.S. Industrial Outlook 1992. Washington, DC. January 1992, p. 7-6.

one state agency and 34 companies operating Portland cement manufacturing plants in 1993.[38]

Firms are grouped into small and large categories using Small Business Association (SBA) general size standard definitions for SIC codes. These size standards are presented either by number of employees or by annual receipt levels, depending on the SIC code. The manufacture of Portland cement is covered by SIC code 3241 for hydraulic cements. Thus, according to SBA size standards, firms owning Portland cement manufacturing plants are categorized as small if the total number of employees at the firm is less than 750; otherwise the firm is classified as large. As shown in Table 2-13, potentially affected firms range in size from 10 to over 20,000 employees. A total of 9 firms, or 25.7 percent, are categorized as small, while the remaining 26 firms, or 74.2 percent, are in the large category.

TABLE 2-13. SUMMARY OF SALES AND EMPLOYMENT FOR PORTLAND CEMENT COMPANIES

Company name	Sales ($000)	Employment
Armstrong Cement & Supply Corp.[a]	NA	110
Ash Grove Cement Company[b]	$330,000	1,655
Blue Circle America Inc.	$600,000	2,800
California Portland Cement[c]	$190,000	950
Centex[d]	$3,102,987	6,395
Cimeneries CBR[a,e]	NA	> 1,500
CSR Inc.[f]	$4,347,698	23,200
Dacotah Cement[g]	NA	NA
Dragon Products Company	$50,000	270
ESSROC Corp.	$900,000	5,000
Florida Crushed Stone	$70,000	500
Giant Group, Ltd.[h]	$78,000	800
Glens Falls Cement Company Inc.	$30,000	140
Hanson Trust, PLC[a,i]	NA	> 1,500
Holnam Inc.	$1,500,000	3,000
H.B. Zachry[j]	$920,000	10,000
LaFarge Corporation	$1,598,000	8,500
Lehigh Portland Cement	$250,000	1,900
Lone Star Industries, Inc.[k]	$254,000	2,000
Medusa Cement Company	$192,000	1,000
Mitsubishi Cement Corp.[a]	NA	200
Monarch Cement Company	$58,300	175
Phoenix Cement Company	$30,000	100
Prairie Material, Inc.[l]	$80,000	800
Presa S.P.A. Cementeria Robilante[a,m]	NA	> 750

TABLE 2-13. SUMMARY OF SALES AND EMPLOYMENT FOR PORTLAND CEMENT COMPANIES (CONTINUED)

Company name	Sales ($000)	Employment
Riverside Cement Co.	$68,000	500
Riverton Corp.[n]	$170,000	350
RMC Lonestar	$120,000	900
Scancem Industries[o]	$2,070,321	8,429
Societe des Ciments Vicat[a,p]	NA	> 1,500
Southdown Inc.[k]	$596,100	2,500
St. Lawrence Cement[q]	$410,307	2,200
Tarmac[r]	$3,041,469	19,981
Texas Industries	$830,526	2,800
UNICEM[s]	$499,739	2,452

[a] Employment estimate or range taken from survey response to EPA's Information Collection Request (ICR).
[b] Joint owner of North Texas Cement with Pioneer.
[c] Owned by Onoda Cement Co.
Owns Texas-Lehigh Cement Company.
[e] Owns Calaveras Cement Company.
[f] Owns Rinker Portland Cement Corporation.
[g] Owned by State of South Dakota.
[h] Owns Keystone Cement Company and Giant Cement Company.
[i] Owns Kaiser Cement Corporation.
[j] Owns Capitol Aggregates, Inc.
[k] Joint owners of Kosmos Cement Co.
[l] Owns Dixon-Marquette.
[m] Owns Alamo Cement Company.
[n] Owns Capitol Cement Corporation.
[o] Owns Allentown Cement Co. and Continental Cement Company.
[p] Owns National Cement Company of Alabama and National Cement Company of California.
[q] Owns Independent Cement Corporation.
[r] Pennsuco Cement Company and Roanoke Cement Company.
[s] Owns RC Cement Company, Inc.

Source: Ward's Business Directory of U.S. Private and Public Companies. Washington, DC, Gale Research, Inc. 1994.

SECTION 3
REGULATORY ALTERNATIVES AND CONTROL COSTS

The EPA's engineering analysis has identified the available technologies on which this NESHAP is based.[39] Model plants were developed to evaluate the effects of various control options on the Portland cement industry. Control options were selected based on the application of presently available control equipment and technologies and varying levels of capture consistent with different levels of overall control. Section 3.1 presents a brief description of the model plants. Section 3.2 provides an overview of the control options and determination of applicability, and Section 3.3 summarizes the compliance costs associated with the regulatory control options.

3.1 MODEL PLANTS

The large number of cement kilns in the Portland cement industry necessitates using model kilns to simulate the effects of applying the regulatory control options to this industry. A model kiln does not represent any single actual kiln, rather it represents a range of kilns with similar characteristics that may be affected by the regulation. Each model kiln is characterized by process type, size, and other parameters that influence the estimates of emissions and control costs.

Table 3-1 presents a summary of the characteristics for each model kiln and its associated clinker cooler, as well as the number of actual kilns in the U.S. assigned by EPA to each model type.[40] These model kilns serve as the basis for

TABLE 3-1. SUMMARY OF MODEL KILN CHARACTERISTICS WITH CORRESPONDING MODEL CLINKER COOLER

Model kiln	Process[a]	Size[b]	Clinker (ton/yr) (10^3)	Number of actual kilns	Model Clinker Coolers	CC capacity (ton/yr) (10^3)
A	wet	S	150	16	U	150
B	wet	S	300	12	W	300
C	wet	S	400	9	X	400
D	wet	M	600	5	Y	600
E	wet	L	875	2	Z	875
F	dry	S	55	2	T	55
G	dry	S	130	4	U	150
H	dry	S	200	20	V	200
I	dry	S	300	28	W	300
J	dry	M	600	9	Y	600
K	PH	S	160	7	U	150
L	PH	S	250	10	W	300
M	PH	S	450	6	X	400
N	PH	M	600	8	Y	600
O	PC	M	600	2	Y	600
P	PC	L	1200	2	AA	1,200
Q	PC	M	600	8	Y	600
R	PC	L	1200	11	AA	1,200
S-new	PC	M	650	NA	Y	600

[a] PH = preheater
PC = preheater/precalciner.

[b] Included to demonstrate the how the differences in costs are related to differences in capacity size. The size categories are defined as follows:

Small = 0 to 500,000 tons per year
Medium = 500,000 to 750,000 tons per year
Large = 750,000 to 1,000,000 tons per year.

Source: Memorandum from Jim Crowder, EPA, to Ron Evans, EPA. January 29, 1996. "Additional Engineering Inputs for Economic Impacts Analysis for the Portland Cement Industry NESHAP."

estimating the compliance costs associated with the MACT standards proposed under the authority of the Clean Air Act.

3.2 REGULATORY CONTROL OPTIONS

Sources of HAP emissions in Portland cement production include the cement kiln, clinker cooler, raw and finish mills, and materials handling facilities. The proposed MACT standards to control HAPs from cement kilns will potentially affect only non-hazardous waste burning kilns. However, the proposed controls for clinker coolers, raw and finish mills, and materials handling facilities will potentially affect all cement plants, i.e., those with hazardous waste burning kilns and those that do not have hazardous waste burning kilns. Furthermore, the proposed MACT standards are evaluated as applicable to both major and area sources within the industry.

Based on the engineering analysis, the MACT Floor for existing sources is defined to include upgrading the fabric filter (FF) or electrostatic precipitator (ESP) to control particulate matter (PM) at the kilns, upgrade FF's for associated clinker coolers, water injection to control dioxin and furan at the kilns, and the applicable monitoring requirements (COM as well as initial M5, M9 and M23 performance tests). Table 3-2 summarizes the MACT Floor control options under evaluation for HAP emission points within an existing cement plant.[41]

Alternatively, the MACT Floor for new sources is defined to include water injection to control dioxin and furan at the kiln, a lime wet scrubber for control hydrogen chloride (HCl) at the kiln, and applicable monitoring requirements (THC and HCl CEM as well as initial M23 performance test). Table 3-3 summarizes the MACT Floor control options for new sources under evaluation for HAP emission points within a new cement plant.

TABLE 3-2. SUMMARY OF MACT FLOOR CONTROL OPTIONS ON EXISTING MAJOR AND AREA SOURCES

Emission point/HAP	Emission limit	Control option		Monitoring	
		Requirement	National applicability	Requirement	National applicability
Kiln PM	0.3 lb/ton dry feed and opacity level at performance test + 5%, no greater than 20%	Upgrade FF or ESP	21% of non-hazardous waste burning kilns with FF and 43% of non-hazardous waste burning kilns with ESP	COM and initial M5 performance test	Kilns needing to upgrade FF or ESP
Kiln D/F	0.2 TEQ ng/dscm or 400° F	Water injection for gas temp. control	42% of non-hazardous waste burning kilns	Initial M23 performance test	100% of non-hazardous waste burning kilns
Clinker cooler PM	0.1 lb/ton dry feed and opacity limit at 10%	Upgrade FF	20% of all clinker coolers	COM and initial M5 performance test	CCs needing to upgrade FF
Raw & finish mills[a]	10% opacity	None	NA	1 COM per raw mill and 1 COM per finish mill	100% of all kilns
Materials handling facilities	10% opacity	None	NA	One-time M9 readings	100% of all plants

[a] Assumes one raw mill and one finish mill per kiln.
Note: COM equals continuous opacity monitor.

Source: Memorandum from Jim Crowder, EPA, to Ron Evans, EPA. January 29, 1996. "Additional Engineering Inputs for Economic Impacts Analysis for the Portland Cement Industry NESHAP." Attachment 1, Table 1.

TABLE 3-3. SUMMARY OF MACT FLOOR CONTROL OPTIONS ON NEW SOURCES

		Control option		Monitoring	
Emission point/HAP	Emission limit	Requirement	National applicability	Requirement	National applicability
Kiln PM	0.3 lb/ton dry feed	None[a]	NA	None[a]	NA
Kiln D/F	0.2 TEQ ng/dscm or 400° F	Water injection for gas temp. control	42% of all new non-hazardous waste burning kilns	Initial M23 performance test	100% of new non-hazardous waste burning kilns
Kiln THC	50 ppm	None[b]	NA	THC CEM	100% of new non-hazardous waste burning kilns
Kiln HCl[c]	15% ppm or 90% removal	Lime wet scrubber	44% of all new non-hazardous waste burning kilns	Monitor scrubber parameters if add scrubber, or HCl CEM if not	100% of new non-hazardous waste burning kilns
Clinker cooler PM	0.1 lb/ton dry feed and opacity limit at 10%	None[a]	NA	None[a]	NA
Raw & finish mills[d]	10% opacity	None	NA	1 COM per raw mill and 1 COM per finish mill	100% of all kilns
Materials handling facilities	10% opacity	None	NA	One-time M9 readings	100% of all plants

[a] New sources do not incur costs associated with this control option because costs are attributed to NSPS.

[b] New sources do not incur costs associated with this control option because assumed to locate only near raw materials with low HC levels.

[c] Since costs of a wet scrubber with lime sorbent apply only to new sources, there is not a separate table within this section detailing these costs. For model kiln S-new, the total capital cost is $1.9 million, the annual fixed cost is $0.2 million, the annual operating and maintenance cost is $0.5 million, and total annual cost is $0.6 million.

[d] Assumes one raw mill and one finish mill per kiln.

Note: CEM = continuous emission monitor
COM = continuous opacity monitor

Source: Memorandum from Jim Crowder, EPA, to Ron Evans, EPA. January 29, 1996. "Additional Engineering Inputs for Economic Impacts Analysis for the Portland Cement Industry NESHAP." Attachment 1, Table 1.

Based on the engineering analysis, the beyond-the-floor (BTF) option for existing and new sources is defined to include carbon injection followed by a fabric filter to control dioxin, furan, and mercury at each model kiln and the applicable monitoring requirements (initial M29 performance test) in addition to the MACT Floor controls for those kilns without water injection in the baseline.* The carbon is injected downstream of the existing PM collector, and a new FF is used to collect the injected carbon and the mercury adsorbed by the carbon. Two BTF control options are being evaluated assuming the same carbon injection rates, control efficiencies, and costs of control, but specifying different emission limits for mercury of 30 and 50 ug/dscm. Therefore, the number of kilns applicable to each option will be different. BTF option 1 specifies an emission limit of 30 ug/dscm Hg (more stringent) and applies to 30 percent of the non-hazardous waste burning kilns, while BTF option 2 specifies an emission limit of 50 ug/dscm Hg (less stringent) and applies to 20 percent of the non-hazardous waste burning kilns. Table 3-4 summarizes each BTF control option under evaluation for non-hazardous waste burning cement kilns.[42]

In regard to the applicability of controls, the engineering analysis has estimated national applicability percentages for each control option as shown in Tables 3-2 and 3-3 for the MACT Floor and Table 3-4 for the BTF options. However, the engineering analysis has concluded that there is no known correlation between model or actual kiln characteristics and the need for additional control or whether a plant is an area or major source.[43] Absent identification of area sources, the engineering analysis has estimated that

*The engineering analysis estimates that for the mercury limit of 30 ug/dscm, 23 percent of all nonhazardous waste burning kiln require only carbon injection and 7 percent require carbon injection and water injection (for temperature reasons); while for the mercury limit of 50 ug/dscm, 16 percent of all nonhazardous waste burning kiln require only carbon injection and 4 percent require carbon injection and water injection.

TABLE 3-4. SUMMARY OF BTF CONTROL OPTIONS ON EXISTING AND NEW MAJOR AND AREA SOURCES

Emission point/HAP	Emission limit	Control option: Requirement	Control option: National applicability	Monitoring: Requirement	Monitoring: National applicability
BTF Option 1					
Kiln D/F and mercury	0.2 ng/dscm TEQ D/F and 30 ug/dscm Hg	Carbon injection (assuming water injection already used for gas temp. control)	30% of non-hazardous waste burning kilns	Initial M29 performance test for mercury	100% of non-hazardous waste burning kilns
BTF option 2					
Kiln D/F and mercury	0.2 ng/dscm TEQ D/F and 50 ug/dscm Hg	Carbon injection (assuming water injection already used for gas temp. control)	20% of non-hazardous waste burning kilns	Initial M29 performance test for mercury	100% of non-hazardous waste burning kilns

Note: COM equals continuous opacity monitor.

Source: Memorandum from Jim Crowder, EPA, to Ron Evans, EPA. January 29, 1996. "Additional Engineering Inputs for Economic Impacts Analysis for the Portland Cement Industry NESHAP." Attachment 1, Table 2.

20 percent of the plants are area sources.[44] Furthermore, the engineering analysis has concluded that there is no known correlation between a plant's need for PM control and its need for D/F and/or mercury control so that the national applicability percentages from Tables 3-2 to 3-4 for each control option are independent.[45,*] Due to this uncertainty in determining the actual kilns that will be subject to each control option and the independent nature of the control options the economic analysis has chosen to randomly determine the applicability of the control options and associated costs to each kiln. Thus, the economic analysis will perform multiple simulations of the economic impact model to provide national-level impacts based on the engineering estimates of the national applicability percentages for each control option.

For the purpose of this analysis, the following 9 regulatory alternatives will be evaluated in regard to their economic impacts:

- Regulatory Alternative 1--MACT Floor on Major and Area Sources,
- Regulatory Alternative 2--Beyond-the-Floor (BTF) Option 1 on Major and Area Sources,
- Regulatory Alternative 3--BTF Option 2 on Major and Area Sources,
- Regulatory Alternative 4--MACT Floor on Major Sources only,
- Regulatory Alternative 5--BTF Option 1 on Major Sources only,
- Regulatory Alternative 6--BTF Option 2 on Major Sources only,

---

[*] One exception to this is that the BTF option of carbon injection includes a FF that would also collect PM from the kiln's existing control devices so that a kiln subject to the BTF option not meeting its PM limit would not need to upgrade the FF under the MACT Floor.

- Regulatory Alternative 7--MACT Floor on Major Sources and Dioxin/Furan (D/F) and Mercury (Hg) Controls on Area Sources,
- Regulatory Alternative 8--BTF Option 1 on Major Sources and D/F and Hg Controls on Area Sources, and
- Regulatory Alternative 9--BTF Option 2 on Major Sources and D/F and Hg Controls on Area Sources.

3.3 REGULATORY CONTROL COSTS

Tables 3-5 through 3-8 summarize the total and annualized capital costs, annual variable costs, total annual cost, and monitoring costs for each of the options under the MACT Floor by model kiln. Table 3-9 summarizes the same cost components for the BTF option by model kiln. All cost estimates are expressed in 1993 dollars. The annualized capital cost is calculated using a capital recovery factor of 0.094 based on an equipment life of 20 years and a 7 percent discount rate. Variable costs reflect the operating and maintenance expenses associated with control equipment and management practices. The total annual cost of control is equal the sum of the annual capital and variable costs. For each control option, the costs for all monitoring requirements are shown separately, since they are in some cases incurred without the associated costs of controls. Table 3-10 provides the costs of each specific monitoring requirement.

Based on these tables, the estimated control costs for new sources under the MACT Floor and BTF regulatory alternatives are, on average, less than those projected for existing sources. Thus, the Agency does not anticipate any differential impact on new sources and, as a result, the economic impact analysis described in Section 4 focuses on the effects on existing sources only.

TABLE 3-5. MACT FLOOR COSTS FOR UPGRADING AN ELECTROSTATIC PRECIPITATOR (ESP) TO CONTROL KILN PM

Model kiln ID	Process	Clinker capacity (10^3 tpy)	Total capital costs ($\$10^3$)	Annual control cost: Fixed ($\$10^3$)	Annual control cost: Variable ($\$10^3$)	Total annual costs ($\$10^3$)	Annual monitoring ($\$10^3$)
A	wet	150	$1,244	$117	$138	$255	$23
B	wet	300	$1,921	$181	$184	$365	$23
C	wet	400	$2,307	$218	$211	$429	$23
D	wet	600	$2,903	$274	$257	$532	$23
E	wet	875	$3,990	$377	$334	$711	$23
F	dry	55	$532	$50	$94	$144	$23
G	dry	130	$912	$86	$116	$203	$23
H	dry	200	$1,196	$113	$135	$248	$23
I	dry	300	$1,542	$146	$157	$303	$23
J	dry	600	$2,383	$225	$216	$441	$23
K	PH	160	$850	$80	$113	$193	$23
L	PH	250	$1,125	$106	$130	$236	$23
M	PH	450	$1,627	$154	$163	$317	$23
N	PH	600	$1,949	$184	$185	$369	$23
O	PC bypass	600	$2,488	$235	$277	$512	$23
P	PC bypass	1,200	$3,844	$363	$370	$733	$23
Q	PC	600	$1,949	$184	$185	$369	$23
R	PC	1,200	$2,949	$278	$260	$539	$23
S-new	PC	650	$0	$0	$0	$0	$0

Source: Memorandum from Jim Crowder, EPA, to Ron Evans, EPA. January 29, 1996. "Additional Engineering Inputs for Economic Impacts Analysis for the Portland Cement Industry NESHAP." Attachment 3, Table 1.

TABLE 3-6. MACT FLOOR COSTS FOR UPGRADING A FABRIC FILTER (FF) TO CONTROL KILN PM

Model kiln ID	Process	Clinker capacity (10^3 tpy)	Total capital costs ($\$10^3$)	Annual control cost: Fixed ($\$10^3$)	Annual control cost: Variable ($\$10^3$)	Total annual costs ($\$10^3$)	Annual monitoring ($\$10^3$)
A	wet	150	$54	$30	$9	$39	$23
B	wet	300	$108	$60	$9	$69	$23
C	wet	400	$144	$80	$9	$88	$23
D	wet	600	$216	$119	$9	$128	$23
E	wet	875	$314	$174	$9	$183	$23
F	dry	55	$14	$8	$9	$17	$23
G	dry	130	$33	$18	$9	$27	$23
H	dry	200	$51	$28	$9	$37	$23
I	dry	300	$76	$42	$9	$51	$23
J	dry	600	$152	$84	$9	$93	$23
K	PH	160	$29	$16	$9	$25	$23
L	PH	250	$46	$25	$9	$34	$23
M	PH	450	$83	$46	$9	$55	$23
N	PH	600	$110	$61	$9	$70	$23
O	PC bypass	600	$113	$63	$18	$81	$23
P	PC bypass	1,200	$227	$125	$18	$143	$23
Q	PC	600	$110	$61	$9	$70	$23
R	PC	1,200	$220	$122	$9	$131	$23
S-new	PC	650	$0	$0	$0	$0	$0

Source: Memorandum from Jim Crowder, EPA, to Ron Evans, EPA. January 29, 1996. "Additional Engineering Inputs for Economic Impacts Analysis for the Portland Cement Industry NESHAP." Attachment 3, Table 2.

TABLE 3-7. MACT FLOOR COSTS FOR WATER INJECTION TO CONTROL KILN DIOXINS AND FURANS

Model kiln ID	Process	Clinker capacity (10^3 tpy)	Total capital costs ($\$10^3$)	Annual control cost: Fixed ($\$10^3$)	Annual control cost: Variable ($\$10^3$)	Total annual costs ($\$10^3$)	Annual monitoring ($\$10^3$)
A	wet	150	$498	$55	$57	$112	$4
B	wet	300	$698	$77	$71	$148	$4
C	wet	400	$824	$90	$80	$170	$4
D	wet	600	$1,066	$117	$96	$213	$4
E	wet	875	$1,386	$152	$119	$271	$4
F	dry	55	$325	$36	$46	$82	$4
G	dry	130	$413	$45	$52	$98	$4
H	dry	200	$485	$53	$57	$111	$4
I	dry	300	$583	$64	$65	$128	$4
J	dry	600	$852	$94	$84	$178	$4
K	PH	160	$397	$44	$51	$95	$4
L	PH	250	$467	$51	$57	$108	$4
M	PH	450	$608	$67	$67	$133	$4
N	PH	600	$707	$78	$75	$152	$4
O	PC bypass	600	$1,009	$111	$118	$229	$4
P	PC bypass	1,200	$1,424	$156	$149	$305	$4
Q	PC	600	$707	$78	$75	$152	$4
R	PC	1,200	$1,082	$119	$103	$221	$4
S-new	PC	650	$592	$65	$68	$133	$4

Source: Memorandum from Jim Crowder, EPA, to Ron Evans, EPA. January 29, 1996. "Additional Engineering Inputs for Economic Impacts Analysis for the Portland Cement Industry NESHAP." Attachment 3, Table 3.

TABLE 3-8. MACT FLOOR COSTS FOR UPGRADING A FABRIC FILTER (FF) TO CONTROL CLINKER COOLER PM

Model kiln ID	Process	Clinker capacity (10^3 tpy)	Total capital costs ($\$10^3$)	Annual control cost: Fixed ($\$10^3$)	Annual control cost: Variable ($\$10^3$)	Total annual costs ($\$10^3$)	Annual monitoring ($\$10^3$)
A	wet	150	$29	$16	$9	$25	$23
B	wet	300	$57	$32	$9	$41	$23
C	wet	400	$78	$43	$9	$52	$23
D	wet	600	$143	$79	$9	$88	$23
E	wet	875	$170	$94	$9	$103	$23
F	dry	55	$11	$6	$9	$15	$23
G	dry	130	$29	$16	$9	$25	$23
H	dry	200	$40	$22	$9	$31	$23
I	dry	300	$57	$32	$9	$41	$23
J	dry	600	$143	$79	$9	$88	$23
K	PH	160	$29	$16	$9	$25	$23
L	PH	250	$57	$32	$9	$41	$23
M	PH	450	$78	$43	$9	$52	$23
N	PH	600	$143	$79	$9	$88	$23
O	PC bypass	600	$143	$79	$9	$88	$23
P	PC bypass	1,200	$200	$111	$9	$120	$23
Q	PC	600	$143	$79	$9	$88	$23
R	PC	1,200	$200	$111	$9	$120	$23
S-new	PC	600	$143	$79	$9	$88	$23

Source: Memorandum from Jim Crowder, EPA, to Ron Evans, EPA. January 29, 1996. "Additional Engineering Inputs for Economic Impacts Analysis for the Portland Cement Industry NESHAP." Attachment 3, Table 6.

TABLE 3-9. BEYOND-THE-FLOOR COSTS FOR CARBON INJECTION TO CONTROL DIOXIN AND MERCURY

Model kiln ID	Process	Clinker capacity (10^3 tpy)	Total capital costs ($\$10^3$)	Annual control cost: Fixed ($\$10^3$)	Annual control cost: Variable ($\$10^3$)	Total annual costs ($\$10^3$)	Annual monitoring ($\$10^3$)
A	wet	150	$1,030	$100	$646	$745	$1
B	wet	300	$2,139	$202	$1,107	$1,310	$1
C	wet	400	$2,869	$273	$1,421	$1,694	$1
D	wet	600	$3,572	$336	$2,000	$2,336	$1
E	wet	875	$4,858	$453	$2,813	$3,266	$1
F	dry	55	$675	$69	$357	$426	$1
G	dry	130	$910	$91	$558	$648	$1
H	dry	200	$997	$96	$732	$828	$1
I	dry	300	$1,654	$158	$1,013	$1,171	$1
J	dry	600	$2,704	$255	$1,806	$2,061	$1
K	PH	160	$976	$99	$542	$640	$1
L	PH	250	$1,208	$119	$724	$845	$1
M	PH	450	$1,931	$187	$1,135	$1,322	$1
N	PH	600	$2,410	$231	$1,440	$1,670	$1
O	PC bypass	600	$2,674	$260	$1,636	$1,894	$1
P	PC bypass	1,200	$4,014	$381	$2,834	$3,214	$1
Q	PC	600	$2,430	$233	$1,441	$1,673	$1
R	PC	1,200	$3,784	$356	$2,636	$2,993	$1
S-new	PC	650	$2,442	$233	$1,533	$1,765	$1

Source: Memorandum from Jim Crowder, EPA, to Ron Evans, EPA. January 29, 1996. "Additional Engineering Inputs for Economic Impacts Analysis for the Portland Cement Industry NESHAP." Attachment 3, Table 4.

TABLE 3-10. SUMMARY OF COSTS FOR MONITORING REQUIREMENTS

Monitoring requirement	Total capital costs ($10^3^)	Annual control cost: Fixed ($10^3^)	Annual control cost: Variable ($10^3^)	Total annual costs ($10^3^)
COM	$35	5	17	22
Initial M.5[a]	--	--	--	1
Initial M.9[b]	NA	NA	NA	NA
Initial M.23[a]	--	--	--	4
Initial M.29[a]	--	--	--	1
THC CEM	$144	$20	$65	$85
HCl CEM	$144	$20	$65	$85

[a] Costs for initial M.5, M.23, and M.29 performance tests are annualized over 10 years at 7% interest rate.
[b] Costs for initial M.9 visual opacity readings are estimated for each individual plant and provided in Attachment 10, Table 9 in Memorandum from Jim Crowder, EPA, to Ron Evans, EPA. January 29, 1996. "Additional Engineering Inputs for Economic Impacts Analysis for the Portland Cement Industry NESHAP."

Note: CEM = continuous emission monitor
COM = continuous opacity monitor

Source: Memorandum from Jim Crowder, EPA, to Ron Evans, EPA. January 29, 1996. "Additional Engineering Inputs for Economic Impacts Analysis for the Portland Cement Industry NESHAP." Attachment 3, Table 8.

SECTION 4
ECONOMIC IMPACT ANALYSIS

The proposed NESHAP to control air pollution from cement kilns will directly (through imposition of control costs) or indirectly (through changes in market prices) affect all of the 201 kilns operating in the Portland cement industry as of 1993. Implementation of the proposed regulations affect the costs of producing Portland cement at affected kilns, as described in Section 3. The compliance costs will vary kilns in the industry depending on their physical characteristics and existing level of control. The response to these additional costs will determine the economic impacts of the regulations. Specifically, the cost of the regulations may induce some owners to close their operations or to change their current operating rates. These choices affect, and in turn are affected by, the market price for Portland cement.

Because of the low value and high transport cost of Portland cement, the U.S. cement industry is divided into a number of independent regional markets. For each of these markets, the analysis characterizes domestic and foreign producers and consumers of Portland cement and their behavioral responses to each regulatory scenario. Given the compliance costs for directly affected kilns, each model determines a new equilibrium solution for the Portland cement market in a comparative static approach to determine the policy outcomes of the regulatory action. An oligopolistic market structure is employed by the model to compute the new equilibrium prices and quantities associated with imposition of the regulatory option(s). As opposed to the models of perfect and monopolistic competition, the general model of oligopolistic competition stresses the strategic interaction between producers in that each must take into account the output choices of others in determining its own output choice.

The major results of this modeling approach are market-level adjustments in price and quantity (including foreign trade) within each regional Portland cement market and thus for the U.S. as a whole, as well as the facility- and industry-level adjustments in production, revenues, costs, profits, and operating facilities and kilns. Furthermore, based on the market adjustments, the analysis can estimated the social cost of each regulatory alternative and assess the impacts on small businesses.

The remainder of this section describes the data and methodology used to estimate these impacts and the results of the analysis. Section 4.1 presents the data inputs for the economic analysis including producer characterization, market identification, and regulatory cost estimates. Section 4.2 follows with a description of the conceptual approach to estimating the economic impacts on Portland cement manufacturers along with some operational details of the economic model, and Section 4.3 presents the resulting economic impacts.

4.1 ANALYSIS INPUTS

Inputs to the analysis include a description of the economic and operating conditions at Portland cement plants and the estimated costs of compliance with the proposed regulatory option(s).

4.1.1 Producer Characterization

Characterizing the manufacturers of Portland cement requires information on their physical characteristics (i.e., location, technology, inputs, and capacity), cement production, and the associated costs of production.

4.1.1.1 Physical Characteristics. The baseline characterization of Portland cement producers is based principally on 1993 data from the Portland Cement Association's (PCA) U.S. and Canadian Portland Cement Industry: Plant Information Summary.[46] These kiln- and plant-specific data are supplemented with secondary information on final product and input price data from the Bureau of Mines and the Energy Information Administration and with kiln-specific cost equations based on an equation estimated from the literature and modified for this analysis.[47,48] Appendix A provides baseline data for each of the 201 Portland cement kilns included in this analysis.

4.1.1.2 Cement Production. The first level of production occurs at the cement kiln resulting in what is known as clinker--the major input into Portland cement. As Das points out, there is no jointness in cement production across kilns, i.e., one kiln does not require the use of another kiln in the production of cement.[49] This observation implies that a cement plant's total cost function is additively separable in kilns. Thus, the decision for any particular kiln is independent of all other existing kilns. Assuming Portland cement is a homogeneous product and because the marginal cost of kilns increases with age within a production process, a profit-maximizing firm will use kilns of a particular process in the reverse order of their ages.[50,51] For example, the output of the youngest kiln equals the minimum of plant output and its capacity output. If plant output is smaller than the capacity of the youngest kiln, then the youngest kiln is assigned total output and if any other kilns exist, they are assigned zero output. However, if plant production is greater than the capacity of the youngest kiln then the youngest kiln is assigned its capacity output and the remaining plant output is assigned to the next youngest kiln and this process continues until the total plant production has been assigned.

If two identical kilns are operable and output is less than the capacity of one kiln, due to the high start-up cost of production, all output will be assigned to one kiln. The high start-up cost of production results from obtaining the high temperature required to operate a kiln. In addition, frequent heating and cooling of kilns damages the firebrick lining. Therefore, it is more efficient for a plant to continuously operate kilns if possible. If plant output is greater than the capacity of one kiln; however, it is assumed that one kiln operates at 100 percent capacity while the other kiln operates to produce the remaining output. Obviously, the level of production from the cement kilns will be determined by their underlying operating costs as described below.

Das estimates a kiln-level average variable cost function in her microeconomic study of kiln utilization and retirement.[52] There are five variable inputs in cement production--labor, fuel, electricity, raw material and maintenance. Labor is used in the quarry and for packing, fuel is largely consumed by the kilns, electricity is consumed mainly by the auxiliary equipment, raw materials serve as the kiln-feed, and maintenance is required for periodic upkeep of the kiln. Das assumes a fixed coefficient technology as the variable inputs are not deemed substitutable. Accordingly, the average variable cost function is independent of output and may be expressed such that the contribution of each variable input to the cost per ton of cement is equal to the average variable input (fixed requirement of the input per ton of cement) times the price of the input (per unit cost). Using the f.o.b. price of Portland cement as a proxy for the unobserved price of raw materials and maintenance inputs, Das estimated the kiln-level average variable costs (AVC) as:

$$AVC = 0.4965 P + 0.5744 w + (1.0087)^A 5.0832 P_f + 0.3667 P_e \quad (1)$$

where P is the f.o.b. price of Portland cement (P), w is the wage rate of labor inputs, A is the age of the kiln, P_f is the price of fuel used to fire the kiln per million Btu, and P_e is the price of electricity per million Btu.

For the purposes of this analysis, the cost function estimated by Das was modified as detailed in Appendix C to better reflect the operating costs of kilns as of 1993 across different processes and kiln sizes. The analysis incorporates the modified versions of Eq. (1) to estimate the AVC for each U.S. kiln as of 1993 given the location and age of the kiln and input price data by state from the Bureau of Labor Statistics and the Department of Energy's State Energy Price and Expenditure Report.[53],[54]

The modified AVC functions based on Eq. (1) provide inverted L-shaped supply functions as shown in Figure 4-1(a) for the single kiln plant. In this case, marginal cost equals average variable cost and is constant up to the production capacity given by q^M where it then becomes infinite. The minimum economically achievable price level is equal to P^m. Below this price level, $P^m < AVC$ and the supplier would choose to shut down rather than to continue to produce Portland cement. Conceptually, we can construct step supply functions for suppliers with multiple kilns by assigning production to the kilns from least-to highest cost (See Figure 4-1(b)).

4.1.2 Portland Cement Markets

The economic literature indicates that Portland cement provides the textbook case of localized, imperfectly competitive markets due to its low value and high cost of transport. The following subsections identify and

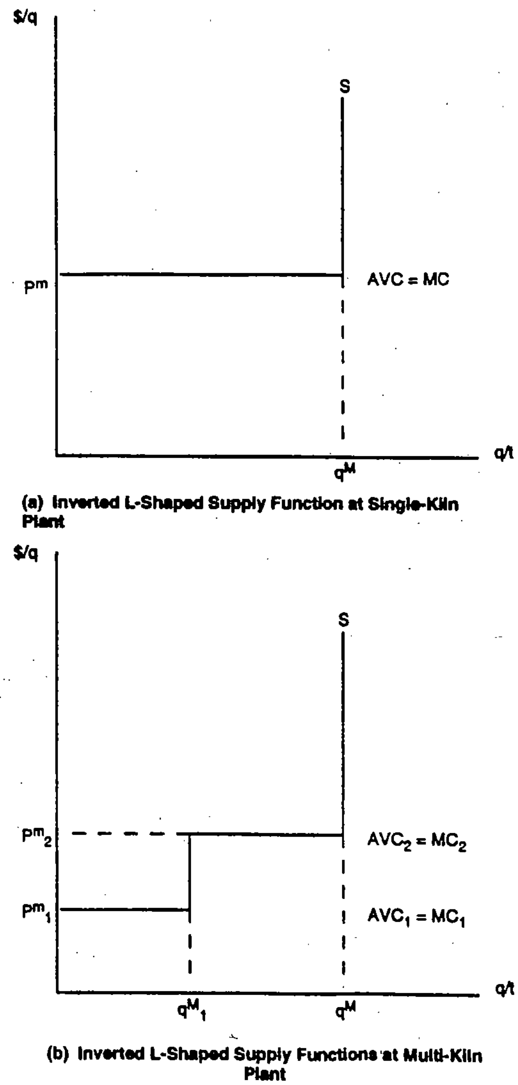

Figure 4-1. Facility-level supply functions for Portland cement.

characterize the markets for Portland cement as well as the behavior of Portland cement producers.

4.1.2.1 Market Identification and Characterization. Because transportation costs are high relative to the value of the products, Portland cement markets are regional. Portland cement is a homogeneous product that is manufactured to meet standardized technical specification so that buyers do not distinguish between the product of sellers in the market and thus the geographic boundaries of each market are solely determined by the costs of transporting the Portland cement, which are borne by the consumers. Consequently, researchers have typically divided the Portland cement industry into a number of independent regional markets. For example, studies by Iwand and Rosenbaum in 1991 and Rosenbaum and Reading in 1988 identified 25 and 20 regional markets, respectively, consisting of a major metropolitan area and all Portland cement plants located within 200 miles of the central city.[55,56] Furthermore, since all producers offer the same product no price difference within a market can persist in equilibrium. Based on this literature, the Agency assumes that the U.S. Portland cement industry is divided into a number of independent regional markets with each having a single market-clearing price.

Table 4-1 lists the 20 regional markets for Portland cement included in this analysis. All U.S. Portland cement plants and kilns operating during 1993 are included in these 20 markets, which are fully characterized in Appendix B. The f.o.b. price of Portland cement for each regional market is derived as the capacity weighted average of the state level f.o.b. prices obtained from the U.S. Bureau of Mines.[57,*]

---

*For 4 markets, the capacity weighted average f.o.b. price was less than the highest kiln-level AVC which is inconsistent with economic theory. Thus, the f.o.b. prices for the Los Angeles, New York/Boston, Florida, and Pittsburgh markets were derived based on the optimal output condition for Cournot-Nash competition.

The production of Portland cement within each market is the sum of the individual kiln production levels taken from EPA's industry survey and adjusted to reflect 1993 levels according to regional production trends from the U.S. Bureau of Mines.[58] Imports of Portland cement were obtained from the U.S. Bureau of Mines and mapped to each market based on the port of entry to the U.S. and distinguished by importing country--Canada versus rest of the world (ROW).[59]

4.1.2.2 Market Structure. Once the markets are defined, the analyst must determine the behavior of the producers of Portland cement. The discussion on behavior generally focuses on monopolistic, oligopolistic, and competitive pricing. Making inferences about the behavior of producers often requires assessing barriers to entry and developing a measure of concentration within each market, both of which should reflect the ability of firms to raise prices above the competitive level. Markets with barriers to entry (e.g., licenses, legal restrictions, or high fixed costs) are expected to be less competitive than those without such barriers. In addition, less concentrated markets are predicted to be more competitive and should result in a low value of the concentration measure, while a higher value should indicate a higher price-cost margin or a higher likelihood of noncompetitive behavior on the part of producers.

An oligopolistic market structure exists for Portland cement because these plants operate under conditions of high, location-specific fixed costs and substantial returns to scale that act as a barrier to entry. The capital investment required for the production of cement involves use of large rotary kilns that are not readily movable or transferable to other uses. Because the minimum efficient scale of cement operations is a significant share of local demand, each regional Portland cement market can sustain only a small

TABLE 4-1. SUMMARY DATA FOR PORTLAND CEMENT MARKETS: 1993

Market	Number of: Operating plants	Number of: Operating kilns	F.O.B. price ($/ton)	Production (million tons): U.S.	Production (million tons): Canadian	Production (million tons): Rest of world	Production (million tons): Total	Top 2-plant concentration ratio
Atlanta	8	19	$51.99	5.69	--	0.50	6.19	34.1%
Baltimore/Philadelphia	10	24	$51.51	7.18	--	0.01	7.18	27.2%
Birmingham	6	7	$50.84	4.29	--	0.26	4.54	48.0%
Chicago	6	10	$53.57	3.50	0.15	--	3.66	44.8%
Cincinnati	4	7	$53.73	2.88	--	--	2.88	58.0%
Dallas	6	15	$48.25	5.19	--	--	5.19	43.4%
Denver	5	9	$63.72	2.69	--	--	2.69	54.0%
Detroit	4	10	$56.73	4.76	1.13	--	5.89	49.4%
Florida	4	8	$59.71	3.08	--	1.42	4.50	36.3%
Kansas City	7	18	$53.79	3.86	--	--	3.86	40.9%
Los Angeles	7	15	$61.86	6.72	--	0.46	7.18	42.3%
Minneapolis	2	3	$60.85	1.44	0.18	--	1.62	100.0%
New York/Boston	5	6	$59.18	3.53	0.41	0.25	4.19	34.9%
Phoenix	4	10	$64.88	2.69	--	--	2.69	64.8%
Pittsburgh	4	8	$63.44	1.85	1.04	--	2.88	74.8%
Salt Lake City	5	7	$76.41	1.53	0.31	--	1.84	49.7%
San Antonio	7	11	$46.16	5.11	--	0.17	5.27	36.6%
San Francisco	4	5	$51.18	3.08	--	0.31	3.40	68.5%
Seattle	2	2	$62.27	1.13	0.74	0.41	2.27	60.4%
St. Louis	5	7	$49.75	5.04	--	--	5.04	45.9%
U.S. average/total	105	201	$55.49	75.2	4.0	3.8	83.0	--

number of firms that are able to earn positive profits without inviting entry. Entry is expected to occur only in the event of growth in the local demand for Portland cement.

In regard to seller concentration, based on a panel data from 25 regional cement markets in the U.S. over an 8-year period, a study by Iwand and Rosenbaum concludes that all of these markets are oligopolistic in nature because the lowest four firm concentration ratio (based on production capacity) for any of the regional markets was 47, and the average across all markets was 76.[60] Thus based on the nature of these markets, the economic model employs an oligopolistic market structure that stresses the strategic interaction between producers to compute the new equilibrium prices and quantities associated with imposition of the regulatory option(s).

4.1.3 Regulatory Control Costs

As shown in Section 3, compliance cost estimates for model kilns are developed by an EPA engineering analysis. To serve as inputs to the analysis, the model kilns and the associated compliance costs for each control option are mapped to the actual kilns included in the economic model based on technology and capacity. The total annual compliance costs per unit of capacity associated with each model kiln are applied to each actual kiln as an input to the economic analysis, or the "cost shifters" of the baseline kiln-level AVC curves. Absent engineering determination of the applicability of controls, the economic analysis randomly determines affected producers based on national population rates of applicability from the engineering analysis. This random determination approach can provide some insight on the likely economic impacts at the national-level through multiple simulations of the economic models given different random assignment of applicability at the national level.

Determining the applicability of the control option for each kiln (i) is performed by comparing its random indicator (R_i) to the national applicability percentage (N%) for each control option, i.e.,

kiln affected by control option if $R_i \leq N\%$,

or kiln not affected by control option if $R_i > N\%$.

As applied to each kiln across the nation, this procedure should result in a national estimate of the number of affected kilns that closely approximates the engineering estimate based on the national applicability percentage.

This procedure is repeated to yield separate estimates of the distribution of affected kilns across the U.S. for a given control option. Based on these separate distributions, each regional market model will run multiple simulations consisting of single simulation runs that impose the control costs for each affected kiln (that is different for each random distribution) and computes the associated economic impact estimates. The multiple simulations for each regional market model consist of 35 independent simulations to provide a range of likely economic impacts associated with the uncertainty of applicability. This number of simulations is deemed sufficient to estimate a well-defined distribution of likely economic impacts based on the observation that additional simulations above 35 did not notably reduce the variability of the impact measures.

4.2 ECONOMIC MODEL

This section provides the conceptual and operational approach to modeling the Portland cement markets.

4.2.1 Conceptual Approach

When a supplier in a competitive market makes its production decision, it only needs to examine market price. By definition, the supplier is such a small part of the market that it views itself as being unable to influence the market price through its own actions. Thus, it can ignore the impact of its own production decision on market price. However, when a supplier in an oligopolistic market makes its production decision, it must take into account the behavior of other suppliers and the effect of their output decisions on market price. In oligopoly, each supplier forms expectations, or conjectures, about its competitors' production decisions to make decisions on its own optimal production level.

Unlike perfect competition and monopoly, there is no single, complete model of oligopoly. Most empirical studies of oligopoly present competition as a quantity game among few producers of a homogenous product, as first described by Cournot.[61] Numerous oligopoly models of quantity competition have been developed by economists with each addressing a narrowly defined set of behavioral assumptions explicitly accounting for firm interdependence. The assumptions regarding each firm's conjectural variations, or the expectation of its competitors' response, differ across oligopoly models. These models include the following:

- dominant firm model, where the output decision of a dominant firm, or group of firms, takes into account its impact on both market price and the output decisions of "fringe" firms assumed to act as price-takers, i.e., each firm acts as if it expects its output change to be met by an off-setting change in its competitors' total output so that market price is unchanged.
- Cournot-Nash model, where each firm does not expect its competitors to react to its output decision so that each firm's output decision depends on the firm's

market share, market price, and market demand elasticity.

- collusive model, where joint industry profits are maximized with all firms in the industry acting together as a multiplant monopolist.

- Stackleberg leader-follower model, which is similar to the dominant firm model except that the leading firm hypothesizes that the "follower" firms respond with Cournot conjectures rather than price-taking conjectures.

Due to the absence of collusion or a dominant firm in any market, the Cournot-Nash model is the most appropriate type of oligopolistic behavior to hypothesize for this industry. Following this model, each supplier maximizes its profits, given its conjectures about other supplier's output choices. Furthermore, those beliefs are confirmed in equilibrium as each supplier chooses to produce the optimal amount of output given the other supplier's output choices. Thus, in a Cournot-Nash equilibrium no supplier will find it profitable to change its production decision once it discovers the choices actually made by the other suppliers.

As illustrated in Figure 4-2, the oligopolistic firm faces a downward sloping marginal revenue curve (MR) derived from a downward sloping residual demand curve (not shown). As discussed previously, the production costs at the Portland cement facility are characterized by the inverted L-shaped cost function, or supply curve (S). The profit-maximizing producer will choose to produce at the intersection of its' marginal cost and marginal revenue curves. Because average variable cost is constant, average variable cost (AVC) equals marginal cost (MC). Thus, the optimal production level for this firm is q^*.

Now consider the effect of the regulatory control costs. These proposed costs are all avoidable because a firm can

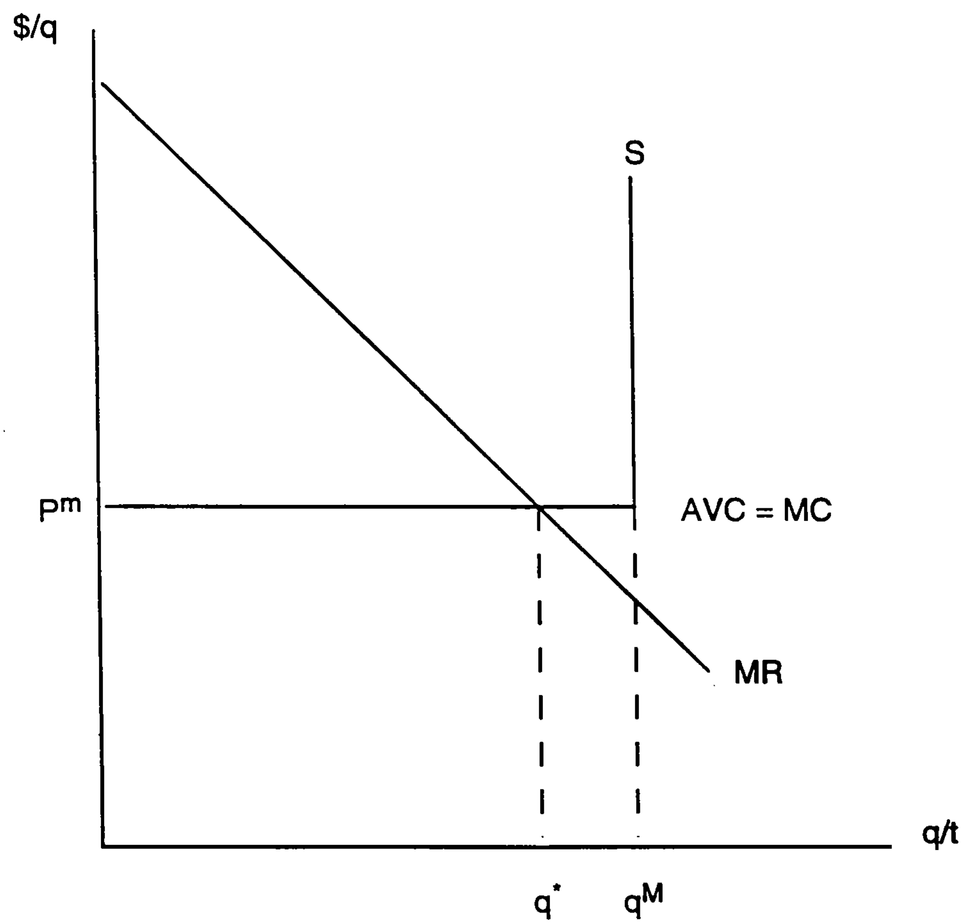

Figure 4-2. Ogilopolistic plant without regulation.

choose to cease operation of the kiln and thus avoid incurring the costs of compliance. Figure 4-3 illustrates that imposing the regulation will shift the horizontal portion of the firm's marginal cost curve up by the total compliance costs per unit, i.e., from MC to MC'. Given this shift, the firm's optimal production level is reduced to q*' at the intersection of the MC' and MR curves. Figure 4-3 depicts the new higher minimum price level (P^{m}') associated with the regulation-induced shift in marginal cost at the firm.

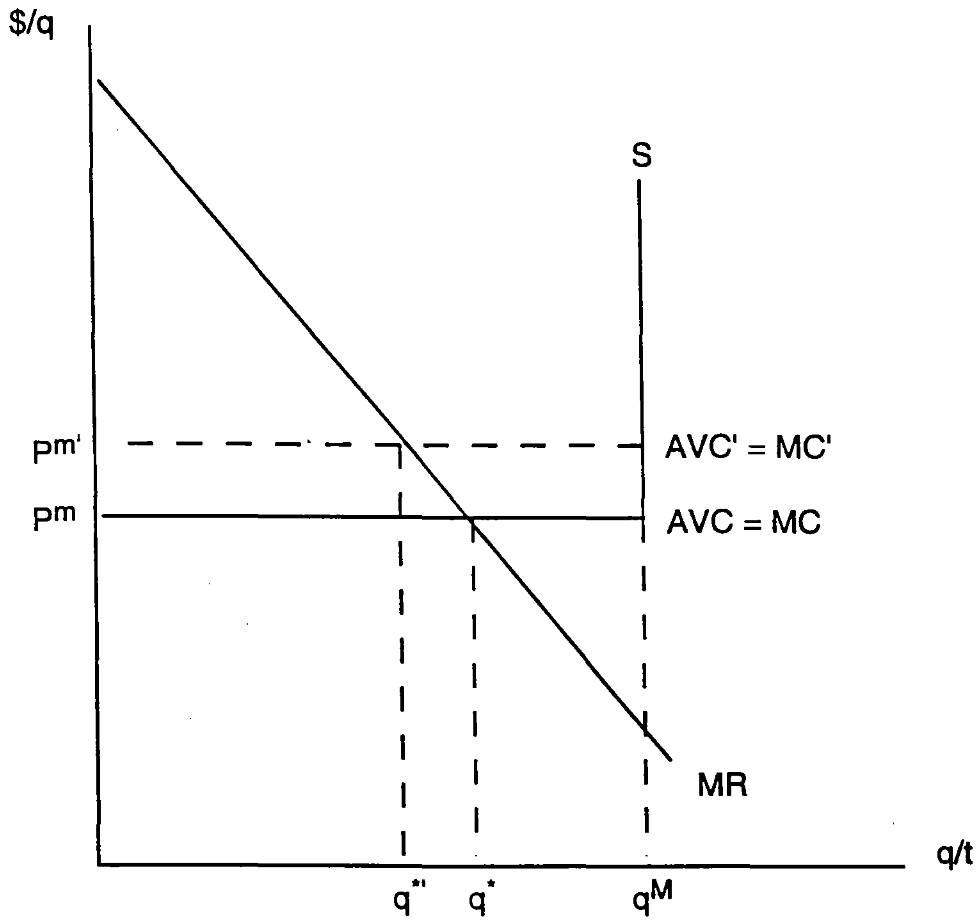

Figure 4-3. Ogilopolistic plant with regulation.

In evaluating the market effects for Portland cement, the analysis must account for the initial effect of the regulation and the net effect after the market has adjusted. Initially, the cost curves at all affected plants and/or kilns shift upward as shown above in Figure 4-3. However, the combined effect across these producers causes an upward shift in the market supply curve for Portland cement, which pushes up the price given the downward sloping market demand curve. Determining the effects for a particular plant and/or kiln depends upon the relative magnitude of the control costs of regulation and the change in market price.

Given changes in market prices and costs, operators of cement plants will elect to either

- continue to operate, adjusting production and input use based on new prices and costs, or
- close the plant and/or kiln if revenues do not exceed operating costs.

The standard closure evaluation is based on the comparison of revenues to the opportunity costs of production. If operators of plants and/or kilns anticipate that these costs with the controls will exceed revenues at either level, they will shut down the appropriate unit of production.

Plant and/or kiln closures directly translate into output reductions. However, these quantity reductions will not be the only source of output change in response to the regulation. The output of kilns that continue operating with regulation will also change as will the output supplied from foreign sources. Affected plants and/or kilns may increase or decrease their output depending on the increase in control cost that shifts their marginal cost curve and the shift in their marginal revenue curve that results from either an inward or outward shift in their residual demand curve. Unaffected plants and/or kilns will not face an increase in compliance costs, so their response to higher product price is to increase production given capacity constraints. Foreign producers, who do not incur higher production costs because of the regulation, will similarly respond by increasing their supply to U.S. markets.

4.2.2 Operational Model

To estimate the economic impacts of the regulation, the conceptual view outlined above was operationalized in a Lotus 1-2-3 multiple spreadsheet model for each regional market. The purpose of the model is to provide a structure for analyzing the market adjustments associated with the regulations to control HAPs from the Portland cement industry. For each of the 20 regional markets, the model characterizes domestic and foreign producers and consumers of Portland cement and their behavioral responses to the imposition of the regulatory costs. Given the compliance costs for directly affected kilns, each model determines a new equilibrium solution for the Portland cement market in a comparative static approach to determine the policy outcomes of the regulatory action. Appendix D provides a more detailed description of this modeling approach. This section summarizes the behavioral responses for producers and consumers as well as the model solution mechanism.

4.2.2.1 Domestic Supply. Following the Cournot-Nash model of oligopolistic behavior for Portland cement markets, each supplier maximizes its profits given its conjectures that its competitors will not react to its output decision so that each firm's output decision depends on the firm's market share, market price, and market demand elasticity. In general, each plant i maximizes profits by choosing its level of production (q_i), i.e.,

$$\text{Max } \pi_i = P(Q)\ q_i - C(q_i) - F \tag{2}$$

where Q is market output, $C(q_i)$ is the plant's variable cost function, and F reflects fixed costs at the plant. The resulting first-order condition and the Cournot-Nash assumption dictates that each profit-maximizing supplier determines the optimal level of output by equating marginal revenue (MR) and marginal cost (MC), i.e.,

$$MR_i = P\left[1 + \frac{s_i}{\eta}\right] = MC_i \qquad (3)$$

where P is the market price, s_i is the market share of plant i defined as q_i/Q with Q being market output, and η is the market demand elasticity for Portland cement.

The regulatory compliance costs provide the exogenous shock to the model with the total compliance cost per ton (c_i) being the change in the marginal cost of production for each affected supplier (dMC_i), i.e., the shift in the MC curve for the marginal kiln (i.e., kiln with highest AVC) at each plant.* Based on the optimal output condition in Eq. (3), the change in marginal revenue (dMR_i) must equal the change in the marginal cost (dMC_i) for each plant in the post-compliance equilibrium so that

$$dMR_i = dMC_i \qquad (4a)$$

or

$$dP\left[1 + \frac{s_i}{\eta}\right] + \frac{P}{\eta}\, dq_i \left[\frac{Q}{Q_2}\right] - \frac{P}{\eta}\, dQ \left[\frac{q_i}{Q^2}\right] = c_i \qquad (4b)$$

where each parameter is defined as described above. For each plant within the market, Eq. (4b) describes its behavioral response to the regulation based on the given parameters and the shift in the MC curve for its marginal kiln.

---

*This analysis accounts for the possible reorganization of production from kilns at a plant with the regulation so that the appropriate shift in MC at the plant is defined as the highest kiln-level AVC with regulation minus the highest kiln-level AVC in baseline. Given no reorganization this yields the shift for the individual marginal kiln.

4.2.2.2 Foreign Supply. If applicable to the market, international trade may also be included by specifying additional equations to characterize foreign imports of Portland cement to the U.S. from Canada and/or the rest-of-the-world (ROW). In such cases, the change in imports of Portland cement from these foreign sources is included through the following equation for each:

$$dq^I = \xi \, dP \left(\frac{q^I}{P} \right) \tag{5}$$

where ξ is the import supply elasticity. The U.S. International Trade Commission's report of August 1990 on its dumping investigation of grey Portland cement from Mexico suggests that the supply elasticity of foreign imports to the southern-tier of the U.S. is between 6 and 8.[62] Although this parameter is likely to vary across regions and foreign sources, the absence of region and source-specific estimates necessitates that this analysis assume a value of 7 for both Canadian and rest-of-world suppliers to each U.S. market. It is believed that institutional factors (trade restrictions, dumping fees) have a great impact on not only the level of imports from year to year but also the composition of foreign suppliers to the individual U.S. markets. However, these factors cannot be parameterized so as to include them in this specification of demand.

4.2.2.3 Market Supply. The change in market supply of Portland cement (dQ) must equal the change in Portland cement production from the individual suppliers both domestic and foreign, i.e.,

$$dQ = \sum_{i=1}^{N} dq_i + dq^I \tag{6}$$

This condition ensures that the market quantity is consistent with the individual supply decisions of domestic and foreign suppliers in the new post-compliance equilibrium for each regional market.

4.2.2.4 Market Demand. The demand for Portland cement is derived from the demand for concrete products which, in turn, is derived largely from the demand for construction. Based on a linear demand equation, the market demand condition for Portland cement must hold based on the projected change in market price, i.e.,

$$dQ = \eta \, dP \left[\frac{Q}{P}\right] \tag{7}$$

where the market demand elasticity, η, is estimated to be -0.884 based on the econometric approach described in Appendix E.* This estimate is consistent with the literature in that demand is inelastic reflecting the lack of substitute products for cement in the production of concrete and the small cost share of cement in construction activities.

4.2.2.5 Model Solution for Post-Compliance Equilibrium. The above specified equations provide N + 3 linear equations in N + 3 unknowns (dq_i, dq^I, dQ, and dP) that can be solved using matrix algebra, i.e.,

$$b = A^{-1}c'$$

where b is the vector containing the unknowns (dP, dq_i, dq^I, and dQ), A^{-1} is the inverse of A, an N + 3 X N + 3 matrix, and c is the vector containing (c_i, 0, 0, 0).

*Specification of a linear demand equation facilitates the model's solution algorithm but may introduce slight imprecision in the individual supply responses from Eq. (4b) since the value of the market demand elasticity changes as one moves up the linear demand curve from baseline to post-regulatory output levels. This imprecision is not expected to alter the direction or significantly change the magnitude of the aggregate results since most of the changes introduced by the control costs for individual suppliers are small and influenced more so by other uncertainties such as the random allocation of control costs across kilns.

After solving for the unknowns (i.e., dP, dq_i, dq^I, and dQ), the model must adjust one or more of the linear equations and resolve in the following situations:

- capacity violation, in which a plant exceeds its maximum capacity,
- kiln closure, in which the decline in production in response to the regulatory costs is greater than the baseline production from the marginal kiln (equal to a plant closure for single-kiln plants),
- plant closure, in which the profits at the plant-level are less than zero.

Each of these situations is addressed in the given sequence such that no later response/outcome would change the previous response/outcome.

4.3 ECONOMIC IMPACT ESTIMATES

This section provides the economic impacts at the national-level, which reflect the sum of the mean outcomes for each of the 20 regions. Based on the random determination of applicability, a 95 percent confidence interval is provided for each impact measure. The length of these intervals indicate the reliance of the estimates. The model results are summarized below as market-, industry-, and society-level impacts due to the regulation. Appendix F provides detailed result tables at the national and regional levels for each regulatory alternative.

4.3.1 Market-Level Results

Market-level impacts include the regional market adjustments in price and quantity for Portland cement, including the changes in foreign imports for the appropriate regions. Table 4-2 provides the market adjustments for each regulatory alternative. As shown, the MACT Floor options are

TABLE 4-2. SUMMARY OF NATIONAL-LEVEL MARKET IMPACTS BY REGULATORY ALTERNATIVE: 1993

	Change in market price[a]		Change in annual output (10^6 short tons)[b]					
			Domestic production		Imports		Market total	
Regulatory alternative	$/ton	Percent change	10^6 tpy	Percent change	10^6 tpy	Percent change	10^6 tpy	Percent change
Major and area sources								
MACT floor	$0.63	1.1%	-1.37	-1.8%	0.54	7.0%	-0.83	-1.0%
	[$0.60, $0.66]		[-1.33, -1.41]		[0.51, 0.57]		[-0.81, -0.85]	
BTF option 1	$1.58	2.8%	-3.37	-4.5%	1.26	16.3%	-2.11	-2.5%
	[$1.48, $1.67]		[-3.11, -3.62]		[1.09, 1.42]		[-2.00, -2.27]	
BTF option 2	$1.43	2.6%	-3.01	-4.0%	1.10	14.2%	-1.91	-14.22%
	[$1.36, $1.50]		[-2.87, -3.14]		[1.01, 1.19]		[-1.82, -1.99]	
Major sources only								
MACT floor	$0.57	1.0%	-1.22	-1.6%	0.48	6.2%	-0.75	-0.9%
	[$0.53, $0.60]		[-1.19, -1.26]		[0.45, 0.51]		[-0.73, -0.76]	
BTF option 1	$1.61	2.9%	-3.44	-4.5%	1.29	16.7%	-2.14	-2.6%
	[$1.53, $1.68]		[-3.29, -3.59]		[1.20, 1.39]		[-2.04, -2.25]	
BTF option 2	$1.29	2.3%	-2.74	-3.6%	1.03	13.3%	-1.71	-2.1%
	[$1.22, $1.36]		[-2.61, -2.87]		[0.94, 1.12]		[-1.63, -1.80]	
Major sources and D/F controls on area sources								
MACT floor	$0.58	1.1%	-1.26	-1.7%	0.49	6.3%	0.77	0.9%
	[$0.52, $0.62]		[-1.23, -1.29]		[0.46, 0.52]		[-0.75, -0.79]	
BTF option 1	$1.40	2.5%	-2.98	-3.9%	1.11	14.3%	-1.87	-2.3%
	[$1.31, $1.50]		[-2.74, -3.22]		[0.97, 1.27]		[-1.72, -2.03]	
BTF option 2	$1.37	2.5%	-2.93	-3.9%	1.11	14.3%	-1.83	-2.2%
	[$1.30, $1.44]		[-2.80, -3.08]		[1.01, 1.21]		[-1.74, -1.92]	

Note: The 95 percent confidence interval for each national estimate is provided in brackets.

[a] Changes from baseline at the national-level reflect the production weighted average of the mean observations across each of the 20 regions.

[b] Changes from baseline at the national-level reflect the sum of the mean observations across each of the 20 regions.

expected to increase the national price for Portland cement by roughly 1 percent, or $0.60 per short ton, while reducing domestic production by almost 2 percent, or close to 1.3 million tons per year. The projected increase in price associated with the MACT Floor is just over half of the 1.7 percent increase observed for Portland cement from 1992 to 1993, while the projected decline in domestic production reflects almost 40 percent of the increase in domestic production of Portland cement from 1992 to 1993.

Alternatively, imposition of the BTF options appear to more than double the magnitude of the market impacts observed for the MACT Floor options. The BTF options are projected to increase the national price by over 2.5 percent, or close to $1.50 per short ton, while reducing domestic production by almost 4 percent, or close to 3 million tons per year.

Foreign imports of Portland cement to the U.S. are projected to increase as a result of the regulations. As shown in Table 4-2, based on a foreign supply elasticity of 7, the MACT Floor options are projected to increase foreign imports by roughly 6.5 percent, or nearly 500,000 short tons per year, while the BTF options are expected to increase foreign imports by more than 14 percent, or over 1 million tons per year. Regional markets that incur significant increases in foreign imports of Portland cement include Chicago, Detroit, New York/Boston, and Pittsburgh from Canadian sources and Atlanta, Birmingham, Florida, Los Angeles, and San Francisco from rest-of-the-world sources. The impacts of foreign imports are significant in these regions as a result of the very elastic supply elasticity from foreign sources that limits the ability of affected domestic producers to pass on costs to consumers.

4.3.2 Industry-Level Results

Industry-level impacts include an evaluation of the changes in revenue, costs, and profits; the post-regulatory compliance cost; and cement plant and kiln closures; and the change in employment attributable to the change in industry output. Table 4-3 summarizes these industry-level impacts by regulatory alternative.

4.3.2.1 Post-Regulatory Compliance Cost. For each regulatory alternative, the post-regulatory compliance cost shown in Table 4-3 reflects the sum of the total annual compliance cost across all facilities continuing to operate in the post-compliance equilibrium. At the industry-level, the post-regulatory compliance cost of the MACT Floor options varied from $28.8 million as applied to major sources only and $31.3 million as applied to major and area sources, while the post-regulatory compliance cost of the BTF options varied from $48 million as applied to major sources only and $81.2 million as applied to major and area sources.

4.3.2.2 Revenue, Production Cost, and Earnings Impacts. The economic models generate information on the change in individual and market quantities and market prices. This allows computation of the change in total revenue and total cost at the industry level. For the MACT Floor options, the industry revenues are projected to decline by roughly 0.5 percent, or $20 million annually, associated with the change in domestic production and market prices. For the BTF options, the industry revenues are expected to decline from 1 to 1.5 percent, or $45 to $60 million annually.

Furthermore, the change in domestic output of Portland cement effects a change in production costs that can be added to the post-compliance regulatory costs to estimate the change in total costs for the industry. For the MACT Floor options,

TABLE 4-3. SUMMARY OF NATIONAL-LEVEL INDUSTRY IMPACTS ON REVENUES, COSTS, AND EARNINGS BY REGULATORY ALTERNATIVE[a]

	Change in revenue ($$10^3$)		Change in cost ($$10^6$)					Change in pre-tax earnings ($$10^3$)	
			Regulatory cost	Production cost		Total cost			
Regulatory alternative	$$10^6$/yr	Percent	$$10^6$/yr	$$10^6$/yr	Percent	$$10^6$/yr	Percent	$$10^6$/yr	Percent
Major and area sources									
MACT floor	-$22.1	-0.5%	$31.3	-$63.4	-1.8%	-$32.1	-0.9%	$10.0	1.5%
	[-$21.2, -$23.1]		[$30.7, $32.0]	[-$61.9, -$64.9]		[-$30.8, -$33.3]		[$9.2, $10.8]	
BTF option 1	-$60.6	-1.5%	$81.2	-$154.2	-4.4%	-$72.9	-2.1%	$12.3	1.9%
	[-$53.7, -$67.5]		[$74.8, $87.7]	[-$142.7, -$165.7]		[-$66.7, -$79.2]		[$9.7, $14.9]	
BTF option 2	-$48.9	-1.17%	$55.4	-$137.1	-3.9%	-$81.7	-2.3%	$32.8	5.1%
	[-$45.4, -$52.4]		[$53.4, $57.4]	[-$131.1, -$143.1]		[-$76.5, -$86.9]		[$29.3, $36.4]	
Major sources only									
MACT floor	-$19.2	-0.5%	$28.6	-$56.4	-1.6%	-$27.8	-0.8%	$8.6	1.3%
	[-$18.2, -$20.2]		[$27.9, $29.2]	[-$54.8, -$58.0]		[-$26.4, -$29.1]		[$7.7, $9.4]	
BTF option 1	-$56.8	-1.4%	$59.4	-$154.3	-4.4%	-$94.9	-2.7%	$38.1	5.9%
	[-$53.0, -$60.7]		[$57.1, $61.8]	[-$147.5, -$161.2]		[-$89.0, -$100.8]		[$34.1, $42.1]	
BTF option 2	-$45.7	-1.1%	$48.0	-$125.6	-3.6%	-$77.5	-2.2%	$31.9	4.9%
	[-$42.4, -$49.0]		[$46.2, $49.9]	[-$119.8, -$131.4]		[-$72.4, -$82.7]		[$28.4, $35.3]	
Major sources and D/F controls on area sources									
MACT floor	-$19.5	-0.5%	$28.8	-$57.6	-1.6%	-$28.8	-0.8%	$9.3	1.4%
	[-$18.5, -$20.4]		[$28.2, $29.4]	[-$56.1, -$59.2]		[-$27.8, -$30.1]		[$8.5, $10.1]	
BTF option 1	-$53.9	-1.3%	$73.6	-$137.9	-3.9%	-$64.3	-1.8%	$10.4	1.6%
	[-$47.2, -$60.6]		[$67.2, $80.0]	[-$126.7, -$149.0]		[-$58.3, -$70.3]		[$7.9, $12.9]	
BTF option 2	-$48.7	-1.2%	$50.0	-$133.2	-3.8%	-$83.2	-2.4%	$34.5	5.3%
	[-$45.2, -$52.3]		[$48.1, $52.0]	[-$127.1, -$139.4]		[-$77.8, -$88.6]		[$30.9, $38.0]	

Note: The 95 percent confidence interval for each national estimate is provided in brackets.

[a] Changes from baseline at the national-level reflect the sum of the mean observations across each of the 20 regions.

the analysis projects a reduction in total production costs of almost 1 percent, or roughly $30 million annually, reflecting the increase in costs due to regulation of roughly $30 million and the decrease in cost due to the lower output rate of between $56 and $63 million. The MACT Floor options impose costs of almost $0.42 per short ton produced, while the associated reductions in Portland cement production for each plant will necessarily come from its highest cost kiln operating at near $50 per short ton. Thus, the cost savings observed are consistent with the projected reductions in domestic production of 1.3 million tons.

For the BTF options, the analysis projects a reduction in total production costs of roughly 2 percent, or $75 million, reflecting the increase in costs due to regulation of between $48 and $81 million and the decrease in cost due to the lower output rate of between $125 and $155 million. Again, the projected cost savings are consistent with the magnitude of the regulatory cost per unit and the projected reductions in domestic production of Portland cement.

Lastly, the changes in total revenue and total cost are used to measure the earnings impact of the regulations at the facility level, and thus, the industry level. For the MACT Floor options, the pre-tax earnings at the industry level are projected to increase by 1.5 percent, or almost $10 million annually, while the pre-tax earnings under the BTF options are expected to increase between 1.5 and 6 percent, or $10 to $38 million annually. These projected increases in industry earnings result from the dynamics of the oligopolistic markets for Portland cement. In this case, the observed price changes are greater than the regulatory costs per unit as the nature of competition becomes more concentrated because producers gain market share over others and utilize this market power to further increase price. Thus, the improved earnings of this industry reflect a change in the distribution of earnings across producers of Portland cement (i.e., transfer from affected and/or exiting producers to unaffected producers) and the increased seller concentration within markets that allow producers to extract greater rents from consumers of Portland cement.

4.3.2.3 Closure Impacts. The economic models accommodate closures of cement plants and kilns in moving from the baseline to post-compliance equilibrium. It is important to point out that the estimates of cement plant and kiln closures are sensitive to the accuracy of the baseline characterization of the cement plants and kilns and the allocation of compliance costs across these plants and kilns. Uncertainty regarding the accuracy of the closure estimates is introduced through the use of a generalized cost function to project baseline operating costs at specific kilns, model kilns to project compliance costs at specific kilns, and the random determination of applicability of the regulatory controls and associated costs. These uncertainties are likely to influence the specific type of plant or kiln projected to close more so than the aggregate estimate of closures.

Table 4-4 provides the projected plant and kiln closures by regulatory alternative. As shown, no cement plants are projected to close due to the imposition of the MACT Floor or BTF control options. However, this analysis does project kilns to close as a result of imposing each regulatory alternative. As many as three kilns, or 1.5 percent those operating in 1993, are projected to close due to imposition of each of the MACT Floor options. Based on observations across the model simulations, all of the cement kilns projected to close under the MACT Floor options are dry process kilns with clinker capacity of less than 500,000 tpy. A priori, one would expect closures of wet process kilns that typically operate at higher costs than dry process kilns. However, the projection of kiln closures depends upon the market-specific

TABLE 4-4. SUMMARY OF NATIONAL-LEVEL PLANT AND KILN CLOSURES BY REGULATORY ALTERNATIVE[a]

Regulatory alternative	Plant closures		Kiln closures	
	Number	Percent	Number	Percent
Major and area sources				
MACT floor	0.0	--	2.8	1.4%
	[NA]		[2.4, 3.1]	
BTF option 1	0.0	--	5.8	2.9%
	[NA]		[5.2, 6.4]	
BTF option 2	0.0	--	8.8	4.4%
	[NA]		[8.2, 9.5]	
Major sources only				
MACT floor	0.0	--	2.4	1.2%
	[NA]		[2.0, 2.7]	
BTF option 1	0.0	--	9.7	4.8%
	[NA]		[9.0, 10.4]	
BTF option 2	0.0	--	8.2	4.1%
	[NA]		[7.6, 8.8]	
Major sources and D/F controls on area sources				
MACT floor	0.0	--	2.3	1.2%
	[NA]		[2.0, 2.6]	
BTF option 1	0.0	--	5.2	2.6%
	[NA]		[4.6, 5.7]	
BTF option 2	0.0	--	8.6	4.3%
	[NA]		[7.9, 9.3]	

Note: The 95 percent confidence interval for each national estimate is provided in brackets.

[a] Changes from baseline at the national-level reflect the sum of the mean observations across each of the 20 regions.

composition of competing kilns and the relative operating costs across these kilns after imposition of the pollution abatement controls. In this case, the dry process kilns projected to close were older and more costly to operate after including regulatory controls than wet process kilns competing in those particular markets. Furthermore, smaller capacity kilns have higher operating costs per ton so they are more likely to be the marginal kiln at a particular facility. Thus, as expected, these kilns make up the entire population of closures associated with the MACT floor option.

Imposition of the BTF options is projected to close from 6 to 10 cement kilns, or between 3 and 5 percent of the kilns operating in 1993. Based on observations across the model simulations, all of the cement kilns projected to close under the BTF options have clinker capacity of less than 500,000 tpy and are distributed evenly across dry and wet processes.

4.3.2.4 Employment Impacts. The regulation will also displace workers from jobs through its impacts on production. In this case, changes in employment for the entire U.S. industry can be obtained by multiplying the change in production at each plant (Δq_i) by that plant's employment to output ratio (e_i), i.e.,

$$\Delta E_{U.S.\ Industry} = \sum_i (e_i * \Delta q_i).$$

This estimate will aggregate the job losses at Portland cement facilities with reduced or zero output and job gains at those facilities with increased output. As shown in Table 4-5, based on the estimated reductions in domestic production of Portland cement, the MACT Floor options are projected to reduce employment by almost 2 percent, or between 220 and 250 employees, and the BTF options are projected to reduce employment by roughly 4 percent, or between 450 and 560 employees.

Worker displacement costs are computed to measure the costs borne by displaced workers. Building on the work by

TABLE 4-5. SUMMARY OF NATIONAL-LEVEL EMPLOYMENT LOSSES AND WORKER DISPLACEMENT COSTS BY REGULATORY ALTERNATIVE[a]

Regulatory alternative	Change in employment: Number	Change in employment: Percent	Worker displacement costs (10^6/yr)[b]
Major and area sources			
MACT floor	-250	-1.8%	$2.0
	[-242, -258]		[$1.9, $2.0]
BTF option 1	-560	-4.1%	$4.4
	[-519, -601]		[$4.0, $4.7]
BTF option 2	-485	-3.6%	$1.7
	[-459, -512]		[$1.6, $1.8]
Major sources only			
MACT floor	-220	-1.6%	$1.71
	[-211, -229]		[$1.64, $1.78]
BTF option 1	-540	-4.0%	$4.2
	[-511, -569]		[$4.0, $4.4]
BTF option 2	-449	-3.3%	$3.5
	[-424, -474]		[$3.3, $3.7]
Major sources and D/F controls on area sources			
MACT floor	-227	1.7%	$1.8
	[-219, -234]		[$1.7, $1.8]
BTF option 1	-509	-3.7%	$4.0
	[-469, -549]		[$3.7, $4.3]
BTF option 2	-459	-3.4%	$3.6
	[-432, -486]		[$3.4, $3.8]

Note: The 95 percent confidence interval for each national estimate is provided in brackets.

[a] Changes from baseline at the national-level reflect the sum of the mean observations across each of the 20 regions.

[b] Reflects the annualized value of the total worker displacement costs based on a 7 percent discount rate and a 15-year time period.

Adams[63] and Topel[64], Anderson and Chandran[65] constructed incremental willingness-to-pay measures for job dislocations in a hedonic wage framework. Their method is analogous to that used by economists to estimate the implicit value of a enjoyment). The hedonic displacement cost estimate is a net life using labor market data. The hedonic displacement cost estimate conceptually approximates the one-time willingness-to-pay to avoid an involuntary unemployment episode. Theoretically, it includes all worker-borne costs net of any off-setting pecuniary or nonpecuniary "benefits" of unemployment (e.g., unemployment compensation, leisure time present value valuation.

According to Bureau of Labor Statistics data, average annual earnings in the Portland cement industry for 1993 was $30,240.[66] Using Topel's compensating differential estimate and the Anderson-Chandran methodology, industry workers would demand an annual compensating differential of $756 ($30,240 * 0.025) to accept a one-point increase in the probability of displacement. It is assumed that they would be willing to pay an equivalent amount to avoid such an increase in the probability of displacement. The implied statistical cost of an involuntary layoff is thus $75,600 ($756 / 0.01).

As shown in Table 4-5, the annualized value of this estimate is multiplied by the total number of displaced workers estimated by the market model to calculate the annual worker displacement cost. The annual worker displacement cost under the MACT Floor options is roughly $2 million, while the annual cost under the BTF options is about $4 million.

4.3.3 Social Costs of the Regulations

The value of a regulatory policy is traditionally measured by the change in economic welfare that it generates. Welfare impacts resulting from the regulatory controls on the Portland cement industry will extend to the many consumers and producers of Portland cement. Consumers of Portland cement will experience welfare impacts due to the adjustments in price and output of Portland cement caused by the imposition of the regulations. Producer welfare impacts result from the changes in product revenues to all producers associated with the additional costs of production and the corresponding market adjustments. The theoretical approach used in applied welfare economics to evaluate policies is presented in Appendix D and indicates our approach to estimation of the changes in economic welfare.

The market adjustments in price and quantity were used to estimate the changes in aggregate economic welfare using applied welfare economics principles. Table 4-6 presents the estimates of the social costs and their distribution by regulatory alternative. For each regulatory alternative, consumers of Portland cement are worse off due to the increase in prices and reductions in consumption, while both domestic (in aggregate) and foreign producers are better off due to the increase in prices. It is important to note that individual domestic producers will gain or lose as a result of regulation depending on its change in cost versus the change in market price.

As shown in Table 4-6, the estimated annual social cost under the MACT Floor options varies from $34 million as applied to major sources only to $37 million as applied to major and area sources with consumers experiencing a welfare loss of as much as $52 million annually and domestic and foreign producers gaining as much as $15 million. Furthermore, the estimated annual social cost under the BTF options varies from $64 million as applied to major sources only to $103 million as applied to major and area sources with consumers experiencing a welfare loss of as much as $132 million annually and domestic and foreign producers gaining as much as $50 million.

The deadweight loss, or excess burden, to society is measured as the difference between the social cost estimate and the post-regulatory compliance costs. Due to the

TABLE 4-6. SUMMARY OF NATIONAL-LEVEL SOCIAL COSTS BY REGULATORY ALTERNATIVE[a]

Regulatory alternative	Change in consumer surplus ($10^6)	Change in producer surplus ($10^6)			Social cost ($10^6)
		Domestic	Foreign	Total	
Major and area sources					
MACT floor	-$52.3	$10.0	$5.0	$15.0	$37.3
	[-$51.1, -$53.5]	[$9.2, $10.8]	[$4.8, $5.2]	[$14.1, $15.8]	[$36.6, $38.1]
BTF option 1	-$128.7	$12.3	$12.8	$25.1	$103.6
	[-$119.4, -$138.0]	[$9.7, $14.9]	[$11.5, $14.1]	[$22.5, $27.7]	[$95.3, $111.9]
BTF option 2	-$117.2	$32.8	$10.7	$43.5	$73.6
	[-$112.1, -$122.2]	[$29.3, $36.4]	[$10.0, $11.4]	[$39.8, $47.2]	[$70.8, $76.5]
Major sources only					
MACT floor	-$46.9	$8.6	$4.5	$13.0	$33.9
	[-$45.8, -$48.1]	[$7.7, $9.4]	[$4.3, $4.7]	[$12.1, $13.9]	[$33.1, $34.7]
BTF option 1	-$132.0	$38.1	$12.8	$50.9	$81.1
	[-$126.0, -$137.9]	[$34.1, $42.1]	[$12.0, $13.6]	[$46.7, $55.1]	[$77.8, $84.4]
BTF option 2	-$105.9	$31.9	$9.9	$41.8	$64.2
	[-$101.0, -$110.9]	[$28.4, $35.3]	[$9.2, $10.6]	[$38.1, $45.4]	[$61.5, $66.8]
Major sources and D/F controls on area sources					
MACT floor	-$48.4	$9.3	$4.5	$13.9	$34.5
	[-$47.3, -$49.5]	[$8.5, $10.1]	[$4.4, $4.7]	[$13.0, $14.7]	[$33.8, $35.3]
BTF option 1	-$114.5	$10.4	$11.0	$21.4	$93.1
	[-$105.4, -$123.6]	[$7.9, $12.9]	[$9.8, $12.3]	[$19.0, $23.8]	[$84.9, $101.3]
BTF option 2	-$112.8	$34.5	$10.9	$45.3	$67.5
	[-$107.7, -$118.0]	[$30.9, $38.0]	[$10.1, $11.6]	[$41.5, $49.1]	[$64.8, $70.2]

Note: The 95 percent confidence interval for each national estimate is provided in brackets.

[a] Changes from baseline at the national-level reflect the sum of the mean observations across each of the 20 regions.

oligopolistic nature of Portland cement markets, the excess burden associated with regulation is as much as 19 percent of total social cost for the MACT Floor options and 27 percent for the BTF options. These estimates are much higher than those observed for regulations imposed on perfectly competitive markets because the regulatory market distortion exacerbates the pre-existing market distortion of imperfect competition (i.e., market price for Portland cement is not equal to the marginal cost of production). The imposition of the regulatory cost tends to widen the gap between price and marginal cost in these markets and, thus, contributes more to the deadweight loss than under the case of perfectly competitive markets.

4.3.4 Small Business Impacts

This small business assessment focuses on the regulatory impacts on the 9 cement plants and 22 cement kilns operating during 1993 that are owned by the 9 small companies identified in Section 2.4.2. Small companies are defined according to the SBA size standard for SIC 3241--hydraulic cement as those companies that own Portland cement plants and have less than 750 total employees. Given the small number of cement plants and kilns owned by small businesses relative to the industry as a whole (8.5 percent of all plants and 10.9 percent of all kilns), it is important to point out that the random determination of applicability of the regulatory controls and associated costs will introduce some uncertainties regarding the impacts projected for particular plants or kilns more so than the aggregate estimates. The measures of economic impact presented for this small business analysis include the changes in revenue, costs, and pre-tax earnings; the post-regulatory compliance costs; cement plant and kiln closures; the change in employment attributable to the change in output at these plants; and the engineering control cost share of baseline revenues.

Table 4-7 provides a summary of the small business impacts by regulatory alternative. As shown, the post-regulatory control cost of the MACT Floor options varied from $3.1 million to $3.3 million annually, or between 10.5 and 11.2 percent of total regulatory cost imposed on the industry by these options. These percentages are very close to the share of all cement kilns owned by small businesses, 10.9 percent. Alternatively, the post-regulatory control cost of the BTF options varied from $4.9 million to $8.9 million annually, or between 10.1 and 11.6 percent of total regulatory costs imposed by these options on the industry. The effect of these costs on profitability is demonstrated through the impacts on pre-tax earnings. The observed variation of the change in pre-tax earnings across regulatory options shows that these results are sensitive to the particular markets that these plants and kilns are located in and the imposition of regulatory costs across all producers within the market. For the MACT Floor options, the change in pre-tax earnings is projected to be very slight with an overall increase of only 0.2 percent when imposed on major and area sources and an overall decrease of 0.7 percent when imposed on major sources only. For the BTF options, the observed changes are greater and range from an increase of 0.5 percent when applied to major sources only and a decrease of 4.2 percent when applied to major and area sources.

Table 4-7 also provides the projected plant and kiln closures and change in employment associated with each regulatory alternative. For the MACT Floor options, no cement plants or kilns owned by small businesses are projected to close but will reduce employment by just over 3.5 percent, or roughly 45 employees. In percentage terms, the job losses at these plants are greater than the overall change in industry employment of 2 percent under the MACT Floor options. For the BTF options, at least one kiln owned by a small business is projected to close, while employment is anticipated to fall

TABLE 4-7. SUMMARY OF SMALL BUSINESS IMPACTS BY REGULATORY ALTERNATIVE

	Post-Regulatory Control Costs		Change in Pre-Tax Earnings		Closures		Change in Employment		
Regulatory alternative	(10^3)/yr	Share of Industry Total	(10^3)/yr	Percent	Plants	Kilns	Number	Percent	Control Cost Share of Revenue[a]
Major and area sources									
MACT Floor	$3,307	10.5%	$135	0.2%	0	0	-45	-3.7%	0.92%
BTF Option 1	$8,905	10.9%	($2,460)	-4.2%	0	1	-84	-7.0%	2.62%
BTF Option 2	$6,424	11.6%	$437	0.7%	0	1	-77	-6.4%	2.08%
Major sources only									
MACT Floor	$3,198	11.2%	($419)	-0.7%	0	0	-45	-3.7%	0.89%
BTF Option 1	$6,769	11.4%	$304	0.5%	0	2	-101	-8.5%	2.31%
BTF Option 2	$4,921	10.2%	$1,197	2.0%	0	1	-82	-6.9%	1.69%
Major sources and D/F and Hg controls on area sources									
MACT Floor	$3,071	10.7%	($120)	-0.2%	0	0	-43	-3.6%	0.85%
BTF Option 1	$7,681	10.4%	($2,244)	-3.8%	0	1	-76	-6.4%	2.26%
BTF Option 2	$5,031	10.1%	$2,305	3.9%	0	1	-67	-5.6%	1.70%

Note: These impact estimates reflect changes observed for the 9 cement plants and 22 kilns owned by small companies within this industry.

[a] Defined as engineering control costs (not reflecting facility production changes due to market adjustments) divided by baseline revenues for cement plants owned by small companies.

from 5.5 to 8.5 percent, or between 67 and 101 employees. As with the MACT Floor, the projected job losses at these plants under the BTF options are greater than the overall change in industry employment of 4 percent.

An additional measure of small business impacts is the share of control cost to baseline revenues at cement plants owned by small businesses. For this calculation, control costs are defined as the engineering control costs imposed on these plants and, thus, do not reflect the individual plant or kiln production changes associated with imposition of these costs and the resulting market adjustments. For the MACT Floor options, the control cost share of revenue is less than 1 percent for each potentially affected population of cement plants and kilns. Alternatively, for the BTF options, the control cost share is over 2 percent under option 1 (affecting 30 percent of non-hazardous waste burning kilns) across all potentially affected populations and under option 2 (affecting 20 percent of non-hazardous waste burning kilns) when applied to major and area sources.

REFERENCES

1. Soloman, Cheryl. Cement: Annual Report 1991. Washington, DC, U.S. Department of the Interior, Bureau of Mines. 1993.

2. Helmuth, R.A., F.M. Miller, T.R. O'Conner, and N.R. Greening. Kirk-Othmer Encyclopedia of Chemical Technology. Vol. 5. Third Ed. New York, John Wiley & Sons, Inc. 1979. pp. 163-193.

3. Johnson, W. Cement: Annual Report 1990. Washington, DC, U.S. Department of the Interior, Bureau of Mines. 1992.

4. Ref. 1.

5. Ref. 3.

6. U.S. Department of Interior, Bureau of Mines. Mineral Commodity Summaries 1987. Washington, DC, U.S. Government Printing Office. 1987.

7. Solomon, Cheryl. Cement: Annual Report 1993. Washington, DC, U.S. Department of the Interior, Bureau of Mines. 1995.

8. Ref. 1.

9. Ref. 3.

10. Ref. 6.

11. Ref. 1, p. 6-8.

12. U.S. Department of Commerce. U.S. Industrial Outlook 1992. Washington, DC. January 1992. p. 7-6.

13. Ref. 1, p. 3.

14. Ref. 1.

15. Ref. 3.

16. Ref. 6.

17. Ref. 1.

18. Iwand, Thomas, and David I. Rosenbaum. Pricing Strategies in Supergames with Capacity Constraints: Some Evidence from the U.S. Portland Cement Industry. International Journal of Industrial Organization 9(4):497-511. 1991.

19. Rosenbaum, David I., and Steven L. Reading. Market Structure and Import Share: A Regional Market Analysis. Southern Economic Journal. 54(3):694-700. 1988.

20. U.S. Department of Commerce, Bureau of the Census. 1977 Census of Transportation. Washington, DC, U.S. Government Printing Office. 1979.

21. Engineering News Record. ENR Materials Prices. January 1983 through December 1993.

22. Portland Cement Association. U.S. and Canadian Portland Cement Industry: Plant Information Summary. Skokie, IL, Portland Cement Association. 1994.

23. Ref. 22.

24. Ref. 22.

25. U.S. Environmental Protection Agency. Information Collection Request. Database. 1993.

26. Ref. 22.

27. Ref. 25.

28. Ref. 22.

29. Ref. 27.

30. Ref. 22.

31. Ref. 22.

32. Ref. 22.

33. Huhta, R.S. Operating Costs of U.S. Cement Plants. Rock Products. November. 1992. pp. 29-31.

34. Ref. 33.

35. Ref. 22.

36. Ref. 12, p. 7-6.

37. Ref. 12, p. 7-6.

38. Ward's Business Directory of U.S. Private and Public Companies. Washington, DC, Gale Research, Inc. 1994.

39. Memorandum from Jim Crowder, EPA, to Ron Evans, EPA. January 29, 1996. "Additional Engineering Inputs for Economic Impacts Analysis for the Portland Cement Industry NESHAP."

40. Ref. 39.

41. Ref. 39.

42. Ref. 39.

43. Ref. 39.

44. Ref. 39.

45. Ref. 39.

46. Ref. 22.

47. Ref. 7.

48. U.S. Department of Energy. State Energy Price and Expenditure Report 1990. Energy Information Administration, Washington, DC. September 1992.

49. Das, Sanghamitra 1992. "A Micro-Econometric Model of Capital Utilization and Retirement: The Case of the U.S. Cement Industry." Review of Economic Studies 59(2):277-297.

50. Das, Sanghamitra 1991. "A semiparametric structural analysis of the idling of cement kilns." Journal of Econometrics 50():235-256.

51. McBride, Mark E. 1981. "The Nature and Sources of Economics of Scale in Cement Production" Southern Economic Journal 48(1):105-115.

52. Ref. 49.

53. Telecon. U.S. Department of Labor, Bureau of Labor Statistics, Office of Employment and Unemployment Statistics with Randall, C., Research Triangle Institute. August, 1995. Average Hourly Earnings for Production Workers for SIC 32 by State: Annual Averages 1990-1994.

54. Ref. 48.

55. Ref. 18.

56. Ref. 19.

57. Ref. 7.

58. Ref. 25.

59. Ref. 7.

60. Ref. 18.

61. Cournot, Augustin. Researches into the Mathematical Principles of the Theory of Wealth. 1838.

62. U.S. International Trade Commission. Grey Portland Cement and Cement Clinker from Mexico, Publication 2305. USITC, Washington, DC. August 1990.

63. Adams, James D. Permanent Differences in Unemployment and Permanent Wage Differentials. Quarterly Journal of Econometrics. 100(1):29-56. 1985.

64. Topel, Robert H. Equilibrium Earnings, Turnover, and Unemployment: New Evidence. Journal of Labor Economics. 2(4):500-522. 1984.

65. Anderson, D.W., and Ram V. Chandran. Market Estimates of Worker Dislocation Costs. Economic Letters. 24:381-384. 1987.

66. Telecon. U.S. Department of Labor, Bureau of Labor Statistics, Department of Monthly Industry Employment Statistics with Randall, C., Research Triangle Institute. May, 1995. Average hourly earnings, weekly hours, weekly earnings for SIC 324--Hydraulic Cement in 1993 from Current Employment Statistics, Payroll Survey.

Appendix A

Data Summary for U.S. Portland Cement Kilns

TABLE A-1. DATA SUMMARY FOR U.S. PORTLAND CEMENT KILNS

									Major input prices		
Fac. ID	Kiln ID	Facility name	City	State	Kiln process	Capacity (10^3 tpy)	Kiln age as of '93	Primary fuel	Primary fuel ($/MMBtu)	Labor ($/Hr)	Electricity ($/MMBtu)
1	1	Ash Grove Cement Co.	Foreman	AR	Wet	403	29	Coal	$1.96	$10.39	$16.31
1	2	Ash Grove Cement Co.	Foreman	AR	Wet	271	31	Coal	$1.96	$10.39	$16.31
1	3	Ash Grove Cement Co.	Foreman	AR	Wet	271	35	Coal	$1.96	$10.39	$16.31
2	1	Ash Grove Cement Co.	Chanute	KS	Wet	248	29	Coal	$1.16	$11.60	$15.84
2	2	Ash Grove Cement Co.	Chanute	KS	Wet	248	29	Coal	$1.16	$11.60	$15.84
3	1	Ash Grove Cement Co.	Nephi	UT	Dry-C	600	12	Coal	$1.63	$11.43	$12.16
4	1	Ash Grove Cement Co.	Inkom	ID	Wet	125	43	Coal	$1.74	$11.43	$8.40
4	2	Ash Grove Cement Co.	Inkom	ID	Wet	95	64	Coal	$1.74	$11.43	$8.40
5	1	Dacotah Cement	Rapid City	SD	Dry-X	450	15	Coal	$1.76	$11.60	$14.88
5	2	Dacotah Cement	Rapid City	SD	Wet	151	36	Coal	$1.76	$11.60	$14.88
5	3	Dacotah Cement	Rapid City	SD	Wet	151	38	Coal	$1.76	$11.60	$14.88
6	1	Ash Grove Cement Co.	Louisville	NE	Dry-C	549	11	Coal	$1.46	$9.95	$13.45
6	2	Ash Grove Cement Co.	Louisville	NE	Dry-X	427	17	Coal	$1.46	$9.95	$13.45
7	1	Lafarge Corporation	Fredonia	KS	Wet	228	37	Waste	NA	$11.60	$15.84
7	2	Lafarge Corporation	Fredonia	KS	Wet	146	72	Waste	NA	$11.60	$15.84
8	1	Medusa Cement Company	Demopolis	AL	Dry-X	810	16	Coal	$1.73	$10.44	$13.90
9	1	Ash Grove Cement Co.	Durkee	OR	Dry-X	494	14	Gas	$3.47	$13.67	$10.13
10	1	Blue Circle Inc.	Calera	AL	Dry	318	36	Coal	$1.73	$10.44	$13.90
10	2	Blue Circle Inc.	Calera	AL	Dry	318	37	Coal	$1.73	$10.44	$13.90
11	1	Ash Grove Cement Co.	Montana City	MT	Wet	304	30	Gas	$3.36	$11.43	$9.17
12	1	Holnam Inc.	La Porta	CO	Dry-C	480	4	Coal	$1.27	$11.43	$14.39
14	1	National Cement Company	Ragland	AL	Dry-C	894	18	Coal	$1.73	$10.44	$13.90

(continued)

TABLE A-1. DATA SUMMARY FOR U.S. PORTLAND CEMENT KILNS (CONTINUED)

									Major input prices		
Fac. ID	Kiln ID	Facility name	City	State	Kiln process	Capacity (10^3 tpy)	Kiln age as of '93	Primary fuel	Primary fuel ($/MMBtu)	Labor ($/Hr)	Electricity ($/MMBtu)
15	1	Monarch Cement Company	Humbolt	KS	Dry-X	279	18	Coal	$1.16	$11.60	$15.84
15	2	Monarch Cement Company	Humbolt	KS	Dry-X	279	20	Coal	$1.16	$11.60	$15.84
15	3	Monarch Cement Company	Humbolt	KS	Dry	116	36	Coal	$1.16	$11.60	$15.84
16	1	Natl. Cement Co. of California	Lebec	CA	Dry	650	27	Coke	$1.76	$13.67	$23.33
17	1	Independent Cement Corporation	Hagerstown	MD	Dry	521	22	Coal	$1.48	$12.07	$16.32
18	1	Ash Grove Cement Co.	Seattle	WA	Dry-C	682	1	Gas	$2.78	$13.67	$7.65
199	1	Centex	Laramie	WY	Dry-X	428	5	Coal	$1.10	$11.43	$11.10
201	1	Blue Circle Inc.	Harleyville	SC	Dry-X	687	19	Coal	$1.72	$11.13	$13.37
202	1	Blue Circle Inc.	Atlanta	GA	Dry	301	25	Coal	$1.75	$10.93	$15.47
202	2	Blue Circle Inc.	Atlanta	GA	Dry	301	30	Coal	$1.75	$10.93	$15.47
203	1	Blue Circle Inc.	Ravena	NY	Wet	854	31	Coal	$1.72	$13.19	$18.51
203	2	Blue Circle Inc.	Ravena	NY	Wet	854	31	Coal	$1.72	$13.19	$18.51
204	1	Blue Circle Inc.	Tulsa	OK	Dry	300	30	Coal	$1.31	$11.92	$11.63
204	2	Blue Circle Inc.	Tulsa	OK	Dry	300	32	Coal	$1.31	$11.92	$11.63
205	1	Allentown Cement Company Inc.	Blandon	PA	Dry-X	465	28	Coal	$1.63	$12.37	$19.13
205	2	Allentown Cement Company Inc.	Blandon	PA	Dry	465	28	Coal	$1.63	$12.37	$19.13
206	1	Lafarge Corporation	Sugar Creek	MO	Dry	281	36	Coal	$1.29	$12.08	$15.84
206	2	Lafarge Corporation	Sugar Creek	MO	Dry	248	40	Coal	$1.29	$12.08	$15.84

(continued)

TABLE A-1. DATA SUMMARY FOR U.S. PORTLAND CEMENT KILNS (CONTINUED)

Fac. ID	Kiln ID	Facility name	City	State	Kiln process	Capacity (10^3 tpy)	Kiln age as of '93	Primary fuel	Major input prices: Primary fuel ($/MMBtu)	Major input prices: Labor ($/Hr)	Major input prices: Electricity ($/MMBtu)
207	1	Glens Falls Cement Co., Inc.	Glens Falls	NY	Dry-X	507	20	Coal	$1.72	$13.19	$18.51
209	1	Signal Mountain Cement Company	Chattanooga	TN	Wet	215	29	Coal	$1.39	$12.24	$15.01
209	2	Signal Mountain Cement Company	Chattanooga	TN	Wet	215	37	Coal	$1.39	$12.24	$15.01
210	1	Texas-Lehigh Cement Company	Buda	TX	Dry-C	1,086	15	Coal	$1.12	$9.84	$12.92
211	1	Phoenix Cement Company	Clarkdale	AZ	Dry	235	32	Coal	$1.94	$11.43	$17.88
211	2	Phoenix Cement Company	Clarkdale	AZ	Dry-X	235	34	Coal	$1.94	$11.43	$17.88
211	3	Phoenix Cement Company	Clarkdale	AZ	Dry-X	235	34	Coal	$1.94	$11.43	$17.88
212	1	Armstrong Cement & Sup. Corp.	Cabot	PA	Wet	163	67	Coal	$1.63	$12.37	$19.13
212	2	Armstrong Cement & Sup. Corp.	Cabot	PA	Wet	163	67	Coal	$1.63	$12.37	$19.13
213	1	Florida Crushed Stone	Brooksville	FL	Dry-X	571	6	Coal	$1.86	$10.19	$16.28
214	1	Lafarge Corporation	New Braunfels	TX	Dry-C	880	13	Coal	$1.12	$9.84	$12.92
301	1	Keystone Cement Group	Bath	PA	Wet	473	26	Coal	$1.63	$12.37	$19.13
301	2	Keystone Cement Group	Bath	PA	Wet	129	37	Coal	$1.63	$12.37	$19.13
302	1	Giant Cement Company	Harleyville	SC	Wet	270	20	Waste	NA	$11.13	$13.37
302	2	Giant Cement Company	Harleyville	SC	Wet	200	31	Waste	NA	$11.13	$13.37
302	3	Giant Cement Company	Harleyville	SC	Wet	200	37	Waste	NA	$11.13	$13.37
302	4	Giant Cement Company	Harleyville	SC	Wet	200	42	Waste	NA	$11.13	$13.37

(continued)

TABLE A-1. DATA SUMMARY FOR U.S. PORTLAND CEMENT KILNS (CONTINUED)

Fac. ID	Kiln ID	Facility name	City	State	Kiln process	Capacity (10^3 tpy)	Kiln age as of '93	Primary fuel	Major input prices: Primary fuel ($/MMBtu)	Labor ($/Hr)	Electricity ($/MMBtu)
303	1	Rinker Materials	Miami	FL	Wet	276	35	Coal	$1.86	$10.19	$16.28
303	2	Rinker Materials	Miami	FL	Wet	276	35	Coal	$1.86	$10.19	$16.28
304	1	Riverside Cement Co.	Oro Grande	CA	Dry	165	34	Coal	$1.97	$13.67	$23.33
304	2	Riverside Cement Co.	Oro Grande	CA	Dry	165	34	Coal	$1.97	$13.67	$23.33
304	3	Riverside Cement Co.	Oro Grande	CA	Dry	170	41	Coal	$1.97	$13.67	$23.33
304	4	Riverside Cement Co,	Oro Grande	CA	Dry	170	41	Coal	$1.97	$13.67	$23.33
304	5	Riverside Cement Co.	Oro Grande	CA	Dry	170	45	Coal	$1.97	$13.67	$23.33
304	6	Riverside Cement Co.	Oro Grande	CA	Dry	170	45	Coal	$1.97	$13.67	$23.33
304	7	Riverside Cement Co.	Oro Grande	CA	Dry	170	45	Coal	$1.97	$13.67	$23.33
306	1	River Cement	Festus	MO	Dry	576	24	Coke	$1.76	$12.08	$15.84
306	2	River Cement	Festus	MO	Dry	576	28	Coke	$1.76	$12.08	$15.84
308	1	Holnam Inc.	Artesia	MS	Wet	500	19	Coal	$1.72	$9.05	$14.89
309	1	Heartland Cement	Independence	KS	Dry	83	7	Coke	$1.76	$11.60	$15.84
309	2	Heartland Cement	Independence	KS	Dry	83	7	Coke	$1.76	$11.60	$15.84
309	3	Heartland Cement	Independence	KS	Dry	83	7	Coke	$1.76	$11.60	$15.84
309	4	Heartland Cement	Independence	KS	Dry	83	7	Coke	$1.76	$11.60	$15.84
310	1	Independent Cement Corporation	Catskill	NY	Wet	595	28	Coal	$1.72	$13.19	$18.51
311	1	Lafarge Corporation	Grand Chain	IL	Dry-X	651	18	Coal	$1.56	$12.33	$17.30
311	2	Lafarge Corporation	Grand Chain	IL	Dry	546	30	Coal	$1.56	$12.33	$17.30
312	1	RMC Lone Star	Davenport	CA	Dry-C	800	12	Coal	$1.97	$13.67	$23.33
313	1	Dragon Products Company	Thomaston	ME	Wet	432	22	Coal	$2.57	$12.13	$19.08

(continued)

TABLE A-1. DATA SUMMARY FOR U.S. PORTLAND CEMENT KILNS (CONTINUED)

Fac. ID	Kiln ID	Facility name	City	State	Kiln process	Capacity (10^3 tpy)	Kiln age as of '93	Primary fuel	Major input prices: Primary fuel ($/MMBtu)	Labor ($/Hr)	Electricity ($/MMBtu)
314	1	Holnam Inc.	Clarksville	MO	Wet	1,300	26	Coal	$1.29	$12.08	$15.84
315	1	Holnam Inc.	Morgan	UT	Wet	159	45	Coal	$1.63	$11.43	$12.16
315	2	Holnam Inc.	Morgan	UT	Wet	159	45	Coal	$1.63	$11.43	$12.16
316	1	Holnam Inc.	Dundee	MI	Wet	515	34	Coal	$1.75	$13.74	$18.73
316	2	Holnam Inc.	Dundee	MI	Wet	515	34	Coal	$1.75	$13.74	$18.73
318	1	Holnam Inc.	Florence	CO	Wet	485	19	Coal	$1.27	$11.43	$14.39
318	2	Holnam Inc.	Florence	CO	Wet	160	47	Coal	$1.27	$11.43	$14.39
318	3	Holnam Inc.	Florence	CO	Wet	160	47	Coal	$1.27	$11.43	$14.39
319	1	Holnam Inc.	Seattle	WA	Wet	460	26	Coal	$2.41	$13.67	$7.65
320	1	Holnam Inc.	Theodore	AL	Dry-C	1,500	12	Coal	$1.73	$10.44	$13.90
321	1	Holnam Inc.	Three Forks	MT	Wet	298	20	Coal	$1.70	$11.43	$9.17
322	1	Holnam Inc.	Tijeras	NM	Dry-X	237	33	Coal	$1.28	$11.43	$15.96
322	2	Holnam Inc.	Tijreras	NM	Dry-X	237	34	Coal	$1.28	$11.43	$15.96
401	1	Kaiser Cement Plant	Permanente	CA	Dry-C	1,550	13	Coal	$1.97	$13.67	$23.33
402	1	Hercules Cement	Stockertown	PA	Dry-C	576	0	Coal	$1.63	$12.37	$19.13
402	2	Hercules Cement	Stockertown	PA	Dry-X	350	38	Coal	$1.63	$12.37	$19.13
403	1	Dixon-Marquette	Dixon	IL	Dry	146	33	Coal	$1.56	$12.33	$17.30
403	2	Dixon-Marquette	Dixon	IL	Dry-X	126	37	Coal	$1.56	$12.33	$17.30
403	3	Dixon-Marquette	Dixon	IL	Dry-X	126	37	Coal	$1.56	$12.33	$17.30
403	4	Dixon-Marquette	Dixon	IL	Dry-X	126	37	Coal	$1.56	$12.33	$17.30
405	1	Mitsubishi Cement Corp	Lucerne Valley	CA	Dry-C	1,706	11	Coal	$1.97	$13.67	$23.33

(continued)

TABLE A-1. DATA SUMMARY FOR U.S. PORTLAND CEMENT KILNS (CONTINUED)

									Major input prices		
Fac. ID	Kiln ID	Facility name	City	State	Kiln process	Capacity (10^3 tpy)	Kiln age as of '93	Primary fuel	Primary fuel ($/MMBtu)	Labor ($/Hr)	Electricity ($/MMBtu)
406	1	Lafarge Corporation	Alpena	MI	Dry	527	17	Coal	$1.75	$13.74	$18.73
406	2	Lafarge Corporation	Alpena	MI	Dry	525	17	Coal	$1.75	$13.74	$18.73
406	3	Lafarge Corporation	Alpena	MI	Dry	329	28	Coal	$1.75	$13.74	$18.73
406	4	Lafarge Corporation	Alpena	MI	Dry	331	28	Coal	$1.75	$13.74	$18.73
406	5	Lafarge Corporation	Alpena	MI	Dry	317	28	Coal	$1.75	$13.74	$18.73
407	1	Centex	Fernley	NV	Dry-X	214	24	Coal	$1.49	$11.43	$15.04
407	2	Centex	Fernley	NV	Dry	214	29	Coal	$1.49	$11.43	$15.04
408	1	Lafarge Corporation	Buffalo	IA	Dry-C	894	12	Coal	$1.32	$11.25	$12.73
409	1	Lafarge Corporation	Paulding	OH	Wet	241	36	Coal	$1.61	$12.56	$12.90
409	2	Lafarge Corporation	Paulding	OH	Wet	241	37	Coal	$1.61	$12.56	$12.90
410	1	Lafarge Corporation	Whitehall	PA	Dry-X	271	18	Coal	$1.63	$12.37	$19.13
410	2	Lafarge Corporation	Whitehall	PA	Dry-X	406	28	Coal	$1.63	$12.37	$19.13
410	3	Lafarge Corporation	Whitehall	PA	Dry-X	196	37	Coal	$1.63	$12.37	$19.13
411	1	Capitol Aggregates, Inc.	San Antonio	TX	Dry-C	503	10	Coal	$1.12	$9.84	$12.92
411	2	Capitol Aggregates, Inc.	San Antonio	TX	Wet	352	28	Coal	$1.12	$9.84	$12.92
413	1	Holnam Inc.	Midlothian	TX	Dry-C	1,066	6	Coal	$1.12	$9.84	$12.92
414	1	Centex	La Salle	IL	Dry-X	476	19	Coal	$1.56	$12.33	$17.30
415	1	Texas Industries	Midlothian	TX	Wet	316	21	Coal	$1.12	$9.84	$12.92
415	2	Texas Industries	Midlothian	TX	Wet	316	26	Coal	$1.12	$9.84	$12.92
415	3	Texas Industries	Midlothian	TX	Wet	316	30	Coal	$1.12	$9.84	$12.92
415	4	Texas Industries	Midlothian	TX	Wet	316	33	Coal	$1.12	$9.84	$12.92
416	1	Texas Industries	New Braunfels	TX	Dry-C	759	13	Coal	$1.12	$9.84	$12.92

(continued)

TABLE A-1. DATA SUMMARY FOR U.S. PORTLAND CEMENT KILNS (CONTINUED)

Fac. ID	Kiln ID	Facility name	City	State	Kiln process	Capacity (10^3 tpy)	Kiln age as of '93	Primary fuel	Major input prices: Primary fuel ($/MMBtu)	Major input prices: Labor ($/Hr)	Major input prices: Electricity ($/MMBtu)
501	1	Calaveras Cement Co.	Tehachapi	CA	Dry-C	731	2	Coal	$1.97	$13.67	$23.33
502	1	Capitol Cement Corp.	Martinsburg	WV	Wet	458	28	Coal	$1.48	$11.54	$11.41
502	2	Capitol Cement Corp.	Martinsburg	WV	Wet	249	33	Coal	$1.48	$11.54	$11.41
502	3	Capitol Cement Corp.	Martinsburg	WV	Wet	249	38	Coal	$1.48	$11.54	$11.41
503	1	Medusa Cement Company	Clinchfield	GA	Dry-X	584	19	Coal	$1.75	$10.93	$15.47
503	2	Medusa Cement Company	Clinchfield	GA	Wet	208	32	Coal	$1.75	$10.93	$15.47
504	1	Alamo Cement Co.	San Antonio	TX	Dry-C	769	12	Coal	$1.12	$9.84	$12.92
506	1	Essroc Materials	Nazareth	PA	Dry-X	1,176	15	Coal	$1.63	$12.37	$19.13
507	1	Medusa Cement Company	Charlevoix	MI	Dry-C	1,364	13	Coal	$1.75	$13.74	$18.73
508	1	North Texas Cement	Midlothian	TX	Wet	299	21	Coal	$1.12	$9.84	$12.92
508	2	North Texas Cement	Midlothian	TX	Wet	299	24	Coal	$1.12	$9.84	$12.92
508	3	North Texas Cement	Midlothian	TX	Wet	299	27	Coal	$1.12	$9.84	$12.92
509	1	Southdown Inc.	Knoxville	TN	Dry-C	600	14	Coal	$1.39	$12.24	$15.01
510	1	Kosmos Cement	Kosmosdale	KY	Dry-X	700	19	Coal	$1.62	$11.22	$11.46
511	1	Southdown Inc.	Fairborn	OH	Dry-X	600	19	Coal	$1.61	$12.56	$12.90
512	1	Southdown Inc.	Lyons	CO	Dry-C	419	13	Gas	$2.91	$11.43	$14.39
513	1	Southdown Inc.	Odessa	TX	Dry-X	281	15	Coal	$1.12	$9.84	$12.92
513	2	Southdown Inc.	Odessa	TX	Dry	248	34	Coal	$1.12	$9.84	$12.92
514	1	Kosmos Cement	Pittsburgh	PA	Wet	385	31	Coal	$1.63	$12.37	$19.13
515	1	Southdown Inc.	Victorville	CA	Dry-C	951	9	Coal	$1.97	$13.67	$23.33
515	2	Southdown Inc.	Victorville	CA	Dry	649	28	Coal	$1.97	$13.67	$23.33

(continued)

TABLE A-1. DATA SUMMARY FOR U.S. PORTLAND CEMENT KILNS (CONTINUED)

Fac. ID	Kiln ID	Facility name	City	State	Kiln process	Capacity (10^3 tpy)	Kiln age as of '93	Primary fuel	Major input prices: Primary fuel ($/MMBtu)	Major input prices: Labor ($/Hr)	Major input prices: Electricity ($/MMBtu)
517	1	Holnam Inc.	Holly Hill	SC	Wet	705	20	Coal	$1.72	$11.13	$13.37
517	2	Holnam Inc.	Holly Hill	SC	Wet	361	27	Coal	$1.72	$11.13	$13.37
518	1	Holnam Inc.	Mason City	IA	Dry	316	17	Coal	$1.32	$11.25	$12.73
518	2	Holnam Inc.	Mason City	IA	Dry	538	29	Coal	$1.32	$11.25	$12.73
519	1	Holnam Inc.	Ada	OK	Wet	300	35	Coal	$1.31	$11.92	$11.63
519	2	Holnam Inc.	Ada	OK	Wet	300	35	Coal	$1.31	$11.92	$11.63
520	1	Southdown Inc.	Brooksville	FL	Dry-X	608	11	Coal	$1.86	$10.19	$16.28
520	2	Southdown Inc.	Brooksville	FL	Dry-X	608	17	Coal	$1.86	$10.19	$16.28
521	1	Essroc Materials	Speed	IN	Dry-X	680	15	Coal	$1.70	$12.54	$13.05
521	2	Essroc Materials	Speed	IN	Dry	352	21	Coal	$1.70	$12.54	$13.05
522	1	Roanoke Cement Company Inc.	Cloverdale	VA	Dry-X	489	17	Coal	$1.65	$10.18	$13.67
522	2	Roanoke Cement Company Inc.	Cloverdale	VA	Dry	126	37	Coal	$1.65	$10.18	$13.67
522	3	Roanoke Cement Company Inc.	Cloverdale	VA	Dry	126	40	Coal	$1.65	$10.18	$13.67
522	4	Roanoke Cement Company Inc.	Cloverdale	VA	Dry	126	42	Coal	$1.65	$10.18	$13.67
522	5	Roanoke Cement Company Inc.	Cloverdale	VA	Dry	126	42	Coal	$1.65	$10.18	$13.67
523	1	Essroc Materials	Bessemer	PA	Wet	326	29	Coal	$1.63	$12.37	$19.13
523	2	Essroc Materials	Bessemer	PA	Wet	223	32	Coal	$1.63	$12.37	$19.13

(continued)

TABLE A-1. DATA SUMMARY FOR U.S. PORTLAND CEMENT KILNS (CONTINUED)

Fac. ID	Kiln ID	Facility name	City	State	Kiln process	Capacity (10^3 tpy)	Kiln age as of '93	Primary fuel	Major input prices: Primary fuel ($/MMBtu)	Major input prices: Labor ($/Hr)	Major input prices: Electricity ($/MMBtu)
524	1	Medusa Cement Company	Wampum	PA	Dry	265	24	Coal	$1.63	$12.37	$19.13
524	2	Medusa Cement Company	Wampum	PA	Dry	219	34	Coal	$1.63	$12.37	$19.13
524	3	Medusa Cement Company	Wampum	PA	Dry	219	34	Coal	$1.63	$12.37	$19.13
601	1	Calaveras Cement Co.	Redding	CA	Dry-C	651	12	Coal	$1.97	$13.67	$23.33
602	1	California Portland Cement	Rillito	AZ	Dry-C	990	23	Coal	$1.94	$11.43	$17.88
602	2	California Portland Cement	Rillito	AZ	Dry	95	38	Coal	$1.94	$11.43	$17.88
602	3	California Portland Cement	Rillito	AZ	Dry	95	42	Coal	$1.94	$11.43	$17.88
602	4	California Portland Cement	Rillito	AZ	Dry	95	45	Coal	$1.94	$11.43	$17.88
603	1	California Portland Cement	Mojave	CA	Dry-C	1,200	12	Coal	$1.97	$13.67	$23.33
604	1	Pennsuco Cement Company	Medley	FL	Wet	637	18	Coal	$1.86	$10.19	$16.28
604	2	Pennsuco Cement Company	Medley	FL	Wet	185	24	Gas	$3.46	$10.19	$16.28
604	3	Pennsuco Cement Company	Medley	FL	Wet	185	24	Gas	$3.46	$10.19	$16.28
701	1	Continental Cement Co., Inc.	Hannibal	MO	Wet	599	27	Coal	$1.29	$12.08	$15.84
702	1	California Portland Cement	Colton	CA	Dry	375	30	Coke	$1.76	$13.67	$23.33
702	2	California Portland Cement	Colton	CA	Dry	375	30	Coke	$1.76	$13.67	$23.33
801	1	Lehigh Portland Cement	Leeds	AL	Dry-X	651	17	Coal	$1.73	$10.44	$13.90

(continued)

TABLE A-1. DATA SUMMARY FOR U.S. PORTLAND CEMENT KILNS (CONTINUED)

									Major input prices		
Fac. ID	Kiln ID	Facility name	City	State	Kiln process	Capacity (10^3 tpy)	Kiln age as of '93	Primary fuel	Primary fuel ($/MMBtu)	Labor ($/Hr)	Electricity ($/MMBtu)
802	1	Lehigh Portland Cement	Mitchell	IN	Dry-X	264	17	Coal	$1.70	$12.54	$13.05
802	2	Lehigh Portland Cement	Mitchell	IN	Dry	248	33	Coal	$1.70	$12.54	$13.05
802	3	Lehigh Portland Cement	Mitchell	IN	Dry	248	33	Coal	$1.70	$12.54	$13.05
803	1	Lehigh Portland Cement	Union Bridge	MD	Dry	248	23	Coal	$1.48	$12.07	$16.32
803	2	Lehigh Portland Cement	Union Bridge	MD	Dry	248	36	Coal	$1.48	$12.07	$16.32
803	3	Lehigh Portland Cement	Union Bridge	MD	Dry	248	36	Coal	$1.48	$12.07	$16.32
803	4	Lehigh Portland Cement	Union Bridge	MD	Dry	248	36	Coal	$1.48	$12.07	$16.32
804	1	Lehigh Portland Cement	Mason City	IA	Dry-C	760	15	Coal	$1.32	$11.25	$12.73
805	1	Lehigh Portland Cement	Cementon	NY	Wet	558	29	Coal	$1.72	$13.19	$18.51
901	1	Lone Star Industries	Olgesby	IL	Dry	569	37	Coal	$1.56	$12.33	$17.30
902	1	Lone Star Industries	Greencastle	IN	Wet	748	24	Coal	$1.70	$12.54	$13.05
903	1	Lone Star Industries	Cape Girardeau	MO	Dry-C	1,193	12	Coal	$1.29	$12.08	$15.84
904	1	Lone Star Industries	Pryor	OK	Dry	271	13	Coal	$1.31	$11.92	$11.63
904	2	Lone Star Industries	Pryor	OK	Dry	208	31	Coal	$1.31	$11.92	$11.63
904	3	Lone Star Industries	Pryor	OK	Dry	208	33	Coal	$1.31	$11.92	$11.63
905	1	Lone Star Industries	Nazareth	PA	Dry	191	36	Coal	$1.63	$12.37	$19.13
905	2	Lone Star Industries	Nazareth	PA	Dry	173	36	Coal	$1.63	$12.37	$19.13
905	3	Lone Star Industries	Nazareth	PA	Dry	133	44	Coal	$1.63	$12.37	$19.13
905	4	Lone Star Industries	Nazareth	PA	Dry	130	44	Coal	$1.63	$12.37	$19.13
906	1	Lone Star Industries	Sweetwater	TX	Dry-X	163	22	Coal	$1.12	$9.84	$12.92
906	2	Lone Star Industries	Sweetwater	TX	Dry-X	163	22	Coal	$1.12	$9.84	$12.92
906	3	Lone Star Industries	Sweetwater	TX	Dry-X	163	22	Coal	$1.12	$9.84	$12.92

(continued)

TABLE A-1. DATA SUMMARY FOR U.S. PORTLAND CEMENT KILNS (CONTINUED)

									Major input prices		
Fac. ID	Kiln ID	Facility name	City	State	Kiln process	Capacity (10^3 tpy)	Kiln age as of '93	Primary fuel	Primary fuel ($/MMBtu)	Labor ($/Hr)	Electricity ($/MMBtu)
998	1	Essroc Materials	Logansport	IN	Wet	227	27	Waste	NA	$12.54	$13.05
998	2	Essroc Materials	Logansport	IN	Wet	227	31	Waste	NA	$12.54	$13.05
999	1	Essroc Materials	Frederick	MD	Wet	186	37	Coal	$1.48	$12.07	$16.32
999	2	Essroc Materials	Frederick	MD	Wet	186	37	Coal	$1.48	$12.07	$16.32

Appendix B

Regional Market Data Summary

TABLE B-1. REGIONAL MARKET DATA SUMMARY: ATLANTA

Number of Plants	8			
Number of Companies	7			
Number of Kilns	19			Foreign Imports (10^3 tpy)
Domestic Capacity (10^3 tons)	6,040		Rest of the World	502.0
Domestic Production (10^3 tons)	5,689		Canadian	NA
Delivered Price ($/ton)	$55.00		Total	502.0
F.O.B. Price ($/ton)	$51.99			

Fac ID	Kiln ID	Facility Name	City	State	Model Kiln	FF=1/ ESP=0	Kiln Process	Kiln Capacity (10^3 tpy)	Kiln Production (10^3 tpy)	Cap. Util.	Primary Fuel	Kiln Age	Kiln AVC ($/ton)
201	1	Blue Circle Inc.	Harleyville	SC	N	1	Dry-X	687	650.0	0.95	Coal	19	$43.58
202	1	Blue Circle Inc.	Atlanta	GA	I	1	Dry	301	301.0	1.00	Coal	25	$48.11
202	2	Blue Circle Inc.	Atlanta	GA	I	1	Dry	301	265.0	0.88	Coal	30	$48.47
302	1	Giant Cement Company	Harleyville	SC	B	1	Wet	270	270.0	1.00	Waste	20	$44.46
302	2	Giant Cement Company	Harleyville	SC	B	1	Wet	200	200.0	1.00	Waste	31	$44.26
302	3	Giant Cement Company	Harleyville	SC	B	1	Wet	200	200.0	1.00	Waste	37	$44.77
302	4	Giant Cement Company	Harleyville	SC	B	1	Wet	200	150.0	0.75	Waste	42	$45.21
517	1	Holnam Inc.	Holly Hill	SC	E	0	Wet	705	705.0	1.00	Coal	20	$44.35
517	2	Holnam Inc.	Holly Hill	SC	C	0	Wet	361	210.0	0.58	Coal	27	$46.30
503	1	Medusa Cement Company	Clinchfield	GA	N	1	Dry-X	584	584.0	1.00	Coal	19	$44.72
503	2	Medusa Cement Company	Clinchfield	GA	A	0	Wet	208	208.0	1.00	Coal	32	$49.47
522	1	Roanoke Cement Company Inc.	Cloverdale	VA	L	0	Dry-X	489	489.0	1.00	Coal	17	$42.98
522	2	Roanoke Cement Company Inc.	Cloverdale	VA	H	0	Dry	126	126.0	1.00	Coal	37	$47.11
522	3	Roanoke Cement Company Inc.	Cloverdale	VA	H	0	Dry	126	126.0	1.00	Coal	40	$47.33
522	4	Roanoke Cement Company Inc.	Cloverdale	VA	H	0	Dry	126	126.0	1.00	Coal	42	$47.48
522	5	Roanoke Cement Company Inc.	Cloverdale	VA	H	0	Dry	126	49.0	0.39	Coal	42	$47.48
209	1	Signal Mountain Cement Co.	Chattanooga	TN	B	0	Wet	215	215.0	1.00	Coal	29	$47.84
209	2	Signal Mountain Cement Co.	Chattanooga	TN	B	0	Wet	215	215.0	1.00	Coal	37	$48.38
509	1	Southdown Inc.	Knoxville	TN	Q	1	Dry-C	600	600.0	0.95	Coal	14	$41.42
		Total						6,040	5,689	1.00			

TABLE B-2. REGIONAL MARKET DATA SUMMARY: BALTIMORE/PHILADELPHIA

Number of Plants	10
Number of Companies	9
Number of Kilns	24
Domestic Capacity (10^3 tons)	7,975
Domestic Production (10^3 tons)	7,177
Delivered Price ($/ton)	$62.46
F.O.B. Price ($/ton)	$51.51

	Foreign Imports (10^3 tpy)
Rest of the World	--
Canadian	--
Total	--

Fac ID	Kiln ID	Facility Name	City	State	Model Kiln	FF=1/ ESP=0	Kiln Process	Kiln Capacity (10^3 tpy)	Kiln Production (10^3 tpy)	Cap. Util.	Primary Fuel	Kiln Age	Kiln AVC ($/ton)
205	1	Allentown Cement Company Inc.	Blandon	PA	J	1	Dry-X	465	465.0	1.00	Coal	28	$46.94
205	2	Allentown Cement Company Inc.	Blandon	PA	I	1	Dry	465	307.0	0.66	Coal	28	$50.15
502	1	Capitol Cement Corporation	Martinsburg	WV	C	0	Wet	458	458.0	1.00	Coal	28	$45.91
502	2	Capitol Cement Corporation	Martinsburg	WV	B	0	Wet	249	249.0	1.00	Coal	33	$46.26
502	3	Capitol Cement Corporation	Martinsburg	WV	B	0	Wet	249	192.0	0.77	Coal	38	$46.63
506	1	Essroc Materials	Nazareth	PA	P	0	Dry-X	1,176	909.0	0.77	Coal	15	$46.23
999	1	Essroc Materials	Frederick	MD	A	0	Wet	186	186.0	1.00	Coal	37	$49.16
999	2	Essroc Materials	Frederick	MD	A	0	Wet	186	144.0	0.77	Coal	37	$49.16
402	1	Hercules Cement	Stockertown	PA	H	1	Dry-C	576	576.0	1.00	Coal	0	$44.50
402	2	Hercules Cement	Stockertown	PA	M	1	Dry-X	350	294.0	0.84	Coal	38	$47.54
17	1	Independent Cement Corporation	Hagerstown	MD	J	0	Dry	521	433.0	0.83	Coal	22	$44.03
301	1	Keystone Cement Group	Bath	PA	D	0	Wet	473	457.0	0.97	Coal	26	$48.70
301	2	Keystone Cement Group	Bath	PA	A	0	Wet	129	129.0	1.00	Coal	37	$44.38
410	1	Lafarge Corporation	Whitehall	PA	I	1	Dry-X	271	271.0	1.00	Coal	18	$46.39
410	2	Lafarge Corporation	Whitehall	PA	I	1	Dry-X	406	406.0	1.00	Coal	28	$46.94
410	3	Lafarge Corporation	Whitehall	PA	H	1	Dry-X	196	150.0	0.77	Coal	37	$47.48
803	1	Lehigh Portland Cement	Union Bridge	MD	I	0	Dry	248	248.0	1.00	Coal	23	$47.53
803	2	Lehigh Portland Cement	Union Bridge	MD	I	0	Dry	248	248.0	1.00	Coal	36	$48.35
803	3	Lehigh Portland Cement	Union Bridge	MD	I	0	Dry	248	248.0	1.00	Coal	36	$48.35
803	4	Lehigh Portland Cement	Union Bridge	MD	I	0	Dry	248	180.0	0.73	Coal	36	$48.35
905	1	Lone Star Industries	Nazareth	PA	H	1	Dry	191	191.0	1.00	Coal	36	$50.71
905	2	Lone Star Industries	Nazareth	PA	H	1	Dry	173	173.0	1.00	Coal	36	$50.71
905	3	Lone Star Industries	Nazareth	PA	G	1	Dry	130	130.0	1.00	Coal	44	$51.31
905	4	Lone Star Industries	Nazareth	PA	G	1	Dry	133	133.0	1.00	Coal	44	$51.31
		Total						7,975	7,177.0				

TABLE B-3. REGIONAL MARKET DATA SUMMARY: BIRMINGHAM

Number of Plants	6			
Number of Companies	5			
Number of Kilns	7			Foreign Imports (10^3 tpy)
Domestic Capacity (10^3 tons)	4,991		Rest of the World	257.1
Domestic Production (10^3 tons)	4,286		Canadian	NA
Delivered Price ($/ton)	$60.00		Total	257.1
F.O.B. Price ($/ton)	$50.84			

Fac ID	Kiln ID	Facility Name	City	State	Model Kiln	FF=1/ ESP=0	Kiln Process	Kiln Capacity (10^3 tpy)	Kiln Production (10^3 tpy)	Cap. Util.	Primary Fuel	Kiln Age	Kiln AVC ($/ton)
10	1	Blue Circle Inc.	Calera	AL	I	1	Dry	318	318.0	1.00	Coal	36	$47.18
10	2	Blue Circle Inc.	Calera	AL	I	1	Dry	318	307.4	0.97	Coal	37	$47.26
308	1	Holnam Inc.	Artesia	MS	C	0	Wet	500	450.0	0.90	Coal	19	$43.88
320	1	Holnam Inc.	Theodore	AL	R	1	Dry-C	1,500	1,023.2	0.68	Coal	12	$41.74
801	1	Lehigh Portland Cement	Leeds	AL	N	0	Dry-X	651	581.6	0.89	Coal	17	$42.96
8	1	Medusa Cement Company	Demopolis	AL	O	0	Dry-X	810	781.1	0.96	Coal	16	$41.61
14	1	National Cement Company	Ragland	AL	Q	0	Dry-C	894	824.5	0.92	Coal	18	$42.05
		Total						4,991	4,286				

TABLE B-4. REGIONAL MARKET DATA SUMMARY: CHICAGO

Number of Plants	6
Number of Companies	5
Number of Kilns	10
Domestic Capacity (10^3 tons)	3,665
Domestic Production (10^3 tons)	3,502
Delivered Price ($/ton)	$64.00
F.O.B. Price ($/ton)	$53.57

	Foreign Imports (10^3 tpy)
Rest of the World	NA
Canadian	153.1
Total	153.1

Fac ID	Kiln ID	Facility Name	City	State	Model Kiln	FF=1/ ESP=0	Kiln Process	Kiln Capacity (10^3 tpy)	Kiln Production (10^3 tpy)	Cap. Util.	Primary Fuel	Kiln Age	Kiln AVC ($/ton)
414	1	Centex	La Salle	IL	M	1	Dry-X	476	435.0	0.91	Coal	19	$46.25
403	1	Dixon-Marquette	Dixon	IL	G	1	Dry	146	122.0	0.84	Coal	33	$50.21
403	2	Dixon-Marquette	Dixon	IL	K	0	Dry-X	126	126.0	1.00	Coal	37	$47.24
403	3	Dixon-Marquette	Dixon	IL	K	0	Dry-X	126	126.0	1.00	Coal	37	$47.24
403	4	Dixon-Marquette	Dixon	IL	K	0	Dry-X	126	126.0	1.00	Coal	37	$47.24
998	1	Essroc Materials	Logansport	IN	A	0	Wet	227	227.0	1.00	Waste	27	$42.59
998	2	Essroc Materials	Logansport	IN	A	0	Wet	227	200.0	0.88	Waste	31	$42.93
408	1	Lafarge Corporation	Buffalo	IA	R	1	Dry-C	894	875.0	0.98	Coal	12	$41.39
901	1	Lone Star Industries	Olgesby	IL	J	1	Dry	569	540.0	0.95	Coal	37	$46.75
902	1	Lone Star Industries	Greencastle	IN	D	0	Wet	748	725.0	0.97	Coal	24	$45.16
		Total						3,665	3,502				

TABLE B-5. REGIONAL MARKET DATA SUMMARY: CINCINNATI

Number of Plants	4
Number of Companies	4
Number of Kilns	7
Domestic Capacity (10^3 tons)	3,092
Domestic Production (10^3 tons)	2,882
Delivered Price ($/ton)	$79.65
F.O.B. Price ($/ton)	$53.73

	Foreign Imports (10^3 tpy)
Rest of the World	--
Canadian	--
Total	--

Fac ID	Kiln ID	Facility Name	City	State	Model Kiln	FF=1/ ESP=0	Kiln Process	Kiln Capacity (10^3 tpy)	Kiln Production (10^3 tpy)	Cap. Util.	Primary Fuel	Kiln Age	Kiln AVC ($/ton)
521	1	Essroc Materials	Speed	IN	N	0	Dry-X	680	680.0	1.0	Coal	15	$44.56
521	2	Essroc Materials	Speed	IN	I	1	Dry	352	220.0	0.6	Coal	21	$48.10
510	1	Kosmos Cement	Kosmosdale	KY	N	1	Dry-X	700	622.0	0.9	Coal	19	$43.14
802	1	Lehigh Portland Cement	Mitchell	IN	L	0	Dry-X	264	264.0	1.0	Coal	17	$44.66
802	2	Lehigh Portland Cement	Mitchell	IN	H	0	Dry	248	248.0	1.0	Coal	33	$48.94
802	3	Lehigh Portland Cement	Mitchell	IN	H	0	Dry	248	248.0	1.0	Coal	33	$48.94
511	1	Southdown Inc.	Fairborn	OH	N	1	Dry-X	600	600.0	1.0	Coal	19	$44.37
		Total						3,092	2,882	0.93			

TABLE B-6. REGIONAL MARKET DATA SUMMARY: DALLAS

Number of Plants	6
Number of Companies	5
Number of Kilns	15
Domestic Capacity (10^3 tons)	5,372
Domestic Production (10^3 tons)	5,191
Delivered Price ($/ton)	$49.93
F.O.B. Price ($/ton)	$48.25

	Foreign Imports (10^3 tpy)
Rest of the World	--
Canadian	--
Total	--

Fac ID	Kiln ID	Facility Name	City	State	Model Kiln	FF=1/ ESP=0	Kiln Process	Kiln Capacity (10^3 tpy)	Kiln Production (10^3 tpy)	Cap. Util.	Primary Fuel	Kiln Age	Kiln AVC ($/ton)
1	1	Ash Grove Cement Co.	Foreman	AR	C	0	Wet	403	377.0	0.94	Coal	29	$47.16
1	2	Ash Grove Cement Co.	Foreman	AR	B	0	Wet	271	271.0	1.00	Coal	31	$46.67
1	3	Ash Grove Cement Co.	Foreman	AR	B	0	Wet	271	271.0	1.00	Coal	35	$47.05
204	1	Blue Circle Inc.	Tulsa	OK	I	1	Dry	300	300.0	1.00	Coal	30	$43.04
204	2	Blue Circle Inc.	Tulsa	OK	I	1	Dry	300	275.0	0.92	Coal	32	$43.15
413	1	Holnam Inc.	Midlothian	TX	R	1	Dry-C	1,066	1,026.0	0.96	Coal	6	$37.50
519	1	Holnam Inc.	Ada	OK	B	0	Wet	300	300.0	1.00	Coal	35	$44.17
519	2	Holnam Inc.	Ada	OK	C	0	Wet	300	275.0	0.92	Coal	35	$44.17
508	1	North Texas Cement	Midlothian	TX	B	0	Wet	299	299.0	1.00	Coal	21	$41.68
508	2	North Texas Cement	Midlothian	TX	B	0	Wet	299	299.0	1.00	Coal	24	$41.83
508	3	North Texas Cement	Midlothian	TX	B	0	Wet	299	275.0	0.92	Coal	27	$41.99
415	1	Texas Industries	Midlothian	TX	C	0	Wet	316	316	1.00	Coal	21	$40.30
415	2	Texas Industries	Midlothian	TX	C	0	Wet	316	316	1.00	Coal	26	$40.55
415	3	Texas Industries	Midlothian	TX	C	0	Wet	316	316	1.00	Coal	30	$40.76
415	4	Texas Industries	Midlothian	TX	C	0	Wet	316	275	0.87	Coal	33	$40.92
		Total						5,372	5,191	0.97			

TABLE B-7. REGIONAL MARKET DATA SUMMARY: DENVER

Number of Plants	5
Number of Companies	4
Number of Kilns	19
Domestic Capacity (10^3 tons)	2,884
Domestic Production (10^3 tons)	2,689
Delivered Price ($/ton)	$71.21
F.O.B. Price ($/ton)	$63.72

	Foreign Imports (10^3 tpy)
Rest of the World	--
Canadian	--
Total	--

Fac ID	Kiln ID	Facility Name	City	State	Model Kiln	FF=1/ ESP=0	Kiln Process	Kiln Capacity (10^3 tpy)	Kiln Production (10^3 tpy)	Cap. Util.	Primary Fuel	Kiln Age	Kiln AVC ($/ton)
199	1	Centex	Laramie	WY	N	0	Dry-X	428	406.6	0.95	Coal	5	$45.59
5	1	Dacotah Cement	Rapid City	SD	M	1	Dry-X	450	450.0	1.00	Coal	15	$50.32
5	2	Dacotah Cement	Rapid City	SD	A	0	Wet	151	151.0	1.00	Coal	36	$55.83
5	3	Dacotah Cement	Rapid City	SD	A	0	Wet	151	151.0	1.00	Coal	38	$56.01
12	1	Holnam Inc.	La Porta	CO	K	1	Dry-C	480	356.9	0.74	Coal	4	$46.88
318	1	Holnam Inc.	Florence	CO	C	0	Wet	485	485.0	1.00	Coal	19	$51.66
318	2	Holnam Inc.	Florence	CO	A	0	Wet	160	160.0	1.00	Coal	47	$53.40
318	3	Holnam Inc.	Florence	CO	A	0	Wet	160	130.0	0.81	Coal	47	$53.40
512	1	Southdown Inc.	Lyons	CO	O	1	Dry-C	419	398.1	0.95	Gas	13	$50.54
		Total						2,884	2,689	0.93			

TABLE B-8. REGIONAL MARKET DATA SUMMARY: DETROIT

Number of Plants	4
Number of Companies	3
Number of Kilns	10
Domestic Capacity (10^3 tons)	4,905
Domestic Production (10^3 tons)	4,760
Delivered Price ($/ton)	$68.83
F.O.B. Price ($/ton)	$56.73

	Foreign Imports (10^3 tpy)
Rest of the World	NA
Canadian	1,125.0
Total	1,125.0

Fac ID	Kiln ID	Facility Name	City	State	Model Kiln	FF=1/ ESP=0	Kiln Process	Kiln Capacity (10^3 tpy)	Kiln Production (10^3 tpy)	Cap. Util.	Primary Fuel	Kiln Age	Kiln AVC ($/ton)
316	1	Holnam Inc.	Dundee	MI	D	1	Wet	515	515.0	1.00	Coal	34	$52.46
316	2	Holnam Inc.	Dundee	MI	D	1	Wet	515	500.0	0.97	Coal	34	$52.46
406	1	Lafarge Corporation	Alpena	MI	J	1	Dry	527	527.0	1.00	Coal	17	$48.17
406	2	Lafarge Corporation	Alpena	MI	J	1	Dry	525	525.0	1.00	Coal	17	$48.17
406	3	Lafarge Corporation	Alpena	MI	I	1	Dry	329	309.0	0.94	Coal	28	$53.92
406	4	Lafarge Corporation	Alpena	MI	I	1	Dry	331	331.0	1.00	Coal	28	$52.23
406	5	Lafarge Corporation	Alpena	MI	I	1	Dry	317	317.0	1.00	Coal	28	$53.92
409	1	Lafarge Corporation	Paulding	OH	B	0	Wet	241	241	1.00	Coal	36	$46.83
409	2	Lafarge Corporation	Paulding	OH	B	0	Wet	241	226	0.94	Coal	37	$46.91
507	1	Medusa Cement Company	Charlevoix	MI	P	0	Dry-C	1,364	1,269.2	0.93	Coal	13	$48.38
		Total						4,905	4,760	0.97			

TABLE B-9. REGIONAL MARKET DATA SUMMARY: FLORIDA

Number of Plants	4
Number of Companies	4
Number of Kilns	8
Domestic Capacity (10^3 tons)	3,346
Domestic Production (10^3 tons)	3,077
Delivered Price ($/ton)	NA
F.O.B. Price ($/ton)	$59.71

	Foreign Imports (10^3 tpy)
Rest of the World	1,418.8
Canadian	NA
Total	1,418.8

Fac ID	Kiln ID	Facility Name	City	State	Model Kiln	FF=1/ ESP=0	Kiln Process	Kiln Capacity (10^3 tpy)	Kiln Production (10^3 tpy)	Cap. Util.	Primary Fuel	Kiln Age	Kiln AVC ($/ton)
213	1	Florida Crushed Stone	Brooksville	FL	N	1	Dry-X	571	507.2	0.89	Coal	6	$43.78
604	1	Pennsuco Cement Company	Medley	FL	D	0	Wet	637	637.0	1.00	Coal	18	$46.04
604	2	Pennsuco Cement Company	Medley	FL	A	0	Wet	185	135.0	0.73	Gas	24	$58.30
604	3	Pennsuco Cement Company	Medley	FL	A	0	Wet	185	185.0	1.00	Gas	24	$58.30
303	1	Rinker Materials	Miami	FL	B	0	Wet	276	276.0	1.00	Coal	35	$49.55
303	2	Rinker Materials	Miami	FL	B	0	Wet	276	242.0	0.88	Coal	35	$49.55
520	1	Southdown Inc.	Brooksville	FL	N	1	Dry-X	608	608.0	1.00	Coal	11	$44.06
520	2	Southdown Inc.	Brooksville	FL	N	1	Dry-X	608	487.0	0.80	Coal	17	$44.41
		Total						3,346	3,077	0.92			

TABLE B-10. REGIONAL MARKET DATA SUMMARY: KANSAS CITY

Number of Plants	7
Number of Companies	5
Number of Kilns	18
Domestic Capacity (10^3 tons)	4,068
Domestic Production (10^3 tons)	3,856
Delivered Price ($/ton)	$63.90
F.O.B. Price ($/ton)	$53.79

	Foreign Imports (10^3 tpy)
Rest of the World	--
Canadian	--
Total	--

Fac ID	Kiln ID	Facility Name	City	State	Model Kiln	FF=1/ ESP=0	Kiln Process	Kiln Capacity (10^3 tpy)	Kiln Production (10^3 tpy)	Cap. Util.	Primary Fuel	Kiln Age	Kiln AVC ($/ton)
2	1	Ash Grove Cement Co.	Chanute	KS	B	0	Wet	248	218.0	0.88	Coal	29	$46.17
2	2	Ash Grove Cement Co.	Chanute	KS	B	0	Wet	248	248.0	1.00	Coal	29	$46.17
6	1	Ash Grove Cement Co.	Louisville	NE	Q	0	Dry-C	549	549.0	1.00	Coal	11	$41.09
6	2	Ash Grove Cement Co.	Louisville	NE	O	0	Dry-X	427	297.9	0.70	Coal	17	$42.01
7	1	Lafarge Corporation	Fredonia	KS	B	0	Wet	228	224	0.98	Waste	37	$43.43
7	2	Lafarge Corporation	Fredonia	KS	A	0	Wet	146	146	1.00	Waste	72	$43.28
206	1	Lafarge Corporation	Sugar Creek	MO	J	0	Dry	281	281.0	1.00	Coal	36	$48.27
206	2	Lafarge Corporation	Sugar Creek	MO	J	0	Dry	248	248.0	1.00	Coal	40	$48.51
904	1	Lone Star Industries	Pryor	OK	I	1	Dry	271	271.0	1.00	Coal	13	$44.91
904	2	Lone Star Industries	Pryor	OK	H	1	Dry	208	208.0	1.00	Coal	31	$45.85
904	3	Lone Star Industries	Pryor	OK	H	1	Dry	208	208.0	1.00	Coal	33	$45.96
15	1	Monarch Cement Co.	Humbolt	KS	L	1	Dry-X	279	279.0	1.00	Coal	18	$43.80
15	2	Monarch Cement Co.	Humbolt	KS	L	1	Dry-X	279	279.0	1.00	Coal	20	$43.88
15	3	Monarch Cement Co.	Humbolt	KS	G	1	Dry	116	67.1	0.58	Coal	36	$47.34
309	1	Heartland Cement Co.	Independence	KS	F	1	Dry	83	83.0	1.00	Coke	7	$46.25
309	2	Heartland Cement Co.	Independence	KS	F	1	Dry	83	83.0	1.00	Coke	7	$46.25
309	3	Heartland Cement Co.	Independence	KS	F	1	Dry	83	83.0	1.00	Coke	7	$46.25
309	4	Heartland Cement Co.	Independence	KS	F	1	Dry	83	83.0	1.00	Coke	7	$46.25
		Total						4,068	3,856				

TABLE B-11. REGIONAL MARKET DATA SUMMARY: LOS ANGELES

Number of Plants	7
Number of Companies	6
Number of Kilns	15
Domestic Capacity (10^3 tons)	7,817
Domestic Production (10^3 tons)	6,723
Delivered Price ($/ton)	$63.61
F.O.B. Price ($/ton)	$61.68

	Foreign Imports (10^3 tpy)
Rest of the World	455.7
Canadian	NA
Total	455.7

Fac ID	Kiln ID	Facility Name	City	State	Model Kiln	FF=1/ ESP=0	Kiln Process	Kiln Capacity (10^3 tpy)	Kiln Production (10^3 tpy)	Cap. Util.	Primary Fuel	Kiln Age	Kiln AVC ($/ton)
501	1	Calaveras Cement Co.	Tehachapi	CA	M	0	Dry-C	731	613.8	0.84	Coal	2	$49.70
603	1	California Portland Cement	Mojave	CA	R	1	Dry-C	1,200	963.6	0.80	Coal	12	$50.26
702	1	California Portland Cement	Colton	CA	I	1	Dry	375	375.0	1.00	Coke	30	$55.30
702	2	California Portland Cement	Colton	CA	I	1	Dry	375	263.0	0.70	Coke	30	$55.30
405	1	Mitsubishi Cement Corp	Lucerne Valley	CA	R	1	Dry-C	1,706	1,450.0	0.85	Coal	11	$50.20
16	1	Natl. Cement Co. of California	Lebec	CA	J	1	Dry	650	523.1	0.80	Coke	27	$49.37
304	1	Riverside Cement Co.	Oro Grande	CA	H	1	Dry	165	165.0	1.00	Coal	34	$56.66
304	2	Riverside Cement Co.	Oro Grande	CA	H	1	Dry	165	165.0	1.00	Coal	34	$56.66
304	3	Riverside Cement Co.	Oro Grande	CA	H	1	Dry	170	170.0	1.00	Coal	41	$57.29
304	4	Riverside Cement Co,	Oro Grande	CA	H	1	Dry	170	170.0	1.00	Coal	41	$57.29
304	5	Riverside Cement Co.	Oro Grande	CA	H	1	Dry	170	170.0	1.00	Coal	45	$57.66
304	6	Riverside Cement Co.	Oro Grande	CA	H	1	Dry	170	170.0	1.00	Coal	45	$57.66
304	7	Riverside Cement Co.	Oro Grande	CA	H	1	Dry	170	150.0	0.88	Coal	45	$57.66
515	1	Southdown Inc.	Victorville	CA	Q	1	Dry-C	951	951.0	1.00	Coal	9	$50.08
515	2	Southdown Inc.	Victorville	CA	J	1	Dry	649	424.0	0.65	Coal	28	$51.92
		Total						7,817	6,723	0.86			

TABLE B-12. REGIONAL MARKET DATA SUMMARY: MINNEAPOLIS

Number of Plants	2			
Number of Companies	2			
Number of Kilns	3			Foreign Imports (10^3 tpy)
Domestic Capacity (10^3 tons)	1,614		Rest of the World	NA
Domestic Production (10^3 tons)	1,441		Canadian	178.8
Delivered Price ($/ton)	$62.33		Total	178.8
F.O.B. Price ($/ton)	$60.85			

Fac ID	Kiln ID	Facility Name	City	State	Model Kiln	FF=1/ ESP=0	Kiln Process	Kiln Capacity (10^3 tpy)	Kiln Production (10^3 tpy)	Cap. Util.	Primary Fuel	Kiln Age	Kiln AVC ($/ton)
518	1	Holnam Inc.	Mason City	IA	I	1	Dry	316	247.0	0.78	Coal	17	$48.84
518	2	Holnam Inc.	Mason City	IA	J	1	Dry	538	538.0	1.00	Coal	29	$46.24
804	1	Lehigh Portland Cement	Mason City	IA	Q	0	Dry-C	760	656.3	0.86	Coal	15	$45.12
		Total						1,614	1,441	0.89			

TABLE B-13. REGIONAL MARKET DATA SUMMARY: NEW YORK/BOSTON

Number of Plants	5
Number of Companies	5
Number of Kilns	6
Domestic Capacity (10^3 tons)	3,800
Domestic Production (10^3 tons)	3,530
Delivered Price ($/ton)	$62.71
F.O.B. Price ($/ton)	$59.18

	Foreign Imports (10^3 tpy)
Rest of the World	249.9
Canadian	414.8
Total	664.7

Fac ID	Kiln ID	Facility Name	City	State	Model Kiln	FF=1/ ESP=0	Kiln Process	Kiln Capacity (10^3 tpy)	Kiln Production (10^3 tpy)	Cap. Util.	Primary Fuel	Kiln Age	Kiln AVC ($/ton)
203	1	Blue Circle Inc.	Ravena	NY	E	0	Wet	854	854.0	1.00	Coal	31	$46.81
203	2	Blue Circle Inc.	Ravena	NY	E	0	Wet	854	762.0	0.89	Coal	31	$46.81
313	1	Dragon Products Company	Thomaston	ME	C	1	Wet	432	427.5	0.99	Coal	22	$52.74
207	1	Glens Falls Cement Co., Inc.	Glens Falls	NY	M	0	Dry-X	507	450.0	0.89	Coal	20	$44.59
310	1	Independent Cement Corporation	Catskill	NY	D	0	Wet	595	526.2	0.88	Coal	28	$46.57
805	1	Lehigh Portland Cement	Cementon	NY	D	0	Wet	558	510.0	0.91	Coal	29	$46.65
		Total						3,800	3,530	0.93			

TABLE B-14. REGIONAL MARKET DATA SUMMARY: PHOENIX

Number of Plants	4			
Number of Companies	4			
Number of Kilns	10			Foreign Imports (10^3 tpy)
Domestic Capacity (10^3 tons)	3,054		Rest of the World	--
Domestic Production (10^3 tons)	2,893		Canadian	--
Delivered Price ($/ton)	NA		Total	--
F.O.B. Price ($/ton)	$64.88			

Fac ID	Kiln ID	Facility Name	City	State	Model Kiln	FF=1/ ESP=0	Kiln Process	Kiln Capacity (10^3 tpy)	Kiln Production (10^3 tpy)	Cap. Util.	Primary Fuel	Kiln Age	Kiln AVC ($/ton)
3	1	Ash Grove Cement Co.	Nephi	UT	Q	1	Dry-C	600	593.1	0.99	Coal	12	$47.80
602	1	California Portland Cement	Rillito	AZ	R	1	Dry-C	990	990.0	1.00	Coal	23	$52.43
602	2	California Portland Cement	Rillito	AZ	I	1	Dry	95	95.0	1.00	Coal	38	$57.98
602	3	California Portland Cement	Rillito	AZ	I	1	Dry	95	95.0	1.00	Coal	42	$58.34
602	4	California Portland Cement	Rillito	AZ	I	1	Dry	95	13.4	0.14	Coal	45	$58.62
322	1	Holnam Inc.	Tijeras	NM	L	1	Dry-X	237	237.0	1.00	Coal	33	$50.41
322	2	Holnam Inc.	Tijreras	NM	L	1	Dry-X	237	200.0	0.84	Coal	34	$50.45
211	1	Phoenix Cement Company	Clarkdale	AZ	I	1	Dry	235	200.0	0.85	Coal	32	$57.46
211	2	Phoenix Cement Company	Clarkdale	AZ	L	1	Dry-X	235	235.0	1.00	Coal	34	$54.27
211	3	Phoenix Cement Company	Clarkdale	AZ	L	1	Dry-X	235	235.0	1.00	Coal	34	$54.27
		Total						3,054	2,893	0.95			

TABLE B-15. REGIONAL MARKET DATA SUMMARY: PITTSBURGH

Number of Plants	4
Number of Companies	4
Number of Kilns	8
Domestic Capacity (10^3 tons)	1,963
Domestic Production (10^3 tons)	1,848
Delivered Price ($/ton)	$69.36
F.O.B. Price ($/ton)	$63.44

	Foreign Imports (10^3 tpy)
Rest of the World	NA
Canadian	1,035.7
Total	1,035.7

Fac ID	Kiln ID	Facility Name	City	State	Model Kiln	FF=1/ ESP=0	Kiln Process	Kiln Capacity (10^3 tpy)	Kiln Production (10^3 tpy)	Cap. Util.	Primary Fuel	Kiln Age	Kiln AVC ($/ton)
212	1	Armstrong Cement & Sup. Corp.	Cabot	PA	A	0	Wet	163	152	0.93	Coal	67	$55.99
212	2	Armstrong Cement & Sup. Corp.	Cabot	PA	A	0	Wet	163	163	1.00	Coal	67	$55.99
523	1	Essroc Materials	Bessemer	PA	C	0	Wet	326	326	1.00	Coal	29	$52.56
523	2	Essroc Materials	Bessemer	PA	A	0	Wet	223	175	0.78	Coal	32	$52.79
514	1	Kosmos Cement	Pittsburgh	PA	C	0	Wet	385	372.9	0.97	Coal	31	$52.72
524	1	Medusa Cement Company	Wampum	PA	I	0	Dry	265	265.0	1.00	Coal	24	$50.52
524	2	Medusa Cement Company	Wampum	PA	I	0	Dry	219	175.0	0.80	Coal	34	$50.99
524	3	Medusa Cement Company	Wampum	PA	I	0	Dry	219	219.0	1.00	Coal	34	$50.99
		Total						1,963	1,847.9				

TABLE B-16 REGIONAL MARKET DATA SUMMARY: SAN ANTONIO

Number of Plants	7
Number of Companies	7
Number of Kilns	11
Domestic Capacity (10^3 tons)	5,367
Domestic Production (10^3 tons)	5,269
Delivered Price ($/ton)	$49.93
F.O.B. Price ($/ton)	$46.16

	Foreign Imports (10^3 tpy)
Rest of the World	168.0
Canadian	NA
Total	168.0

Fac ID	Kiln ID	Facility Name	City	State	Model Kiln	FF=1/ ESP=0	Kiln Process	Kiln Capacity (10^3 tpy)	Kiln Production (10^3 tpy)	Cap. Util.	Primary Fuel	Kiln Age	Kiln AVC ($/ton)
504	1	Alamo Cement Co.	San Antonio	TX	Q	0	Dry-C	769	750.0	0.98	Coal	12	$36.66
411	1	Capitol Aggregates, Inc.	San Antonio	TX	O	1	Dry-C	503	503.0	1.00	Coal	10	$36.59
411	2	Capitol Aggregates, Inc.	San Antonio	TX	C	0	Wet	352	335.0	0.95	Coal	28	$41.00
214	1	Lafarge Corporation	New Braunfels	TX	P	0	Dry-C	880	850.0	0.97	Coal	13	$36.69
906	1	Lone Star Industries	Sweetwater	TX	K	1	Dry-X	163	163.0	1.00	Coal	22	$37.81
906	2	Lone Star Industries	Sweetwater	TX	K	1	Dry-X	163	163.0	1.00	Coal	22	$37.81
906	3	Lone Star Industries	Sweetwater	TX	K	1	Dry-X	163	163.0	1.00	Coal	22	$37.81
513	1	Southdown Inc.	Odessa	TX	L	1	Dry-X	281	281.0	1.00	Coal	15	$37.56
513	2	Southdown Inc.	Odessa	TX	I	1	Dry	248	225.0	0.91	Coal	34	$40.76
416	1	Texas Industries	New Braunfels	TX	R	0	Dry-C	759	750.0	0.99	Coal	13	$36.69
210	1	Texas-Lehigh Cement Company	Buda	TX	R	1	Dry-C	1,086	1,086.0	1.00	Coal	15	$36.75
		Total						5,367	5,269	0.98			

TABLE B-17. REGIONAL MARKET DATA SUMMARY: SAN FRANCISCO

Number of Plants	4
Number of Companies	4
Number of Kilns	5
Domestic Capacity (10^3 tons)	3,429
Domestic Production (10^3 tons)	3,082
Delivered Price ($/ton)	$63.67
F.O.B. Price ($/ton)	$51.18

	Foreign Imports (10^3 tpy)
Rest of the World	314.7
Canadian	NA
Total	314.7

Fac ID	Kiln ID	Facility Name	City	State	Model Kiln	FF=1/ ESP=0	Kiln Process	Kiln Capacity (10^3 tpy)	Kiln Production (10^3 tpy)	Cap. Util.	Primary Fuel	Kiln Age	Kiln AVC ($/ton)
601	1	Calaveras Cement Co.	Redding	CA	Q	1	Dry-C	651	600.0	0.92	Coal	12	$48.62
407	1	Centex	Fernley	NV	I	1	Dry-X	214	214.0	1.00	Coal	24	$43.54
407	2	Centex	Fernley	NV	I	1	Dry	214	193.0	0.90	Coal	29	$46.76
401	1	Kaiser Cement Plant	Permanente	CA	R	1	Dry-C	1,550	1,375.0	0.89	Coal	13	$48.67
312	1	RMC Lone Star	Davenport	CA	Q	0	Dry-C	800	700.0	0.88	Coal	12	$48.62
		Total						3,429	3,082				

TABLE B-18. REGIONAL MARKET DATA SUMMARY: SALT LAKE CITY

Number of Plants	5
Number of Companies	2
Number of Kilns	7
Domestic Capacity (10^3 tons)	1,634
Domestic Production (10^3 tons)	1,531
Delivered Price ($/ton)	NA
F.O.B. Price ($/ton)	$76.41

	Foreign Imports (10^3 tpy)
Rest of the World	NA
Canadian	307.1
Total	307.1

Fac ID	Kiln ID	Facility Name	City	State	Model Kiln	FF=1/ ESP=0	Kiln Process	Kiln Capacity (10^3 tpy)	Kiln Production (10^3 tpy)	Cap. Util.	Primary Fuel	Kiln Age	Kiln AVC ($/ton)
4	2	Ash Grove Cement Co.	Inkom	ID	A	0	Wet	125	125.0	1.00	Coal	43	$59.54
4	1	Ash Grove Cement Co.	Inkom	ID	A	0	Wet	95	80.0	0.84	Coal	64	$61.67
9	1	Ash Grove Cement Co.	Durkee	OR	M	0	Dry-X	494	460.7	0.93	Gas	14	$60.82
11	1	Ash Grove Cement Co.	Montana City	MT	B	0	Wet	304	285.0	0.94	Gas	30	$71.07
315	1	Holnam Inc.	Morgan	UT	A	0	Wet	159	159.0	1.00	Coal	45	$60.73
315	2	Holnam Inc.	Morgan	UT	A	0	Wet	159	123.6	0.78	Coal	45	$60.73
321	1	Holnam Inc.	Three Forks	MT	B	0	Wet	298	298.0	1.00	Coal	20	$57.72
		Total						1,634	1,531				

TABLE B-19. REGIONAL MARKET DATA SUMMARY: SEATTLE

Number of Plants	2
Number of Companies	2
Number of Kilns	2
Domestic Capacity (10^3 tons)	1,142
Domestic Production (10^3 tons)	1,127
Delivered Price ($/ton)	$73.00
F.O.B. Price ($/ton)	$62.27

	Foreign Imports (10^3 tpy)
Rest of the World	409.0
Canadian	739.2
Total	1,148.2

Fac ID	Kiln ID	Facility Name	City	State	Model Kiln	FF=1/ ESP=0	Kiln Process	Kiln Capacity (10^3 tpy)	Kiln Production (10^3 tpy)	Cap. Util.	Primary Fuel	Kiln Age	Kiln AVC ($/ton)
18	1	Ash Grove Cement Co.	Seattle	WA	Q	1	Dry-C	682	682.0	1.00	Gas	1	$48.86
319	1	Holnam Inc.	Seattle	WA	C	0	Wet	460	444.7	0.97	Coal	26	$55.63
		Total						1,142	1,127				

TABLE B-20. REGIONAL MARKET DATA SUMMARY: ST. LOUIS

Number of Plants	5
Number of Companies	5
Number of Kilns	7
Domestic Capacity (10^3 tons)	5,441
Domestic Production (10^3 tons)	5,040
Delivered Price ($/ton)	$53.33
F.O.B. Price ($/ton)	$49.75

	Foreign Imports (10^3 tpy)
Rest of the World	--
Canadian	--
Total	--

Fac ID	Kiln ID	Facility Name	City	State	Model Kiln	FF=1/ ESP=0	Kiln Process	Kiln Capacity (10^3 tpy)	Kiln Production (10^3 tpy)	Cap. Util.	Primary Fuel	Kiln Age	Kiln AVC ($/ton)
701	1	Continental Cement Co., Inc.	Hannibal	MO	D	0	Wet	599	588.0	0.98	Coal	27	$39.84
314	1	Holnam Inc.	Clarksville	MO	E	0	Wet	1,300	1,100.0	0.85	Coal	26	$41.80
311	1	Lafarge Corporation	Grand Chain	IL	J	0	Dry-X	651	651.0	1.00	Coal	18	$44.30
311	2	Lafarge Corporation	Grand Chain	IL	J	0	Dry	546	495.5	0.91	Coal	30	$44.46
903	1	Lone Star Industries	Cape Girardeau	MO	R	1	Dry-C	1,193	1,101.0	0.92	Coal	12	$40.30
306	1	River Cement	Festus	MO	J	0	Dry	576	576.0	1.00	Coke	24	$42.01
306	2	River Cement	Festus	MO	J	0	Dry	576	528.0	0.92	Coke	28	$42.25
		Total						5,441	5,040				

Appendix C

Development of Portland Cement Kiln Cost Functions

APPENDIX C
DEVELOPMENT OF PORTLAND CEMENT KILN COST FUNCTIONS

This appendix summarizes RTI's method for modifying the cost functions of Portland cement kilns as estimated by Das (1992) to better reflect the operating costs of kilns by process type and capacity. It begins with some background and interpretation of the research by Das (1992) and then describes the necessary adjustments to account for differences across kiln process types and capacity.

C.1 BACKGROUND

Das (1992) estimates a kiln-level average variable cost function in her microeconomic study of kiln utilization and retirement. There are five variable inputs in cement production--labor, fuel, electricity, raw material and maintenance. Labor is used in the quarry and for packing, fuel is largely consumed by the kilns, electricity is consumed mainly by the auxiliary equipment, raw materials serve as the kiln-feed, and maintenance is required for periodic upkeep of the kiln. Das assumes a fixed coefficient technology as the variable inputs are not deemed substitutable. Accordingly, the total variable cost function is linear in the output and input prices or, in other words, the average variable cost function is independent of output. Thus, the average variable cost function (expressed in $ per ton of cement) may be written as:

$$AVC = AVRI \times P_r + AVLI \times w + AVFI \times P_f + AVEI \times P_e + AVMI \times P_m \quad (1)$$

where AVRI, AVLI, AVFI, AVEI, and AVMI are the average variable input of raw materials, labor, fuel, electricity, and maintenance, respectively, and P_r, w, P_f, P_e, and P_m are the prices of each variable input.

As shown in Eq. (1), the contribution of each variable input to the cost per ton of cement is equal to the average variable input (fixed requirement of the input per ton of cement) times the price of the input (per unit cost). For example, the contribution of fuel to the cost per ton of cement is equal to the MMBtu requirement per ton of cement times the cost per ton of fuel. In fact, this is the exact method used by the editors of Rock Products in estimating cement plant operating costs based on their survey data containing average variable inputs and their costs across cement plants.

Originally, the Portland cement market model developed for OAQPS utilized econometric estimates of cost parameters to project the average variable costs at Portland cement kilns. Using the f.o.b. price of Portland cement as a proxy for the unobserved price of raw materials and maintenance inputs, Das (1992) estimated the kiln-level average variable costs (AVC) as

$$AVC = 0.4965\,P + 0.5744\,w + (1.0087)^{A}\,5.0832\,P_f + 0.3667\,P_e \qquad (2)$$

where P is the f.o.b. price of Portland cement (P), w is the wage rate of labor inputs, A is the age of the kiln, P_f is the price of fuel used to fire the kiln per million Btu, and P_e is the price of electricity per million Btu.

The AVC function in Eq. (2) was estimated using annual data from 1972 to 1980 for dry process kilns across 32 cement plants. However, there are some problems with directly using the coefficients from Eq. (2) to estimate the AVC of kilns in our analysis. These problems include the following:

- As a result of sampling dry-process kilns only, it does not accurately reflect the operating costs at wet process kilns or newer dry process kilns with preheater or precalciner technology,

- As a result of not stratifying the sample by kiln capacity, it does not reflect the economies of scale for larger capacity kilns because only a single function was estimated for all kilns rather than separate functions for kilns of different capacities, and

- As a result of the time period analyzed, it does not account for the improvements in labor productivity and changes in electricity consumption over the past 10 to 15 years.

Therefore, adjustments are necessary to account for the likely variable cost differences across kiln technologies and sizes before extrapolating this cost function to the entire population of kilns in our analysis. These adjustments are described in the following sections.

C.2 COST FUNCTION ADJUSTMENTS

Labor Productivity. Table C-1 shows labor productivity within the U.S. cement industry as measured by equivalent tons of cement per employee hour.[1] As shown, labor productivity has dramatically increased over the past two decades-- 165 percent since 1972. In addition, data indicate a disparity in the labor productivity between kiln process type and size. As shown in Table C-1, labor productivity is higher for dry process kilns than for wet process kilns and for large capacity kilns (> 500,000 tpy) than for small capacity kilns (≤ 500,000 tpy).

To reflect the differences in labor productivity across kiln process type and capacity, the average variable labor

TABLE C-1. LABOR PRODUCTIVITY OF THE U.S. CEMENT INDUSTRY BY PROCESS TYPE AND PLANT SIZE

	Equivalent tons per employee hour		
Process type	1972	1992	1993
Wet process	1.27	2.13	2.10
≤ 500,000 tons capacity	NA	1.61	1.62
> 500,000 tons capacity	NA	2.54	2.42
Dry process	1.33	2.51	2.55
≤ 500,000 tons capacity	NA	1.70	1.77
> 500,000 tons capacity	NA	2.59	2.61
No preheater	NA	2.30	2.25
Precalciner	NA	2.40	2.48
Preheater/precalciner	NA	2.80	2.91
All plants	1.29	2.40	2.41

Source: Portland Cement Association. U.S. and Canadian 1993 and 1992 Labor-Energy Input Survey. PCA's Economic Research Department, Skokie, Ill. November 1994 and 1993.

input (AVLI) estimated in Eq. (2) needs to be updated to reflect the more recent estimates of labor productivity shown in Table C-1. The AVLI is measured as the employee hours required per ton of cement and was estimated at 0.574 employee hours per ton by Das (1992). A revised estimate of AVLI for each kiln process and capacity may be computed as the inverse of the labor productivity estimates for 1993. Thus, the revised estimates of AVLI for use in our analysis are:

- 0.617 emp. hrs. per ton for wet process kilns with capacity ≤ 500,000 tpy,
- 0.413 emp. hrs. per ton for wet process kilns with capacity > 500,000 tpy,
- 0.565 emp. hrs. per ton for dry process kilns with capacity ≤ 500,000 tpy,
- 0.383 emp. hrs. per ton for dry process kilns with capacity > 500,000 tpy,

- 0.403 emp. hrs. per ton for dry process kilns with preheater technology, and
- 0.344 emp. hrs. per ton for dry process kilns with precalciner technology.

These estimates are used to derive the average variable costs for each kiln included in our analysis given its process type and capacity.

Electricity Consumption. Table C-2 shows electricity consumption of the U.S. cement industry by process type.[2] As shown, energy consumption per ton of cement for wet process kilns has been relatively stable over the past two decades, while that for dry process kilns has increased by almost 10 percent since 1972. This increase for dry process kilns may be attributable to the increased use of preheater and precalciner technologies over this period. These technologies require additional auxiliary equipment and therefore expected to consume more electricity per ton of cement. To reflect the differences in electricity consumption across process type, the average variable electricity input (AVEI) estimate of 0.366 MMBtu per ton in Eq. (2) is updated to reflect the 1993 estimates of electricity consumption shown in Table C-2.

TABLE C-2. ELECTRICITY CONSUMPTION OF U.S. CEMENT PRODUCERS BY PROCESS TYPE

	Million Btu per equivalent ton		
Process type	1972	1992	1993
Wet process	0.438	0.442	0.463
Dry process	0.442	0.485	0.509
All plants	0.445	0.473	0.497

Source: Portland Cement Association. U.S. Cement Industry Fact Sheet, 13th Edition. PCA's Economic Research Department, Skokie, Ill. June 1995.

Fuel Efficiency. Table C-3 presents measures of fuel efficiency within the U.S. cement industry by kiln process type and capacity.[3] Since this production process is so energy intensive, the disparities in fuel efficiency across process type and capacity are likely to be the major cause for observed differences in costs across kilns. Wet process kilns are less fuel efficient than dry process kilns because they require greater heat to evaporate the slurry inside the kiln. Furthermore, dry process kilns with preheater and/or precalciner technologies are more fuel efficient than dry process kilns because they utilize combustion exhaust gases to heat the raw materials before entering the dry kiln thereby reducing the energy required at the kiln to produce clinker. It is also the case that smaller kilns (≤ 500,000 tpy) are less fuel efficient than larger kilns (>500,000 tpy).

TABLE C-3. FUEL CONSUMPTION OF U.S. CEMENT PRODUCERS BY PROCESS TYPE

	Million Btu per equivalent ton		
Process type	1972	1992	1993
Wet process	6.816	5.460	5.395
≤ 500,000 tons capacity	NA	5.739	5.558
> 500,000 tons capacity	NA	5.319	5.324
Dry process	5.812	3.943	3.928
≤ 500,000 tons capacity	NA	4.650	4.991
> 500,000 tons capacity	NA	3.896	3.868
No preheater	NA	4.894	4.948
Precalciner	NA	3.783	3.787
Preheater/precalciner	NA	3.411	3.356
All plants	6.301	4.329	4.324

Source: Portland Cement Association. U.S. and Canadian 1993 Labor-Energy Input Survey. PCA's Economic Research Department, Skokie, Ill. November 1994.

In estimating the AVC function, Das points out that the average variable fuel input (AVFI) increases with the age of the kiln. In the AVC function, this is represented through the use of a constant rate of input decay (δ) so that $AVFI_{t+1} = (1 + \delta)\ AVFI_t$. This difference equation leads to the inclusion of the following term for the average variable fuel input of the kiln at time t in Eq. (2):

$$AVFI_t = (1 + \delta)^{A_t} AVFI_0 = (1.0087)^{A_t} 5.0832 \qquad (3)$$

where A_t is the age of the kiln at time t and $AVFI_0$ is the average variable fuel input of a new kiln. The Das estimate of $AVFI_0$ is equal to 5.083 MMBtu per ton of cement and reflects the value for a new dry kiln during the period of her analysis, i.e., 1972 through 1980. This estimate is obviously dated and needs to be adjusted to account for improvements over time as well as the differences across process type and size.

To reflect the differences in fuel efficiency across kiln process and capacity, it is necessary to revise the estimated value of $AVFI_0$ from Eq. (3) based on the average fuel consumption for each process type and capacity. As shown in Table C-3, the PCA estimates of average fuel consumption are the best estimates of the $AVFI_t$ by process type and capacity for any year t. For example, the average variable fuel input across all wet process kilns with capacity $\leq$ 500,000 that operated in 1993 was 5.582 MMBtu per ton of cement. Holding the input decay rate constant across kiln process type and capacity, we can use Eq. (3) with the estimates from Table C-3 of the average variable fuel input in 1993 and PCA data on the process type and age for each kiln operating in 1993 to derive a new estimate of $AVFI_0$ for each kiln process type and size. For this approach, Eq. (3) may be expressed by following equation:

$$AVFI_t^i = \frac{\sum_{i=1}^{N} \left[(1.0087)^{A_t^i} AVFI_0 \cdot Q_t^i \right]}{\sum_{i=1}^{N} Q_t^i} \qquad (4)$$

where $AVFI_t^i$ is the estimate from Table C-3 of the average variable fuel input in time t (1993) for a particular process type and size group i (i.e., small or large wet, small or large dry, preheater, and precalciner), while the right hand side of Eq. (4) represents the formula for the average variable fuel input in 1993 with the numerator being the total MMBtus of fuel consumed by these kilns in 1993 and the denominator being the total Portland cement production by these kilns in 1993. The estimate of $AVFI_0$ for each kiln process type and size group is solved for as the value that equates the right-hand side of Eq. (4) with the appropriate value of $AVFI_t^i$ from Table C-3 based on PCA data on the individual kilns of that process type and size operating in 1993 (i = 1 to N), including their age (A_t^i) and Portland cement production (Q_t^i) for that year.

Based on this approach, the revised estimates of the $AVFI_0$ by process type and size are:

- 4.2087 MMBtu per ton for wet process kilns with capacity ≤ 500,000 tpy,
- 4.2209 MMBtu per ton for wet process kilns with capacity > 500,000 tpy,
- 3.7847 MMBtu per ton for dry process kilns with capacity ≤ 500,000 tpy,
- 3.0871 MMBtu per ton for dry process kilns with capacity > 500,000 tpy,
- 3.2020 MMBtu per ton for dry process kilns with preheater technology, and
- 3.0332 MMBtu per ton for dry process kilns with precalciner technology.

These estimates are used in conjunction with the input decay rate estimated by Das to derive the average variable costs for each kiln included in our analysis given its process type and capacity.

C.3 REVISED COST FUNCTIONS

Absent input from Sanghamitra Das on alternative adjustments, RTI used the adjustments described above in revising the kiln-level AVC functions in the economic model to better reflect the cost difference across kiln technologies and size. These adjustments result in the following AVC functions for each process type and size.

Wet Process Kilns with Capacity ≤ 500,000 tpy

$$AVC^{W}_{Sm} = 0.4965\,P + 0.617\,w + (1.0087)^{A}\,4.2087\,P_f + 0.463\,P_e \tag{5}$$

Wet Process Kilns with Capacity > 500,000 tpy

$$AVC^{W}_{Lg} = 0.4965\,P + 0.413\,w + (1.0087)^{A}\,4.2209\,P_f + 0.463\,P_e \tag{6}$$

Dry Process Kilns with Capacity ≤ 500,000 tpy

$$AVC^{D}_{Sm} = 0.4965\,P + 0.565\,w + (1.0087)^{A}\,3.7847\,P_f + 0.509\,P_e \tag{7}$$

Dry Process Kilns with Capacity > 500,000 tpy

$$AVC^{D}_{Lg} = 0.4965\,P + 0.383\,w + (1.0087)^{A}\,3.0871\,P_f + 0.509\,P_e \tag{8}$$

Dry Process Kilns with Preheater Technology

$$AVC^{PH} = 0.4965\,P + 0.403\,w + (1.0087)^{A}\,3.2020\,P_f + 0.509\,P_e \tag{9}$$

Dry Process Kilns with Precalciner Technology

$$AVC^{PC} = 0.4965\,P + 0.344\,w + (1.0087)^{A}\,3.0332\,P_f + 0.509\,P_e \tag{10}$$

What type of adjustment in estimated AVC can we expect for a given kiln associated with these revised cost functions? Lets take a dry process kiln from our analysis and look at the changes in AVC with different assumed technologies and size.

The example dry process kiln is 25 years old, burns coal for fuel, and located in the Atlanta market with an estimated AVC of $48.81 based on the Das AVC function in Eq. (2). The AVC estimates with different process types and sizes are (with percentage difference in parentheses):

- $48.87 with wet process, small capacity (0.1 percent increase),
- $46.66 with wet process, large capacity (4.4 percent decrease),
- $48.09 with dry process, small capacity (1.5 percent decrease),
- $44.59 with dry process, large capacity (8.6 percent decrease),
- $45.05 with dry process and preheater (7.7 percent decrease), and
- $44.04 with dry process and precalciner (9.8 percent decrease).

As expected, the wet process kilns are more costly than dry process kilns of the same size and small capacity kilns are more costly than the large capacity kilns. Even more significant are the reductions in the estimated AVC for the preheater and precalciner technologies.

REFERENCES

1. Portland Cement Association. U.S. and Canadian 1993 and 1992 Labor-Energy Input Survey. PCA's Economic Research Department, Skokie, Ill. November 1994 and 1993.

2. Portland Cement Association. U.S. Cement Industry Fact Sheet, 13th Edition. PCA's Economic Research Department, Skokie, Ill. June 1995.

3. Portland Cement Association. U.S. and Canadian 1993 Labor-Energy Input Survey. PCA's Economic Research Department, Skokie, Ill. November 1994.

Appendix D

Detailed Economic Methodology

APPENDIX D
DETAILED ECONOMIC METHODOLOGY

This appendix describes the economic modeling approach for assessing the economic impacts of the National Emission Standard for Hazardous Air Pollutants (NESHAP) on manufacturers of Portland cement. Inputs to the analysis include a description of the economic and operating conditions at Portland cement plants and the estimated costs of compliance with the proposed regulatory option(s). The baseline characterization of Portland cement producers is based principally on 1993 data from the Portland Cement Association's (PCA) U.S. and Canadian Portland Cement Industry: Plant Information Summary. These kiln-, plant-, and company-specific data are supplemented with secondary information on final product and input price data from the Bureau of Mines and the Energy Information Administration and with kiln-specific cost equations as detailed in Appendix C. Compliance cost estimates for model kilns are developed by an EPA engineering analysis. These costs include the total capital investment cost, annualized capital cost, annual operating and maintenance costs, and monitoring costs. To serve as inputs to the analysis, the model kilns and the associated compliance costs are mapped to the actual kilns included in the economic model based on technology and capacity.

Because of the low value and high transport cost of Portland cement, the U.S. industry is divided into 20 independent regional markets as described in Table D-1. For each of these markets, the model characterizes domestic and foreign producers and consumers of Portland cement and

TABLE D-1. DESCRIPTION OF REGIONAL PORTLAND CEMENT MARKETS

Market	Geographic area served	Competitors
Atlanta	Central and northern Georgia, eastern Tennessee, South Carolina, North Carolina, and southern Virginia	8 cement plants and foreign imports
Baltimore/ Philadelphia	Eastern Pennsylvania, New Jersey, Delaware, Maryland, and northern Virginia	10 cement plants
Birmingham	Alabama, Mississippi, southwestern Tennessee, and Florida panhandle	6 cement plants and foreign imports
Chicago	Northern Illinois, eastern and central Wisconsin, southeastern Iowa, northern Indiana, and southwestern Michigan	6 cement plants and foreign imports
Cincinnati	Southwestern and central Ohio, northern and central Kentucky, and southern Indiana	4 cement plants
Dallas	East Texas, Louisiana, southeastern and central Oklahoma, and southwestern Arkansas	6 cement plants
Denver	Eastern and central Colorado, Wyoming, western Nebraska and western Kansas	5 cement plants
Detroit	Michigan, northwestern Ohio, southeastern Indiana	4 cement plants and foreign imports
Florida	Southern, central, and northeastern Florida and southern Georgia	4 cement plants and foreign imports
Kansas City	Western Missouri, eastern and central Kansas, northeastern Oklahoma, eastern Nebraska, and southwestern Iowa	7 cement plants
Los Angeles	Southern California and southern Nevada	7 cement plants and foreign imports
Minneapolis	Minnesota, eastern North and South Dakota, western Wisconsin, and northern Iowa	2 cement plants and foreign imports

(continued)

TABLE D-1. DESCRIPTION OF REGIONAL PORTLAND CEMENT MARKETS (CONTINUED)

Market	Geographic area served	Competitors
New York/ Boston	Eastern New York and New England states	5 cement plants and foreign imports
Phoenix	Arizona and western New Mexico	4 cement plants
Pittsburgh	Western Pennsylvania, eastern Ohio, northern West Virginia, and southwestern New York	4 cement plants and foreign imports
Salt Lake City	Utah, northeastern Nevada, southern and central Idaho, eastern Oregon, southwestern Montana, and western Wyoming	5 cement plants and foreign imports
San Antonio	Panhandle and west Texas, eastern New Mexico, Oklahoma panhandle	7 cement plants and foreign imports
San Francisco	Northern California, southwestern Oregon, southwestern and central Nevada	4 cement plants and foreign imports
Seattle	Washington, northern Idaho, northwestern Oregon	2 cement plants and foreign imports
St. Louis	Eastern Missouri, Southern and central Illinois, northern Arkansas, western Kentucky and northwestern Tennessee	5 cement plants

their behavioral responses to the imposition of the regulatory costs. These responses to the additional costs will determine the economic effects of the regulation. Specifically, the cost of the regulations may induce some producers to close their operations or to change their current operating rates. These choices affect, and in turn are affected by, the market price for Portland cement. Because Portland cement plants operate under conditions of high fixed costs and substantial returns to scale with a limited number of competitors, the model employs an oligopolistic market structure to compute the new equilibrium prices and quantities associated with each regulatory option. As opposed to the models of perfect and monopolistic competition, the general model oligopolistic competition stresses the strategic interaction between producers in that each must take into account the output choices of others in determining its own output choice.

D.1 ECONOMIC MODELING APPROACH

When a supplier in a competitive market makes its production decision, it only needs to examine market price. By definition, the supplier is such a small part of the market that it views itself as being unable to influence the market price through its own actions. Thus, it can ignore the impact of its own production decision on market price. However, when a supplier in an oligopolistic market makes its production decision, it must take into account the behavior of other suppliers and the effect of their output decisions on market price. In oligopoly, each supplier forms expectations, or conjectures, about its competitors' production decisions to make decisions on its own optimal production level.

Unlike perfect competition and monopoly, there is no single, complete model of oligopoly. Most empirical studies of oligopoly present competition as a quantity game among few producers of a homogenous product, as first described by Cournot (1838). Numerous oligopoly models of quantity competition have been developed by economists with each addressing a narrowly defined set of behavioral assumptions explicitly accounting for firm interdependence. The assumptions regarding each firm's conjectural variations, or the expectation of its competitors' response, differ across oligopoly models. These models include the following:

- dominant firm model, where the output decision of a dominant firm, or group of firms, takes into account its impact on both market price and the output decisions of "fringe" firms assumed to act as price-takers, i.e., each firm acts as if it expects its output change to be met by an off-setting change in its competitors' total output so that market price is unchanged.

- Cournot-Nash model, where each firm does not expect its competitors to react to its output decision so that each firm's output decision depends on the firm's market share, market price, and market demand elasticity.
- collusive model, where joint industry profits are maximized with all firms in the industry acting together as a multiplant monopolist.
- Stackleberg leader-follower model, which is similar to the dominant firm model except that the leading firm hypothesizes that the "follower" firms respond with Cournot conjectures rather than price-taking conjectures.

Due to the absence of collusion or a dominant firm in any market, the Cournot-Nash model is the most appropriate type of oligopolistic behavior to hypothesize for this industry. Following this model, each supplier maximizes its profits, given its conjectures about other supplier's behavior. Furthermore, those beliefs are confirmed in equilibrium as each supplier chooses to produce the optimal amount of output given the other supplier's output choices. Thus, in a Cournot-Nash equilibrium no supplier will find it profitable to change its production decision once it discovers the choices actually made by the other suppliers.

D.1.1 Domestic Supply

Following the Cournot-Nash model of oligopolistic behavior, each supplier maximizes its profits given its conjectures that its competitors will not react to its output decision. Thus, each supplier i maximizes profits by choosing its level of production (q_i), i.e.,

$$\text{Max } \pi_i = P(Q)\, q_i - C(q_i) - F \tag{1}$$

where Q is market output, $C(q_i)$ is the supplier's variable cost function, and F reflects fixed costs at the plant. The first-order condition is

$$\frac{\partial \pi_i}{\partial q_i} = P + \frac{\partial P}{\partial Q}\frac{\partial Q}{\partial q_i} q_i + \sum_{j \neq i}^{N} \left[\frac{\partial P}{\partial Q}\frac{\partial Q}{\partial q_{j \neq i}}\frac{\partial q_j}{\partial q_i} \right] - C'(q_i) = 0 \qquad (2)$$

The second term in Eq. (2) drops out by imposing the Cournot-Nash assumption that each supplier expects that all other suppliers will not respond directly to its change in production, i.e. $\partial q_j / \partial q_i = 0$. A conjectural variations assumption is necessary for a tractable solution to the model, i.e., Cournot-Nash, Stackleberg leader-follower, dominant firm, or collusion. Further, the partial derivative of market output (Q) with respect to the output level of a single supplier (q_i) holding all other supplier's output decisions constant, is equal to 1, (i.e., $\partial Q / \partial q_i = 1$ and $\partial Q / \partial q_{j \neq i} = 1$). Thus, rearranging terms and dropping the second term in Eq. (2) yields:

$$P + \frac{\partial P}{\partial Q} q_i = C'(q_i) \qquad (2a)$$

Multiplying the second term on the left-hand side of Eq. (2a) by Q/P * P/Q, or 1, results in the following expression that includes the inverse demand elasticity (i.e., $1/\eta = \partial P / \partial Q * Q/P$), the market share of supplier i (i.e., $si = q_i/Q$), and the market price (P):

$$P + P\left(\frac{1}{\eta}\right) s_i = C'(q_i) \qquad (2b)$$

Therefore, after rearranging the terms in Eq. (2b), each profit-maximizing supplier determines the optimal level of output by equating marginal revenue (MR) and marginal cost (MC), i.e.,

$$MR_i = P\left[1 + \frac{S_i}{\eta}\right] = MC_i \qquad (3)$$

where P is the market price, s_i is the market share of supplier i defined as q_i/Q with Q being market output, and η is the market demand elasticity for Portland cement. It is important to note that as s_i for all suppliers goes to zero the profit-maximizing condition stated in Eq. (3) becomes that observed for suppliers under perfect competition, i.e., $P = MC_i$. Alternatively, as s_i moves toward one the profit-maximizing condition stated in Eq. (3) becomes that observed for monopoly suppliers, i.e.,

$$MR_i = P\ [1 + \frac{1}{\eta}] = MC_i$$

The regulatory compliance costs provide the exogenous shock to the model with the total compliance cost per ton (c_i) being the change in the marginal cost of production for each affected supplier (dMC_i), i.e., the shift in the MC curve for the marginal kiln (defined as the kiln with the highest AVC at the plant). Based on the optimal output condition in Eq. (3), the change in marginal revenue (dMR_i) must equal the change in the marginal cost (dMC_i) for each supplier in the post-compliance equilibrium so that

$$dMR_i \quad = \quad dMC_i \qquad \text{(4a)}$$

or

$$dP\left[1 + \frac{s_i}{\eta}\right] + \frac{P}{\eta}\ dq_i\left[\frac{Q}{Q_2}\right] - \frac{P}{\eta}\ dQ\left[\frac{q_i}{Q^2}\right] = c_i \qquad \text{(4b)}$$

where each parameter is defined as described above. For each supplier within the market, Eq. (4b) describes its production response to the regulation based on the given parameters and the shift in the MC curve for its marginal kiln.

D.1.2 Foreign Supply

If applicable to the market, international trade may also be included by specifying additional equations to characterize foreign imports of Portland cement to the U.S. from Canada and/or the rest-of-the-world (ROW). In such cases, the change in imports of Portland cement from these foreign sources can be included through the following equation for each:

$$dq^I = \xi \, dP \left(\frac{q^I}{P} \right) \tag{5}$$

where ξ is the import supply elasticity.

D.1.3 <u>Market Supply</u>

The change in market quantity of Portland cement (dQ) must equal the change in Portland cement production from the individual suppliers both domestic and foreign, i.e.,

$$dQ = \sum_{i=1}^{N} dq_i + dq^I \quad . \tag{6}$$

This condition ensures that the market quantity is consistent with the individual supply decisions of domestic and foreign suppliers in the new post-compliance equilibrium for each regional market.

D.1.4 <u>Market Demand</u>

The demand for Portland cement is derived from the demand for concrete products which, in turn, is derived largely from the demand for construction. Based on a linear demand equation, the market demand condition must hold based on the projected change in market price, i.e.,

$$dQ = \eta \, dP \left[\frac{Q}{P} \right] \tag{7}$$

where η is the market demand elasticity for Portland cement.

D.1.5 Model Solution to Determine Post-Compliance Equilibrium

The above equations (4b), (5), (6), and (7) provide us with N + 3 linear equations in N + 3 unknowns (dq_i, dq^I, dQ, and dP) that can be solved using matrix algebra, i.e.,

$$\mathbf{b} = \mathbf{A}^{-1}\mathbf{c}'$$

where **b** is the vector containing (dP, dq_i, dq^I, and dQ), $\mathbf{A}^{-1}$ is the inverse of **A**, an N + 3 x N + 3 matrix, and **c** is the vector containing (c_i, 0, 0, 0).

For example, assume that our model market consists of two domestic plants, i.e., N = 2, and foreign imports from a Canadian or non-Canadian source. In this case, the model specifies 5 linear equations in 5 unknowns that can be expressed in matrix notation as

$$\underbrace{\begin{bmatrix} (1 + S_1/\eta) & (P/\eta)\cdot(Q/Q^2) & 0 & 0 & -(P/\eta)\cdot(q_1/Q^2) \\ (1 + S_2/\eta) & 0 & (P/\eta)\cdot(Q/Q^2) & 0 & -(P/\eta)\cdot(q_2/Q^2) \\ \xi(q^I/P) & 0 & 0 & -1 & 0 \\ \eta(Q/P) & 0 & 0 & 0 & -1 \\ 0 & -1 & -1 & -1 & 1 \end{bmatrix}}_{\mathbf{A}} \underbrace{\begin{bmatrix} dP \\ dq_1 \\ dq_2 \\ dq^I \\ dQ \end{bmatrix}}_{\mathbf{b}} = \underbrace{\begin{bmatrix} c_1 \\ c_2 \\ 0 \\ 0 \\ 0 \end{bmatrix}}_{\mathbf{c}}$$

After solving for the unknowns (i.e., dq_i, dq^I, dQ, and dP) using matrix inversion and multiplication, the model must check for the following situations:

- capacity violation, in which a plant exceeds its maximum capacity,
- kiln closure, in which the decline in production in response to the regulatory costs is greater than the baseline production from the marginal kiln, and
- plant closure, in which the profits at the plant-level are less than zero.

Each of these situations is addressed in the given sequence such that no later response/outcome would change the previous response/outcome.

D.1.5.1 <u>Capacity Violations</u>. Since the time frame of this analysis does not allow producers to invest in additional capacity, the model must respect the given capacity constraints of each supplier in solving the model. It could be the case that faced with little or no variable control costs a supplier will wish to increase its current level of output. This increase in production is permitted to the extent that excess capacity is available. However, if a plant wishes to exceed its available capacity, the model must limit its increase to the difference between plant capacity and current production, i.e., $q_{max} - q^*$. Operationally, this involves running the model and determining for each supplier whether its optimal decision (dMR = dMC) is feasible given its capacity constraint (q_{max}). For each supplier where $q^* > q_{max}$, the model adjusts the **A** matrix presented above to account for the constraint placed on each supplier due to limited capital capacity.

D.1.5.2 <u>Kiln Closures</u>. After accounting for capacity violations, the model next assesses the viability of each kiln. It could be the case that faced with high variable control costs an individual kiln will no longer cover its variable cost of production given the post-regulatory price level. If the with-regulation AVC at the marginal kiln (i.e., inclusive of the per unit variable compliance cost) is greater than the post-regulatory price level, p*, then the model must shut down that kiln. Operationally, this involves running the model and determining for each plant whether its projected reduction in production is greater than the baseline level of production of the marginal kiln. For each kiln where $\Delta q > q_i$, the model adjusts the **A** matrix presented above to account for the kiln closure and reassess the optimal output level given the new marginal kiln. Obviously, at a single-kiln plant, this result would constitute a plant closure.

D.1.5.3 Plant Closures. The post-compliance output level for each supplier (q_i^*) and product price (P_i^*) are inserted into the profit function of each individual supplier to determine if the supplier shuts down operations, i.e.,

$$\text{operate} \quad \text{if } P(Q)q_i - C(q_i) - C^v(q_i) - F - F^C \geq 0,$$
$$\text{or close} \quad \text{if } P(Q)q_i - C(q_i) - C^v(q_i) - F - F^C < 0,$$

where $C^v(q_i)$ is the total variable compliance costs and F^c is the fixed compliance costs. In this specification of the plant shut down decision, it is assumed that the liquidation value of the capital equipment is offset by the costs of closure. If the individual supplier decides to close, then the model sets the corresponding product supply from that supplier to zero, i.e., $q_i^* = 0$. It then recomputes the market shares for each supplier continuing operations (based on the baseline output level less production from plants or kilns determined to shut down due to the regulation) and reruns the above simultaneous model to determine adjusted values for the unknowns given kiln and plant closures within the market.

Appendix E

Econometric Estimation of the Demand Elasticity for Portland Cement

APPENDIX E
ECONOMETRIC ESTIMATION OF THE DEMAND ELASTICITY FOR PORTLAND CEMENT

This appendix summarizes RTI's estimation of the demand elasticity for Portland cement. These estimates are based on national level data from 1983 through 1993 on Portland cement value of shipments and quantity shipped from the U.S. Bureau of Mines and supplemental data from various government sources. The following sections summarize our econometric procedure and present our estimates of the demand elasticity for Portland cement.

E.1 ECONOMETRIC MODEL

A partial equilibrium market supply/demand model is specified as a system of interdependent equations in which the price and output of a product are simultaneously determined by the interaction of producers and consumers in the market. In simultaneous equation models, where variables in one equation feed back into variables in another equations, the error terms are correlated with the endogenous variables (price and output). In this case, single-equation ordinary least squares (OLS) estimation of individual equations will lead to biased and inconsistent parameter estimates. Thus, simultaneous estimation of this system to obtain elasticity estimates requires that each equation be identified through the inclusion of exogenous variables to control for shifts in the supply and demand curves over time.

Exogenous variables influencing the demand for Portland cement include measures of economic activity such as U.S. gross national and domestic production, housing starts, the value of construction activity, and the value of shipments for cement consuming industries (i.e., ready mix concrete, concrete block and brick, and concrete products not elsewhere classified) as well as the price of substitute products such as asphalt and building materials like lumber/wood and iron/steel (as proxied by the appropriate producer price indices). Exogenous variables influencing the level of Portland cement supply include measures of the change in the costs of cement production caused by changes in prices of key inputs like raw materials, fuel, and labor (as proxied by the producer price index for limestone and coal and the average hourly earnings for industry's production workers).

We define the supply/demand system for Portland cement as follows:

$$Q_t^d = f(P_t, Z_t) + u_t \quad (1)$$

$$Q_t^s = g(P_t, W_t) + v_t \quad (2)$$

$$Q_t^d = Q_t^s \quad (3)$$

Equation (1) shows quantity demanded as a function of price, P_t, an array of demand factors, Z_t (e.g., measures of economic activity and substitute prices), and an error term, u_t. Equation (2) represents quantity supplied as a function of price and other supply factors, W_t (e.g., input prices), and an error term, v_t, while equation (3) specifies the equilibrium condition that quantity supplied equals quantity demanded. Thus, we have a system of three equations in three variables. The interaction of the specified market forces solves this system, generating equilibrium values for the variables, P_t^* and $Q_t^*=Q_t^{d*}=Q_t^{s*}$.

Since our objective is to generate estimates of the demand elasticities, we employ the two stage least squares (2SLS) regression procedure to estimate only the parameters of the demand equation. This 2SLS approach is preferred over the three stage least squares approach since the number of observations limit our degrees of freedom for use in the estimation procedure. We specified the logarithm of the quantity demanded as a linear function of the logarithm of the price so that the coefficient on the price variable yields the estimate of the constant elasticity of demand for Portland cement. All prices employed in the estimation process were deflated by the consumer price index (CPI) to reflect real rather than nominal prices. The first stage of the 2SLS procedure involves regressing the observed price against the supply and demand "shifter" variables that are exogenous to the system. This first stage produces fitted (or predicted) values for the price variable that are, by definition, highly correlated with the true endogenous variable, the observed price, and uncorrelated with the error term. In the second stage, these fitted values are then employed as observations of the right hand side price variable in the demand function. This fitted value is uncorrelated with the error term by construction, and thus does not incur the endogeneity bias.

E.2 ECONOMETRIC RESULTS

Table E-1 provides the most statistically significant estimates of the demand elasticity for various specifications. The coefficients on the price variable, Ln(Price), are the estimates of the demand elasticity. As economic theory predicts, these estimates are negative with a range from -0.55 to -0.96. The most statistically significant estimate of -0.884 was derived from the demand specification with the value of U.S. construction activity. As expected, our regressions found a positive sign for the coefficients on all of the demand growth variables (e.g., GDP, GNP, U.S. housing starts, value of construction, and value of concrete shipments) such that increases in these exogenous variables stimulate cement consumption. For substitute products, our

TABLE E-1. TWO-STAGE LEAST SQUARES REGRESSION ESTIMATION OF PORTLAND CEMENT DEMAND EQUATIONS

Independent variables	Dependent variable: $Ln(Q^d)$				
Constant	-15.88 (-1.09)	-14.99 (-0.98)	6.51 (2.08)	4.03 (2.86)	4.72 (3.09)
Ln(Price)	-0.548 (-0.27)	-0.881 (-0.44)	-0.956 (-0.81)	-0.884 (-1.57)	-0.822 (-0.95)
Ln(GDP)	3.23 (1.69)	--	--	--	--
Ln(GNP)	--	3.09 (1.55)	--	--	--
Ln(USHS)	--	--	0.55 (1.33)	--	--
Ln(VCONST)	--	--	--	1.13 (3.75)	--
Ln(VOS)	--	--	--	--	1.21 (3.85)
Ln(PPIasphalt)	2.35 (2.45)	2.56 (2.71)	0.77 (0.64)	0.82 (1.26)	0.78 (1.31)
Ln(PPIiron/steel)	0.35 (0.61)	0.33 (0.55)	0.87 (1.89)	0.56 (2.19)	-0.24 (-0.38)
Ln(PPIlum/wood)	-0.03 (-0.10)	-0.01 (-0.03)	-0.25 (-0.54)	-0.10 (-0.63)	-0.20 (-0.75)
Ln(Time trend)	--	--	0.16 (1.20)	--	--
R-squared	0.8384	0.8285	0.9387	0.967	0.8461
Observations	11	11	11	11	11
Degrees of freedom	5	5	4	5	5

Note: T-statistics of parameter estimates are in parentheses.
Abbreviations for independent variables are:

GDP = U.S. Gross domestic product,
GNP = U.S. Gross national product,
USHS = U.S. housing starts,
VCONST = Value of U.S. construction activity,
VOS = Value of shipments for cement consuming industries,
PPIasphalt = Producer price index for asphalt,
PPIiron/steel = Producer price index for iron and steel products,
PPIlum/wood = Producer price index for lumber and wood products.

our regressions found a moderately significant and positive sign for the coefficients on the PPIs for asphalt and iron/steel indicating that these products are substitutes for cement (price increases in these products cause increases in cement consumption). Alternatively, the estimated coefficients on the PPI for lumber/wood were negative indicating that it is a compliment to cement (price increases for lumber/wood cause declines in cement consumption) but were generally statistically insignificant.

As a result of our econometric findings, the Portland cement market models will use the demand elasticity estimate of -0.884 as the "best" value for the model simulations. However, sensitivity analysis for this parameter estimate could be incorporated into the analysis by varying its value between -0.55 and -0.96 for additional model simulations.

Appendix F

Regional Market Model Impacts Summary by Regulatory Alternative

FIGURE F-1. U.S. SUMMARY OF ECONOMIC IMPACTS FOR MACT FLOOR ON MAJOR AND AREA SOURCES

Market Impacts	Baseline	With Regulation	Changes from baseline: Absolute	Changes from baseline: Percent
Portland Cement				
Market Price ($/ton)	$55.49	$56.13	$0.63	1.14%
Market Output (10^3 tpy)[a]	83,321.4	82,488.3	(833.1)	-1.00%
Domestic Production	75,592.3	74,222.0	(1,370.3)	-1.81%
ROW Production	3,775.3	4,022.5	247.2	6.55%
CAN Production	3,953.8	4,243.9	290.1	7.34%

Portland Cement Industry Impacts	Baseline	With Regulation	Changes from baseline: Absolute	Changes from baseline: Percent
Revenues ($$10^3$)	$4,165,036	$4,142,923	($22,113)	-0.53%
Costs ($$10^3$)	$3,514,212	$3,482,125	($32,087)	-0.91%
Post-reg. control costs	--	$31,330	--	
Cost of production adj.	$3,514,212	$3,450,795	($63,417)	-1.80%
Pre-tax Earnings ($$10^3$)	$650,824	$660,798	$9,974	1.53%
Operating Entities				
Plants	105	105	0	0.00%
Kilns	201	198	-3	-1.38%
Employment	13603	13353	-250	-1.84%

Small Business Impacts	Baseline	With Regulation	Changes from baseline: Absolute	Changes from baseline: Percent
Revenues ($$10^3$)	$387,053	$380,964	($6,090)	-1.57%
Costs ($$10^3$)	$327,809	$321,854	($5,955)	-1.82%
Post-reg. control costs	--	$3,307	--	
Cost of production adj.	$327,809	$318,547	($9,262)	-2.83%
Pre-tax Earnings ($$10^3$)	$59,244	$59,109	($135)	-0.23%
Operating Entities				
Plants	9	9	0	0.00%
Kilns	22	22	0	-0.26%
Employment	1,199	1,154	-45	-3.71%
Cost Share as % of Revenues[b]	--	0.92%	--	--

Social Cost Impacts	Change in value ($$10^3$)
Consumer Surplus	($52,287)
Producer Surplus	$14,975
Domestic Producers	$9,974
Foreign Producers	$5,001
Worker Dislocation Costs	($1,947)
Social Costs of Regulation[c]	($37,312)

[a] Portland cement quantity measured in short tons.
[b] Defined as engineering compliance cost divided by baseline revenues for facilities owned by small businesses.
[c] Social cost of regulation is the sum of consumer surplus and producer surplus.

TABLE F-1A. MARKET IMPACTS ASSOCIATED WITH MACT FLOOR ON MAJOR AND AREA SOURCES BY REGION: 1993

Market	Change in market price		Change in output: Domestic production		Change in output: Imports		Change in output: Market total	
	$/ton	Percent	10^3 tpy	Percent	10^3 tpy	Percent	10^3 tpy	Percent
Atlanta	$0.72	1.4%	(123.7)	-2.2%	48.4	9.6%	(75.3)	-1.2%
Baltimore/Philadelphia	$0.91	1.8%	(112.6)	-1.6%	0.0	0.0%	(112.6)	-1.6%
Birmingham	$0.38	0.8%	(43.8)	-1.0%	13.6	5.3%	(30.2)	-0.7%
Chicago	$0.43	0.8%	(34.3)	-1.0%	8.5	5.6%	(25.7)	-0.7%
Cincinnati	$0.99	1.8%	(47.0)	-1.6%	0.0	0.0%	(47.0)	-1.6%
Dallas	$0.52	1.1%	(49.9)	-1.0%	0.0	0.0%	(49.9)	-1.0%
Denver	$1.39	2.2%	(52.0)	-1.9%	0.0	0.0%	(52.0)	-1.9%
Detroit	$0.34	0.6%	(79.4)	-1.7%	47.8	4.3%	(31.6)	-0.5%
Florida	$0.66	1.1%	(154.8)	-5.0%	110.6	7.8%	(44.3)	-1.0%
Kansas City	$0.91	1.7%	(57.6)	-1.5%	0.0	0.0%	(57.6)	-1.5%
Los Angeles	$0.42	0.7%	(64.4)	-1.0%	21.5	4.7%	(42.8)	-0.6%
Minneapolis	$0.85	1.4%	(20.7)	-1.4%	0.7	0.4%	(20.0)	-1.2%
New York/Boston	$0.61	1.0%	(86.0)	-2.4%	47.9	7.2%	(38.1)	-0.9%
Phoenix	$0.61	0.9%	(24.1)	-0.8%	0.0	0.0%	(24.1)	-0.8%
Pittsburgh	$1.34	2.1%	(207.0)	-11.2%	153.1	14.8%	(53.8)	-1.9%
Salt Lake City	$1.21	1.6%	(59.9)	-3.9%	34.1	11.1%	(25.8)	-1.4%
San Antonio	$0.49	1.1%	(63.8)	-1.2%	12.5	7.5%	(51.3)	-0.9%
San Francisco	$0.32	0.6%	(32.5)	-1.1%	13.8	4.4%	(18.7)	-0.6%
Seattle	$0.19	0.3%	(30.9)	-2.7%	24.7	2.2%	(6.2)	-0.3%
St. Louis	$0.29	0.6%	(25.9)	-0.5%	0.0	0.0%	(25.9)	-0.5%
U.S. total/average	$0.63	1.1%	(1,370.3)	-1.8%	537.3	7.0%	(833.1)	-1.0%

TABLE F-1B. INDUSTRY IMPACTS ASSOCIATED WITH MACT FLOOR ON MAJOR AND AREA SOURCES BY REGION: 1993

Market	Change in revenue ($10³)	Change in cost ($10³)			Change in pre-tax earnings ($10³)	Closures		Change in emp.
		Regulatory cost	Production cost	Total cost		Plants	Kilns	
Atlanta	($2,362.4)	$2,444.8	($6,542.2)	($4,097.4)	$1,735.0	0	1	(29)
Baltimore/Philadelphia	$654.9	$3,928.5	($5,706.5)	($1,778.0)	$2,432.9	0	1	(41)
Birmingham	($603.6)	$1,265.6	($1,996.6)	($731.1)	$127.5	0	0	(7)
Chicago	($357.1)	$1,046.5	($1,773.8)	($727.3)	$370.3	0	0	(11)
Cincinnati	$280.5	$1,338.5	($2,315.5)	($977.1)	$1,257.6	0	0	(9)
Dallas	$288.4	$1,480.0	($2,288.5)	($808.5)	$1,096.9	0	0	(12)
Denver	$357.9	$1,852.8	($3,218.7)	($1,365.9)	$1,723.8	0	0	(12)
Detroit	($2,895.1)	$1,315.4	($4,220.6)	($2,905.2)	$10.1	0	0	(6)
Florida	($7,308.9)	$1,865.6	($8,722.2)	($6,856.6)	($452.3)	0	0	(31)
Kansas City	$350.1	$1,775.2	($2,878.0)	($1,102.8)	$1,452.9	0	0	(15)
Los Angeles	($1,202.7)	$2,065.8	($3,789.3)	($1,723.5)	$520.8	0	0	(15)
Minneapolis	($55.3)	$602.9	($971.5)	($368.6)	$313.3	0	0	(5)
New York/Boston	($2,999.2)	$2,178.8	($4,027.1)	($1,848.4)	($1,150.9)	0	0	(11)
Phoenix	$189.3	$1,079.8	($1,348.6)	($268.8)	$458.1	0	1	(4)
Pittsburgh	($1,019.2)	$1,393.7	($3,008.4)	($1,614.7)	$595.5	0	0	(15)
Salt Lake City	($2,797.5)	$1,665.8	($3,652.7)	($1,986.9)	($810.6)	0	0	(10)
San Antonio	($386.6)	$1,617.5	($2,485.3)	($867.7)	$481.2	0	0	(6)
San Francisco	($689.9)	$900.5	($1,559.0)	($658.5)	($31.5)	0	0	(8)
Seattle	($1,716.8)	$523.1	($1,674.3)	($1,151.2)	($565.6)	0	0	(3)
St. Louis	$160.5	$989.2	($1,238.0)	($248.8)	$409.3	0	0	(1)
U.S. total	($22,112.7)	$31,329.9	($63,416.8)	($32,086.9)	$9,974.3	0	3	(250)

TABLE F-1C. SOCIAL COSTS ASSOCIATED WITH MACT FLOOR ON MAJOR AND AREA SOURCES BY REGION: 1993

Market	Change in consumer surplus ($10³)	Change in producer surplus ($10³)			Social cost ($10³)[a]
		Domestic	Foreign	Total	
Atlanta	($4,402.1)	$1,735.0	$378.2	$2,113.2	($2,288.8)
Baltimore/Philadelphia	($6,506.7)	$2,432.9	$0.0	$2,432.9	($4,073.7)
Birmingham	($1,745.5)	$127.5	$101.2	$228.7	($1,516.9)
Chicago	($1,553.3)	$370.3	$67.2	$437.5	($1,115.8)
Cincinnati	($2,832.4)	$1,257.6	$0.0	$1,257.6	($1,574.8)
Dallas	($2,709.0)	$1,096.9	$0.0	$1,096.9	($1,612.1)
Denver	($3,709.2)	$1,723.8	$0.0	$1,723.8	($1,985.4)
Detroit	($2,021.6)	$10.1	$396.5	$406.6	($1,615.0)
Florida	($2,973.7)	($452.3)	$982.2	$529.9	($2,443.8)
Kansas City	($3,478.8)	$1,452.9	$0.0	$1,452.9	($2,025.9)
Los Angeles	($2,987.6)	$520.8	$195.0	$715.8	($2,271.8)
Minneapolis	($1,385.1)	$313.3	$152.1	$465.4	($919.7)
New York/Boston	($2,540.2)	($1,150.9)	$420.9	($730.0)	($3,270.2)
Phoenix	($1,760.0)	$458.1	$0.0	$458.1	($1,301.9)
Pittsburgh	($3,824.5)	$595.5	$1,501.0	$2,096.5	($1,728.0)
Salt Lake City	($2,214.5)	($810.6)	$394.1	($416.5)	($2,631.0)
San Antonio	($2,663.1)	$481.2	$86.2	$567.4	($2,095.7)
San Francisco	($1,082.3)	($31.5)	$103.0	$71.5	($1,010.8)
Seattle	($434.8)	($565.6)	$223.2	($342.4)	($777.3)
St. Louis	($1,462.2)	$409.3	$0.0	$409.3	($1,052.9)
U.S. total	($52,286.5)	$9,974.3	$5,000.7	$14,974.9	($37,311.6)

[a] Changes from baseline at the national-level reflect the sum of the mean observations across each of the 20 regions.

FIGURE F-2. U.S. SUMMARY OF ECONOMIC IMPACTS FOR BTF OPTION 1 ON MAJOR AND AREA SOURCES

Market Impacts	Baseline	With Regulation	Changes from baseline: Absolute	Changes from baseline: Percent
Portland Cement				
Market Price ($/ton)	$55.49	$57.07	$1.58	2.84%
Market Output (10^3 tpy)[a]	83,321.4	81,212.9	(2,108.5)	-2.53%
Domestic Production	75,592.3	72,226.2	(3,366.1)	-4.45%
ROW Production	3,775.3	4,377.2	601.9	15.94%
CAN Production	3,953.8	4,609.4	655.7	16.58%

Portland Cement Industry Impacts	Baseline	With Regulation	Changes from baseline: Absolute	Changes from baseline: Percent
Revenues ($$10^3$)	$4,165,036	$4,104,406	($60,630)	-1.46%
Costs ($$10^3$)	$3,514,212	$3,441,283	($72,929)	-2.08%
Post-reg. control costs	--	$81,252	--	
Cost of production adj.	$3,514,212	$3,360,031	($154,181)	-4.39%
Pre-tax Earnings ($$10^3$)	$650,824	$663,122	$12,298	1.89%
Operating Entities				
Plants	105	105	0	0.00%
Kilns	201	195	-6	-2.90%
Employment	13603	13043	-560	-4.12%

Small Business Impacts	Baseline	With Regulation	Changes from baseline: Absolute	Changes from baseline: Percent
Revenues ($$10^3$)	$387,053	$373,292	($13,762)	-3.56%
Costs ($$10^3$)	$327,809	$316,508	($11,302)	-3.45%
Post-reg. control costs	--	$8,905	--	
Cost of production adj.	$327,809	$307,602	($20,207)	-6.16%
Pre-tax Earnings ($$10^3$)	$59,244	$56,784	($2,460)	-4.15%
Operating Entities				
Plants	9	9	0	0.00%
Kilns	22	21	-1	-3.38%
Employment	1,199	1,115	-84	-6.98%
Cost Share as % of Revenues[b]	--	2.62%	--	--

Social Cost Impacts	Change in value ($$10^3$)
Consumer Surplus	($128,672)
Producer Surplus	$25,075
Domestic Producers	$12,298
Foreign Producers	$12,777
Worker Dislocation Costs	($4,362)
Social Costs of Regulation[c]	($103,597)

[a] Portland cement quantity measured in short tons.
[b] Defined as engineering compliance cost divided by baseline revenues for facilities owned by small businesses.
[c] Social cost of regulation is the sum of consumer surplus and producer surplus.

TABLE F-2A. MARKET IMPACTS ASSOCIATED WITH BTF OPTION 1 ON MAJOR AND AREA SOURCES BY REGION: 1993

Market	Change in market price		Change in output: Domestic production		Change in output: Imports		Change in output: Market total	
	$/ton	Percent	10^3 tpy	Percent	10^3 tpy	Percent	10^3 tpy	Percent
Atlanta	$1.46	2.81%	($252.1)	-4.43%	98.58	19.64%	(153.54)	-2.48%
Baltimore/Philadelphia	$2.01	3.90%	($247.7)	-3.45%	0.00	0.00%	(247.65)	-3.45%
Birmingham	$0.89	1.76%	($102.2)	-2.39%	31.64	12.31%	(70.60)	-1.55%
Chicago	$1.49	2.78%	($119.8)	-3.42%	29.83	19.49%	(89.94)	-2.46%
Cincinnati	$1.75	3.25%	($82.8)	-2.87%	0.00	0.00%	(82.79)	-2.87%
Dallas	$1.71	3.54%	($162.3)	-3.13%	0.00	0.00%	(162.31)	-3.13%
Denver	$2.88	4.52%	($107.5)	-4.00%	0.00	0.00%	(107.46)	-4.00%
Detroit	$1.31	2.31%	($302.5)	-6.36%	182.19	16.19%	(120.35)	-2.05%
Florida	$1.21	2.02%	($281.1)	-9.14%	200.78	14.15%	(80.35)	-1.79%
Kansas City	$1.65	3.07%	($104.6)	-2.71%	0.00	0.00%	(104.62)	-2.71%
Los Angeles	$1.30	2.09%	($199.7)	-2.97%	66.82	14.66%	(132.92)	-1.85%
Minneapolis	$2.76	4.53%	($67.2)	-4.66%	2.22	1.24%	(64.93)	-4.01%
New York/Boston	$1.49	2.51%	($210.1)	-5.95%	116.94	17.59%	(93.19)	-2.22%
Phoenix	$1.75	2.69%	($68.9)	-2.38%	0.00	0.00%	(68.88)	-2.38%
Pittsburgh	$2.38	3.76%	($368.0)	-19.92%	272.31	26.29%	(95.74)	-3.32%
Salt Lake City	$1.95	2.55%	($96.2)	-6.28%	54.80	17.84%	(41.43)	-2.25%
San Antonio	$1.87	4.05%	($242.3)	-4.60%	47.64	28.36%	(194.70)	-3.58%
San Francisco	$2.08	4.07%	($211.8)	-6.87%	89.62	28.47%	(122.14)	-3.60%
Seattle	$0.50	0.80%	($80.3)	-7.13%	64.25	5.60%	(16.08)	-0.71%
St. Louis	$0.66	1.32%	($58.9)	-1.17%	0.00	0.00%	(58.92)	-1.17%
U.S. total/average	$1.58	2.84%	($3,366.1)	-4.45%	1,257.61	16.27%	(2,108.53)	-2.53%

TABLE F-2B. INDUSTRY IMPACTS ASSOCIATED WITH BTF OPTION 1 ON MAJOR AND AREA SOURCES BY REGION: 1993

Market	Change in revenue ($10³)	Change in cost ($10³)			Change in pre-tax earnings ($10³)	Closures		Change in emp.
		Regulatory cost	Production cost	Total cost		Plants	Kilns	
Atlanta	($4,505.9)	$5,358.4	($12,036.3)	($6,677.9)	$2,172.0	0	2	(60)
Baltimore/Philadelphia	$842.6	$10,042.3	($12,359.4)	($2,317.0)	$3,159.6	0	2	(70)
Birmingham	($1,583.5)	$2,688.0	($4,581.4)	($1,893.5)	$310.0	0	0	(15)
Chicago	($1,528.6)	$3,436.1	($5,747.8)	($2,311.8)	$783.2	0	0	(30)
Cincinnati	$307.2	$2,289.5	($3,958.5)	($1,669.0)	$1,976.3	0	0	(17)
Dallas	$538.3	$3,705.0	($7,037.1)	($3,332.2)	$3,870.5	0	0	(33)
Denver	$417.4	$4,345.5	($6,143.9)	($1,798.3)	$2,215.7	0	0	(23)
Detroit	($11,648.4)	$4,203.3	($15,875.8)	($11,672.5)	$24.1	0	0	(24)
Florida	($13,600.7)	$4,297.2	($14,871.1)	($10,573.9)	($3,026.9)	0	1	(51)
Kansas City	$483.8	$3,528.4	($5,213.4)	($1,685.0)	$2,168.8	0	0	(22)
Los Angeles	($4,175.3)	$7,191.5	($11,208.4)	($4,016.9)	($158.4)	0	0	(37)
Minneapolis	($474.6)	$1,939.2	($3,195.6)	($1,256.5)	$781.8	0	0	(16)
New York/Boston	($7,784.2)	$5,066.3	($9,981.4)	($4,915.1)	($2,869.2)	0	0	(31)
Phoenix	$355.9	$3,715.3	($3,778.0)	($62.7)	$418.6	0	1	(11)
Pittsburgh	($2,005.8)	$2,345.5	($5,251.8)	($2,906.3)	$900.4	0	0	(25)
Salt Lake City	($4,649.3)	$2,784.4	($5,990.2)	($3,205.8)	($1,443.5)	0	0	(18)
San Antonio	($2,131.9)	$7,086.4	($9,534.6)	($2,448.2)	$316.3	0	0	(26)
San Francisco	($5,292.7)	$3,942.7	($10,247.4)	($6,304.8)	$1,012.0	0	0	(45)
Seattle	($4,522.9)	$1,308.5	($4,284.2)	($2,975.7)	($1,547.2)	0	0	(7)
St. Louis	$328.6	$1,978.7	($2,884.3)	($905.6)	$1,234.2	0	0	0
U.S. total	($60,630.2)	$81,251.9	($154,180.5)	($72,928.6)	$12,298.4	0	6	(560)

TABLE F-2C. SOCIAL COSTS ASSOCIATED WITH BTF OPTION 1 ON MAJOR AND AREA SOURCES BY REGION: 1993

Market	Change in consumer surplus ($10³)	Change in producer surplus ($10³)			Social cost ($10³)[a]
		Domestic	Foreign	Total	
Atlanta	($8,841.7)	$2,172.0	$853.0	$3,025.0	($5,816.7)
Baltimore/Philadelphia	($14,015.0)	$3,159.6	$0.0	$3,159.6	($10,855.4)
Birmingham	($4,134.8)	$310.0	$263.2	$573.2	($3,561.6)
Chicago	($5,325.0)	$783.2	$270.0	$1,053.1	($4,271.9)
Cincinnati	($4,893.9)	$1,976.3	$0.0	$1,976.3	($2,917.7)
Dallas	($8,614.3)	$3,870.5	$0.0	$3,870.5	($4,743.9)
Denver	($7,505.4)	$2,215.7	$0.0	$2,215.7	($5,289.6)
Detroit	($7,577.6)	$24.1	$1,697.0	$1,721.1	($5,856.5)
Florida	($5,351.5)	($3,026.9)	$1,901.6	($1,125.3)	($6,476.8)
Kansas City	($6,238.5)	$2,168.8	$0.0	$2,168.8	($4,069.6)
Los Angeles	($9,124.7)	($158.4)	$679.2	$520.8	($8,603.9)
Minneapolis	($4,646.1)	$781.8	$499.3	$1,281.2	($3,364.9)
New York/Boston	($6,105.5)	($2,869.2)	$1,155.3	($1,713.9)	($7,819.4)
Phoenix	($4,939.8)	$418.6	$0.0	$418.6	($4,521.2)
Pittsburgh	($6,703.5)	$900.4	$2,944.2	$3,844.7	($2,858.8)
Salt Lake City	($3,520.8)	($1,443.5)	$677.7	($765.7)	($4,286.6)
San Antonio	($9,846.1)	$316.3	$392.6	$708.9	($9,137.3)
San Francisco	($6,820.1)	$1,012.0	$839.6	$1,851.6	($4,968.5)
Seattle	($1,124.2)	($1,547.2)	$604.2	($942.9)	($2,067.2)
St. Louis	($3,343.9)	$1,234.2	$0.0	$1,234.2	($2,109.7)
U.S. total	($128,672.3)	$12,298.4	$12,776.9	$25,075.3	($103,597.0)

[a] Changes from baseline at the national-level reflect the sum of the mean observations across each of the 20 regions.

FIGURE F-3. U.S. SUMMARY OF ECONOMIC IMPACTS FOR BTF OPTION 2 ON MAJOR AND AREA SOURCES

Market Impacts	Baseline	With Regulation	Changes from baseline: Absolute	Changes from baseline: Percent
Portland Cement				
Market Price ($/ton)	$55.49	$56.92	$1.43	2.57%
Market Output (10^3 tpy)[a]	83,321.4	81,412.8	(1,908.6)	-2.29%
Domestic Production	75,592.3	72,584.6	(3,007.7)	-3.98%
ROW Production	3,775.3	4,282.8	507.5	13.44%
CAN Production	3,953.8	4,545.4	591.6	14.96%

Portland Cement Industry Impacts	Baseline	With Regulation	Changes from baseline: Absolute	Changes from baseline: Percent
Revenues ($\$10^3$)	$4,165,036	$4,116,176	($48,860)	-1.17%
Costs ($\$10^3$)	$3,514,212	$3,432,514	($81,698)	-2.32%
Post-reg. control costs	--	$55,367	--	
Cost of production adj.	$3,514,212	$3,377,147	($137,065)	-3.90%
Pre-tax Earnings ($\$10^3$)	$650,824	$683,662	$32,838	5.05%
Operating Entities				
Plants	105	105	0	0.00%
Kilns	201	192	-9	-4.39%
Employment	13603	13118	-485	-3.57%

Small Business Impacts	Baseline	With Regulation	Changes from baseline: Absolute	Changes from baseline: Percent
Revenues ($\$10^3$)	$387,053	$375,464	($11,589)	-2.99%
Costs ($\$10^3$)	$327,809	$315,783	($12,026)	-3.67%
Post-reg. control costs	--	$6,424	--	
Cost of production adj.	$327,809	$309,359	($18,450)	-5.63%
Pre-tax Earnings ($\$10^3$)	$59,244	$59,681	$437	0.74%
Operating Entities				
Plants	9	9	0	0.00%
Kilns	22	21	-1	-5.84%
Employment	1,199	1,122	-77	-6.40%
Cost Share as % of Revenues[b]	--	2.08%	--	--

Social Cost Impacts	Change in value ($\$10^3$)
Consumer Surplus	($117,176)
Producer Surplus	$43,534
Domestic Producers	$32,838
Foreign Producers	$10,696
Worker Dislocation Costs	($3,775)
Social Costs of Regulation[c]	($73,642)

[a] Portland cement quantity measured in short tons.
[b] Defined as engineering compliance cost divided by baseline revenues for facilities owned by small businesses.
[c] Social cost of regulation is the sum of consumer surplus and producer surplus.

TABLE F-3A. MARKET IMPACTS ASSOCIATED WITH BTF OPTION 2 ON MAJOR AND AREA SOURCES BY REGION: 1993

Market	Change in market price		Change in output					
			Domestic production		Imports		Market total	
	$/ton	Percent	10^3 tpy	Percent	10^3 tpy	Percent	10^3 tpy	Percent
Atlanta	$1.10	2.12%	(190.4)	-3.35%	74.4	14.83%	(115.9)	-1.87%
Baltimore/Philadelphia	$2.28	4.43%	(281.1)	-3.92%	0.0	0.00%	(281.1)	-3.92%
Birmingham	$1.03	2.03%	(118.3)	-2.76%	36.6	14.24%	(81.7)	-1.80%
Chicago	$0.94	1.76%	(75.7)	-2.16%	18.8	12.31%	(56.8)	-1.55%
Cincinnati	$2.04	3.79%	(96.6)	-3.35%	0.0	0.00%	(96.6)	-3.35%
Dallas	$1.42	2.93%	(134.6)	-2.59%	0.0	0.00%	(134.6)	-2.59%
Denver	$2.58	4.05%	(96.3)	-3.58%	0.0	0.00%	(96.3)	-3.58%
Detroit	$1.00	1.77%	(231.5)	-4.86%	139.4	12.39%	(92.1)	-1.56%
Florida	$1.14	1.90%	(264.7)	-8.60%	189.0	13.32%	(75.6)	-1.68%
Kansas City	$1.96	3.64%	(124.0)	-3.22%	0.0	0.00%	(124.0)	-3.22%
Los Angeles	$1.28	2.07%	(197.0)	-2.93%	65.9	14.46%	(131.1)	-1.83%
Minneapolis	$1.94	3.18%	(47.2)	-3.27%	1.6	0.87%	(45.6)	-2.82%
New York/Boston	$1.33	2.24%	(187.4)	-5.31%	104.3	15.69%	(83.1)	-1.98%
Phoenix	$1.24	1.90%	(48.7)	-1.68%	0.0	0.00%	(48.7)	-1.68%
Pittsburgh	$2.42	3.82%	(374.0)	-20.24%	276.7	26.72%	(97.3)	-3.37%
Salt Lake City	$1.86	2.43%	(91.7)	-5.99%	52.2	17.01%	(39.5)	-2.15%
San Antonio	$1.77	3.83%	(228.9)	-4.34%	45.0	26.78%	(183.9)	-3.38%
San Francisco	$0.85	1.65%	(86.0)	-2.79%	36.4	11.56%	(49.6)	-1.46%
Seattle	$0.45	0.73%	(73.4)	-6.51%	58.7	5.11%	(14.7)	-0.65%
St. Louis	$0.67	1.35%	(60.3)	-1.20%	0.0	0.00%	(60.3)	-1.20%
U.S. total/average	$1.43	2.57%	(3,007.7)	-3.98%	1,099.1	14.22%	(1,908.6)	-2.29%

TABLE F-3B. INDUSTRY IMPACTS ASSOCIATED WITH BTF OPTION 2 ON MAJOR AND AREA SOURCES BY REGION: 1993

Market	Change in revenue ($$10^3$)	Change in cost ($$10^3$) Regulatory cost	Production cost	Total cost	Change in pre-tax earnings ($$10^3$)	Closures Plants	Kilns	Change in emp.
Atlanta	($3,918.1)	$3,706.3	($9,880.4)	($6,174.1)	$2,256.0	0	2	(45)
Baltimore/Philadelphia	$1,169.3	$6,734.3	($13,875.7)	($7,141.4)	$8,310.7	0	2	(76)
Birmingham	($1,741.3)	$2,524.2	($5,445.5)	($2,921.4)	$1,180.1	0	0	(17)
Chicago	($879.0)	$2,100.2	($3,756.3)	($1,656.1)	$777.1	0	0	(23)
Cincinnati	$446.8	$2,490.2	($4,628.1)	($2,137.9)	$2,584.7	0	0	(20)
Dallas	$581.1	$2,110.4	($5,901.9)	($3,791.5)	$4,372.6	0	0	(29)
Denver	$516.4	$3,096.3	($5,624.6)	($2,528.4)	$3,044.7	0	1	(21)
Detroit	($8,669.1)	$2,094.0	($12,269.2)	($10,175.3)	$1,506.2	0	0	(14)
Florida	($12,663.5)	$2,928.6	($13,868.8)	($10,940.3)	($1,723.3)	0	1	(53)
Kansas City	$633.1	$2,902.7	($6,061.8)	($3,159.1)	$3,792.2	0	0	(25)
Los Angeles	($3,883.3)	$5,028.9	($11,321.7)	($6,292.7)	$2,409.4	0	1	(38)
Minneapolis	($246.2)	$1,122.5	($2,235.1)	($1,112.6)	$866.4	0	0	(11)
New York/Boston	($6,726.3)	$3,678.6	($8,958.3)	($5,279.7)	($1,446.6)	0	0	(22)
Phoenix	$313.0	$2,444.7	($2,558.4)	($113.7)	$426.6	0	1	(8)
Pittsburgh	($1,984.4)	$1,863.7	($5,291.4)	($3,427.7)	$1,443.3	0	0	(24)
Salt Lake City	($4,356.5)	$2,038.8	($5,495.0)	($3,456.1)	($900.4)	0	0	(14)
San Antonio	($1,791.1)	$3,507.7	($8,923.9)	($5,416.2)	$3,625.1	0	1	(20)
San Francisco	($1,885.5)	$2,086.2	($4,101.7)	($2,015.5)	$130.0	0	0	(20)
Seattle	($4,110.5)	$1,157.4	($3,924.8)	($2,767.4)	($1,343.2)	0	0	(6)
St. Louis	$335.3	$1,751.7	($2,942.5)	($1,190.7)	$1,526.0	0	0	0
U.S. total	($48,860.0)	$55,367.4	($137,065.1)	($81,697.7)	$32,837.7	0	9	(485)

TABLE F-3C. SOCIAL COSTS ASSOCIATED WITH BTF OPTION 2 ON MAJOR AND AREA SOURCES BY REGION: 1993

Market	Change in consumer surplus ($10^3)	Change in producer surplus ($10^3)			Social cost ($10^3)[a]
		Domestic	Foreign	Total	
Atlanta	($6,725.2)	$2,256.0	$612.9	$2,868.9	($3,856.2)
Baltimore/Philadelphia	($16,015.1)	$8,310.7	$0.0	$8,310.7	($7,704.4)
Birmingham	($4,754.3)	$1,180.1	$290.5	$1,470.6	($3,283.7)
Chicago	($3,396.4)	$777.1	$159.7	$936.9	($2,459.5)
Cincinnati	($5,753.7)	$2,584.7	$0.0	$2,584.7	($3,169.0)
Dallas	($7,210.4)	$4,372.6	$0.0	$4,372.6	($2,837.8)
Denver	($6,800.0)	$3,044.7	$0.0	$3,044.7	($3,755.3)
Detroit	($5,845.5)	$1,506.2	$1,225.3	$2,731.4	($3,114.0)
Florida	($5,058.1)	($1,723.3)	$1,740.0	$16.7	($5,041.4)
Kansas City	($7,404.3)	$3,792.2	$0.0	$3,792.2	($3,612.1)
Los Angeles	($9,077.5)	$2,409.4	$630.6	$3,040.1	($6,037.5)
Minneapolis	($3,221.2)	$866.4	$349.3	$1,215.7	($2,005.6)
New York/Boston	($5,493.0)	($1,446.6)	$970.2	($476.4)	($5,969.4)
Phoenix	($3,524.8)	$426.6	$0.0	$426.6	($3,098.2)
Pittsburgh	($6,839.6)	$1,443.3	$2,915.3	$4,358.6	($2,481.1)
Salt Lake City	($3,371.7)	($900.4)	$624.7	($275.7)	($3,647.5)
San Antonio	($9,389.5)	$3,625.1	$348.9	$3,974.1	($5,415.5)
San Francisco	($2,844.6)	$130.0	$285.2	$415.1	($2,429.4)
Seattle	($1,028.7)	($1,343.2)	$543.8	($799.3)	($1,828.0)
St. Louis	($3,422.8)	$1,526.0	$0.0	$1,526.0	($1,896.8)
U.S. total	($117,176.3)	$32,837.7	$10,696.4	$43,534.1	($73,642.2)

[a] Changes from baseline at the national-level reflect the sum of the mean observations across each of the 20 regions.

FIGURE F-4. U.S. SUMMARY OF ECONOMIC IMPACTS FOR MACT FLOOR ON MAJOR SOURCES

Market Impacts	Baseline	With Regulation	Changes from baseline: Absolute	Changes from baseline: Percent
Portland Cement				
Market Price ($/ton)	$55.49	$56.06	$0.57	1.02%
Market Output (10^3 tpy)[a]	83,321.4	82,575.3	(746.1)	-0.90%
Domestic Production	75,592.3	74,365.3	(1,227.0)	-1.62%
ROW Production	3,775.3	3,986.3	211.0	5.59%
CAN Production	3,953.8	4,223.7	269.9	6.83%

Portland Cement Industry Impacts	Baseline	With Regulation	Changes from baseline: Absolute	Changes from baseline: Percent
Revenues ($\$10^3$)	$4,165,036	$4,145,827	($19,209)	-0.46%
Costs ($\$10^3$)	$3,514,212	$3,486,450	($27,762)	-0.79%
Post-reg. control costs	--	$28,620	--	
Cost of production adj.	$3,514,212	$3,457,830	($56,382)	-1.60%
Pre-tax Earnings ($\$10^3$)	$650,824	$659,377	$8,553	1.31%
Operating Entities				
Plants	105	105	0	0.00%
Kilns	201	199	-2	-1.18%
Employment	13603	13383	-220	-1.62%

Small Business Impacts	Baseline	With Regulation	Changes from baseline: Absolute	Changes from baseline: Percent
Revenues ($\$10^3$)	$387,053	$380,334	($6,720)	-1.74%
Costs ($\$10^3$)	$327,809	$321,509	($6,300)	-1.92%
Post-reg. control costs	--	$3,198	--	
Cost of production adj.	$327,809	$318,310	($9,499)	-2.90%
Pre-tax Earnings ($\$10^3$)	$59,244	$58,825	($419)	-0.71%
Operating Entities				
Plants	9	9	0	0.00%
Kilns	22	22	0	-0.13%
Employment	1,199	1,154	-45	-3.72%
Cost Share as % of Revenues[b]	--	0.89%	--	--

Social Cost Impacts	Change in value ($\$10^3$)
Consumer Surplus	($46,921)
Producer Surplus	$13,023
Domestic Producers	$8,553
Foreign Producers	$4,470
Worker Dislocation Costs	($1,710)
Social Costs of Regulation[c]	($33,898)

[a] Portland cement quantity measured in short tons.
[b] Defined as engineering compliance cost divided by baseline revenues for facilities owned by small businesses.
[c] Social cost of regulation is the sum of consumer surplus and producer surplus.

TABLE F-4A. MARKET IMPACTS ASSOCIATED WITH MACT FLOOR ON MAJOR SOURCES BY REGION: 1993

Market	Change in market price		Change in output					
			Domestic production		Imports		Market total	
	$/ton	Percent	10^3 tpy	Percent	10^3 tpy	Percent	10^3 tpy	Percent
Atlanta	$0.63	1.21%	(108.5)	-1.91%	42.4	8.45%	(66.1)	-1.07%
Baltimore/Philadelphia	$0.85	1.65%	(104.9)	-1.46%	0.0	0.00%	(104.9)	-1.46%
Birmingham	$0.35	0.70%	(40.5)	-0.95%	12.5	4.88%	(28.0)	-0.62%
Chicago	$0.36	0.67%	(28.7)	-0.82%	7.2	4.67%	(21.6)	-0.59%
Cincinnati	$0.85	1.58%	(40.3)	-1.40%	0.0	0.00%	(40.3)	-1.40%
Dallas	$0.45	0.93%	(42.6)	-0.82%	0.0	0.00%	(42.6)	-0.82%
Denver	$1.25	1.97%	(46.7)	-1.74%	0.0	0.00%	(46.7)	-1.74%
Detroit	$0.34	0.61%	(79.4)	-1.67%	47.8	4.25%	(31.6)	-0.54%
Florida	$0.55	0.92%	(127.4)	-4.14%	91.0	6.41%	(36.4)	-0.81%
Kansas City	$0.82	1.52%	(51.7)	-1.34%	0.0	0.00%	(51.7)	-1.34%
Los Angeles	$0.40	0.64%	(61.1)	-0.91%	20.5	4.49%	(40.7)	-0.57%
Minneapolis	$0.79	1.29%	(19.2)	-1.33%	0.6	0.35%	(18.5)	-1.14%
New York/Boston	$0.49	0.83%	(69.6)	-1.97%	38.8	5.83%	(30.9)	-0.74%
Phoenix	$0.62	0.96%	(24.5)	-0.85%	0.0	0.00%	(24.5)	-0.85%
Pittsburgh	$1.28	2.02%	(198.1)	-10.72%	146.6	14.15%	(51.5)	-1.79%
Salt Lake City	$1.02	1.33%	(50.3)	-3.28%	28.6	9.32%	(21.6)	-1.18%
San Antonio	$0.40	0.88%	(52.4)	-0.99%	10.3	6.13%	(42.1)	-0.77%
San Francisco	$0.27	0.52%	(27.2)	-0.88%	11.5	3.65%	(15.7)	-0.46%
Seattle	$0.18	0.29%	(29.0)	-2.57%	23.2	2.02%	(5.8)	-0.26%
St. Louis	$0.28	0.56%	(24.9)	-0.49%	0.0	0.00%	(24.9)	-0.49%
U.S. total/average	$0.57	1.02%	(1,227.0)	-1.62%	480.9	6.22%	(746.1)	-0.90%

TABLE F-4B. INDUSTRY IMPACTS ASSOCIATED WITH MACT FLOOR ON MAJOR SOURCES BY REGION: 1993

Market	Change in revenue ($10³)	Change in cost ($10³)			Change in pre-tax earnings ($10³)	Closures		Change in emp.
		Regulatory cost	Production cost	Total cost		Plants	Kilns	
Atlanta	($2,142.7)	$2,255.0	($5,774.5)	($3,519.5)	$1,376.8	0	1	(25)
Baltimore/Philadelphia	$616.1	$3,807.9	($5,336.0)	($1,528.0)	$2,144.1	0	0	(34)
Birmingham	($557.0)	$1,155.8	($1,846.0)	($690.2)	$133.2	0	0	(6)
Chicago	($297.4)	$924.1	($1,458.3)	($534.2)	$236.7	0	0	(9)
Cincinnati	$245.2	$1,225.0	($1,971.1)	($746.1)	$991.3	0	0	(8)
Dallas	$248.9	$1,284.3	($1,943.8)	($659.5)	$908.4	0	0	(10)
Denver	$328.2	$1,596.1	($2,875.6)	($1,279.4)	$1,607.7	0	0	(11)
Detroit	($2,894.3)	$1,408.0	($4,165.5)	($2,757.5)	($136.9)	0	0	(7)
Florida	($6,002.6)	$1,666.2	($7,142.4)	($5,476.2)	($526.4)	0	0	(26)
Kansas City	$320.9	$1,702.2	($2,574.5)	($872.3)	$1,193.2	0	0	(15)
Los Angeles	($1,141.0)	$2,017.9	($3,704.4)	($1,686.5)	$545.5	0	0	(14)
Minneapolis	($49.0)	$564.9	($904.8)	($340.0)	$291.0	0	0	(4)
New York/Boston	($2,420.6)	$1,775.0	($3,252.8)	($1,477.8)	($942.7)	0	0	(9)
Phoenix	$192.5	$1,056.2	($1,363.3)	($307.1)	$499.6	0	1	(4)
Pittsburgh	($972.0)	$1,235.0	($2,881.1)	($1,646.1)	$674.1	0	0	(15)
Salt Lake City	($2,339.9)	$1,442.4	($3,076.8)	($1,634.4)	($705.5)	0	0	(9)
San Antonio	($314.4)	$1,281.1	($2,042.2)	($761.1)	$446.7	0	0	(4)
San Francisco	($575.4)	$804.2	($1,301.3)	($497.1)	($78.3)	0	0	(7)
Seattle	($1,609.4)	$487.3	($1,576.6)	($1,089.3)	($520.1)	0	0	(2)
St. Louis	$154.7	$931.1	($1,191.2)	($260.0)	$414.8	0	0	(1)
U.S. total	($19,209.3)	$28,619.9	($56,382.1)	($27,762.2)	$8,552.9	0	2	(220)

TABLE F-4C. SOCIAL COSTS ASSOCIATED WITH MACT FLOOR ON MAJOR SOURCES BY REGION: 1993

Market	Change in consumer surplus ($$10^3$)	Change in producer surplus ($$10^3$)			Social cost ($$10^3$)[a]
		Domestic	Foreign	Total	
Atlanta	($3,863.3)	$1,376.8	$329.3	$1,706.1	($2,157.2)
Baltimore/Philadelphia	($6,066.0)	$2,144.1	$0.0	$2,144.1	($3,921.9)
Birmingham	($1,613.9)	$133.2	$93.4	$226.5	($1,387.4)
Chicago	($1,302.5)	$236.7	$56.1	$292.9	($1,009.6)
Cincinnati	($2,431.7)	$991.3	$0.0	$991.3	($1,440.3)
Dallas	($2,315.8)	$908.4	$0.0	$908.4	($1,407.4)
Denver	($3,335.7)	$1,607.7	$0.0	$1,607.7	($1,728.1)
Detroit	($2,021.4)	($136.9)	$396.3	$259.4	($1,762.0)
Florida	($2,448.1)	($526.4)	$804.3	$277.9	($2,170.2)
Kansas City	($3,126.3)	$1,193.2	$0.0	$1,193.2	($1,933.1)
Los Angeles	($2,839.1)	$545.5	$185.0	$730.5	($2,108.6)
Minneapolis	($1,284.9)	$291.0	$141.2	$432.1	($852.8)
New York/Boston	($2,058.5)	($942.7)	$338.6	($604.1)	($2,662.6)
Phoenix	($1,789.6)	$499.6	$0.0	$499.6	($1,290.0)
Pittsburgh	($3,661.8)	$674.1	$1,431.7	$2,105.8	($1,556.0)
Salt Lake City	($1,858.5)	($705.5)	$328.7	($376.8)	($2,235.3)
San Antonio	($2,187.5)	$446.7	$70.5	$517.2	($1,670.4)
San Francisco	($904.7)	($78.3)	$85.8	$7.5	($897.3)
Seattle	($408.0)	($520.1)	$208.9	($311.2)	($719.3)
St. Louis	($1,403.9)	$414.8	$0.0	$414.8	($989.2)
U.S. total	($46,921.2)	$8,552.9	$4,469.8	$13,022.7	($33,898.4)

[a] Changes from baseline at the national-level reflect the sum of the mean observations across each of the 20 regions.

FIGURE F-5. U.S. SUMMARY OF ECONOMIC IMPACTS FOR BTF OPTION 1 ON MAJOR SOURCES

Market Impacts	Baseline	With Regulation	Changes from baseline Absolute	Changes from baseline Percent
Portland Cement				
Market Price ($/ton)	$55.49	$57.10	$1.61	2.90%
Market Output (10^3 tpy)[a]	83,321.4	81,177.8	(2,143.6)	-2.57%
Domestic Production	75,592.3	72,157.3	(3,435.0)	-4.54%
ROW Production	3,775.3	4,345.6	570.3	15.11%
CAN Production	3,953.8	4,674.9	721.2	18.24%

Portland Cement Industry Impacts	Baseline	With Regulation	Changes from baseline Absolute	Changes from baseline Percent
Revenues ($\$10^3$)	$4,165,036	$4,108,208	($56,828)	-1.36%
Costs ($\$10^3$)	$3,514,212	$3,419,293	($94,919)	-2.70%
Post-reg. control costs	--	$59,411	--	
Cost of production adj.	$3,514,212	$3,359,882	($154,330)	-4.39%
Pre-tax Earnings ($\$10^3$)	$650,824	$688,915	$38,091	5.85%
Operating Entities				
Plants	105	105	0	-0.05%
Kilns	201	191	-10	-4.82%
Employment	13603	13063	-540	-3.97%

Small Business Impacts	Baseline	With Regulation	Changes from baseline Absolute	Changes from baseline Percent
Revenues ($\$10^3$)	$387,053	$370,350	($16,703)	-4.32%
Costs ($\$10^3$)	$327,809	$310,802	($17,007)	-5.19%
Post-reg. control costs	--	$6,769	--	
Cost of production adj.	$327,809	$304,034	($23,776)	-7.25%
Pre-tax Earnings ($\$10^3$)	$59,244	$59,548	$304	0.51%
Operating Entities				
Plants	9	9	0	0.00%
Kilns	22	20	-2	-8.18%
Employment	1,199	1,098	-101	-8.45%
Cost Share as % of Revenues[b]	--	2.31%	--	--

Social Cost Impacts	Change in value ($\$10^3$)
Consumer Surplus	($131,969)
Producer Surplus	$50,890
Domestic Producers	$38,091
Foreign Producers	$12,799
Worker Dislocation Costs	($4,205)
Social Costs of Regulation[c]	($81,079)

[a] Portland cement quantity measured in short tons.
[b] Defined as engineering compliance cost divided by baseline revenues for facilities owned by small businesses.
[c] Social cost of regulation is the sum of consumer surplus and producer surplus.

TABLE F-5A. MARKET IMPACTS ASSOCIATED WITH BTF OPTION 1 ON MAJOR SOURCES BY REGION: 1993

Market	Change in market price		Change in output					
			Domestic production		Imports		Market total	
	$/ton	Percent	10^3 tpy	Percent	10^3 tpy	Percent	10^3 tpy	Percent
Atlanta	$1.25	2.41%	(216.3)	-3.80%	84.6	16.85%	(131.7)	-2.13%
Baltimore/Philadelphia	$2.43	4.71%	(298.8)	-4.16%	0.0	0.00%	(298.8)	-4.16%
Birmingham	$1.30	2.56%	(148.6)	-3.47%	46.0	17.89%	(102.6)	-2.26%
Chicago	$1.01	1.89%	(81.3)	-2.32%	20.3	13.23%	(61.1)	-1.67%
Cincinnati	$2.41	4.48%	(114.3)	-3.96%	0.0	0.00%	(114.3)	-3.96%
Dallas	$1.54	3.20%	(146.7)	-2.83%	0.0	0.00%	(146.7)	-2.83%
Denver	$2.92	4.58%	(108.8)	-4.05%	0.0	0.00%	(108.8)	-4.05%
Detroit	$1.24	2.19%	(286.8)	-6.03%	172.7	15.35%	(114.1)	-1.94%
Florida	$1.21	2.03%	(282.1)	-9.17%	201.4	14.20%	(80.6)	-1.79%
Kansas City	$1.97	3.66%	(124.8)	-3.24%	0.0	0.00%	(124.8)	-3.24%
Los Angeles	$1.34	2.16%	(205.8)	-3.06%	68.8	15.11%	(137.0)	-1.91%
Minneapolis	$2.36	3.88%	(57.4)	-3.98%	1.9	1.06%	(55.5)	-3.43%
New York/Boston	$1.56	2.64%	(220.7)	-6.25%	122.8	18.48%	(97.9)	-2.33%
Phoenix	$1.65	2.55%	(65.2)	-2.25%	0.0	0.00%	(65.2)	-2.25%
Pittsburgh	$3.08	4.85%	(475.6)	-25.74%	351.9	33.98%	(123.7)	-4.29%
Salt Lake City	$2.22	2.91%	(109.8)	-7.17%	62.5	20.36%	(47.3)	-2.57%
San Antonio	$1.75	3.78%	(226.4)	-4.30%	44.5	26.49%	(181.9)	-3.35%
San Francisco	$1.38	2.69%	(140.0)	-4.54%	59.2	18.82%	(80.7)	-2.38%
Seattle	$0.42	0.68%	(68.4)	-6.07%	54.7	4.77%	(13.7)	-0.60%
St. Louis	$0.64	1.29%	(57.4)	-1.14%	0.0	0.00%	(57.4)	-1.14%
U.S. total/average	$1.61	2.90%	(3,435.0)	-4.54%	1,291.4	16.71%	(2,143.6)	-2.57%

TABLE F-5B. INDUSTRY IMPACTS ASSOCIATED WITH BTF OPTION 1 ON MAJOR SOURCES BY REGION: 1993

Market	Change in revenue ($10[3])	Change in cost ($10[3])			Change in pre-tax earnings ($10[3])	Closures		Change in emp.
		Regulatory cost	Production cost	Total cost		Plants	Kilns	
Atlanta	($4,275.7)	$3,420.1	($10,834.6)	($7,414.5)	$3,138.7	0	2	(50)
Baltimore/Philadelphia	$1,115.5	$7,040.9	($14,640.8)	($7,600.0)	$8,715.5	0	2	(75)
Birmingham	($2,349.6)	$2,586.5	($6,864.1)	($4,277.6)	$1,928.0	0	0	(21)
Chicago	($955.8)	$2,417.9	($3,819.0)	($1,401.1)	$445.2	0	0	(20)
Cincinnati	$430.9	$2,514.5	($5,482.7)	($2,968.2)	$3,399.1	0	0	(23)
Dallas	$613.2	$2,184.8	($6,391.1)	($4,206.3)	$4,819.4	0	0	(31)
Denver	$552.9	$3,167.5	($6,203.2)	($3,035.7)	$3,588.5	0	1	(24)
Detroit	($10,801.9)	$2,861.3	($15,066.6)	($12,205.3)	$1,403.4	0	0	(19)
Florida	($13,513.6)	$3,003.5	($14,753.1)	($11,749.5)	($1,764.1)	0	1	(54)
Kansas City	$659.6	$2,804.8	($6,068.9)	($3,264.0)	$3,923.6	0	1	(22)
Los Angeles	($4,090.5)	$5,022.8	($11,949.9)	($6,927.1)	$2,836.6	0	1	(44)
Minneapolis	($304.6)	$1,627.1	($2,670.5)	($1,043.5)	$738.9	0	0	(13)
New York/Boston	($7,978.0)	$3,987.8	($10,588.9)	($6,601.1)	($1,377.0)	0	0	(27)
Phoenix	$395.7	$3,028.0	($3,417.3)	($389.2)	$785.0	0	1	(11)
Pittsburgh	($2,583.4)	$2,101.5	($6,769.7)	($4,668.2)	$2,084.9	0	0	(33)
Salt Lake City	($5,260.0)	$2,538.2	($6,881.6)	($4,343.4)	($916.6)	0	0	(21)
San Antonio	($1,752.2)	$3,752.0	($8,677.6)	($4,925.5)	$3,173.4	0	1	(15)
San Francisco	($3,216.2)	$2,665.8	($6,734.9)	($4,069.1)	$852.9	0	0	(31)
Seattle	($3,834.6)	$1,020.0	($3,706.8)	($2,686.8)	($1,147.7)	0	0	(6)
St. Louis	$320.3	$1,665.4	($2,808.3)	($1,142.9)	$1,463.2	0	0	0
U.S. total	($56,828.1)	$59,410.6	($154,329.6)	($94,919.0)	$38,090.9	0	10	(540)

TABLE F-5C. SOCIAL COSTS ASSOCIATED WITH BTF OPTION 1 ON MAJOR SOURCES BY REGION: 1993

Market	Change in consumer surplus ($10³)	Change in producer surplus ($10³)			Social cost ($10³)[a]
		Domestic	Foreign	Total	
Atlanta	($7,646.0)	$3,138.7	$692.1	$3,830.8	($3,815.1)
Baltimore/Philadelphia	($16,957.4)	$8,715.5	$0.0	$8,715.5	($8,242.0)
Birmingham	($6,026.3)	$1,928.0	$390.0	$2,318.0	($3,708.3)
Chicago	($3,645.4)	$445.2	$173.1	$618.3	($3,027.1)
Cincinnati	($6,757.3)	$3,399.1	$0.0	$3,399.1	($3,358.1)
Dallas	($7,849.0)	$4,819.4	$0.0	$4,819.4	($3,029.6)
Denver	($7,665.2)	$3,588.5	$0.0	$3,588.5	($4,076.7)
Detroit	($7,230.3)	$1,403.4	$1,536.4	$2,939.8	($4,290.5)
Florida	($5,388.2)	($1,764.1)	$1,860.6	$96.5	($5,291.6)
Kansas City	($7,453.0)	$3,923.6	$0.0	$3,923.6	($3,529.4)
Los Angeles	($9,473.0)	$2,836.6	$664.4	$3,501.0	($5,972.0)
Minneapolis	($3,922.9)	$738.9	$425.2	$1,164.1	($2,758.8)
New York/Boston	($6,455.6)	($1,377.0)	$1,158.5	($218.5)	($6,674.1)
Phoenix	($4,702.3)	$785.0	$0.0	$785.0	($3,917.3)
Pittsburgh	($8,667.3)	$2,084.9	$3,792.4	$5,877.2	($2,790.1)
Salt Lake City	($4,027.7)	($916.6)	$760.4	($156.2)	($4,183.9)
San Antonio	($9,295.2)	$3,173.4	$343.2	$3,516.6	($5,778.6)
San Francisco	($4,590.5)	$852.9	$495.2	$1,348.0	($3,242.5)
Seattle	($959.8)	($1,147.7)	$507.2	($640.5)	($1,600.3)
St. Louis	($3,256.2)	$1,463.2	$0.0	$1,463.2	($1,793.0)
U.S. total	($131,968.6)	$38,090.9	$12,798.9	$50,889.7	($81,078.9)

[a] Changes from baseline at the national-level reflect the sum of the mean observations across each of the 20 regions.

FIGURE F-6. U.S. SUMMARY OF ECONOMIC IMPACTS FOR BTF OPTION 2 ON MAJOR SOURCES

Market Impacts	Baseline	With Regulation	Changes from baseline: Absolute	Changes from baseline: Percent
Portland Cement				
Market Price ($/ton)	$55.49	$56.78	$1.29	2.32%
Market Output (10^3 tpy)[a]	83,321.4	81,609.1	(1,712.3)	-2.06%
Domestic Production	75,592.3	72,851.1	(2,741.2)	-3.63%
ROW Production	3,775.3	4,224.5	449.2	11.90%
CAN Production	3,953.8	4,533.5	579.7	14.66%

Portland Cement Industry Impacts	Baseline	With Regulation	Changes from baseline: Absolute	Changes from baseline: Percent
Revenues ($$10^3$)	$4,165,036	$4,119,350	($45,686)	-1.10%
Costs ($$10^3$)	$3,514,212	$3,436,675	($77,537)	-2.21%
Post-reg. control costs	--	$48,041	--	
Cost of production adj.	$3,514,212	$3,388,634	($125,578)	-3.57%
Pre-tax Earnings ($$10^3$)	$650,824	$682,675	$31,851	4.89%
Operating Entities				
Plants	105	105	0	-0.08%
Kilns	201	193	-8	-4.08%
Employment	13603	13154	-449	-3.30%

Small Business Impacts	Baseline	With Regulation	Changes from baseline: Absolute	Changes from baseline: Percent
Revenues ($$10^3$)	$387,053	$375,007	($12,047)	-3.11%
Costs ($$10^3$)	$327,809	$314,566	($13,244)	-4.04%
Post-reg. control costs	--	$4,921	--	
Cost of production adj.	$327,809	$309,645	($18,165)	-5.54%
Pre-tax Earnings ($$10^3$)	$59,244	$60,441	$1,197	2.02%
Operating Entities				
Plants	9	9	0	0.00%
Kilns	22	21	-1	-6.23%
Employment	1,199	1,117	-82	-6.88%
Cost Share as % of Revenues[b]	--	1.69%	--	--

Social Cost Impacts	Change in value ($$10^3$)
Consumer Surplus	($105,941)
Producer Surplus	$41,761
Domestic Producers	$31,851
Foreign Producers	$9,910
Worker Dislocation Costs	($3,492)
Social Costs of Regulation[c]	($64,180)

[a] Portland cement quantity measured in short tons.
[b] Defined as engineering compliance cost divided by baseline revenues for facilities owned by small businesses.
[c] Social cost of regulation is the sum of consumer surplus and producer surplus.

TABLE F-6A. MARKET IMPACTS ASSOCIATED WITH BTF OPTION 2 ON MAJOR SOURCES BY REGION: 1993

	Change in market price		Change in output					
			Domestic production		Imports		Market total	
Market	$/ton	Percent	10^3 tpy	Percent	10^3 tpy	Percent	10^3 tpy	Percent
Atlanta	$1.18	2.26%	(203.5)	-3.58%	79.6	15.85%	(124.0)	-2.00%
Baltimore/Philadelphia	$1.79	3.47%	(220.3)	-3.07%	0.0	0.00%	(220.3)	-3.07%
Birmingham	$0.98	1.92%	(111.9)	-2.61%	34.6	13.47%	(77.3)	-1.70%
Chicago	$0.77	1.45%	(62.2)	-1.78%	15.5	10.13%	(46.7)	-1.28%
Cincinnati	$1.77	3.29%	(83.9)	-2.91%	0.0	0.00%	(83.9)	-2.91%
Dallas	$1.42	2.95%	(135.3)	-2.61%	0.0	0.00%	(135.3)	-2.61%
Denver	$2.82	4.43%	(105.2)	-3.91%	0.0	0.00%	(105.2)	-3.91%
Detroit	$1.12	1.98%	(258.4)	-5.43%	155.6	13.83%	(102.8)	-1.75%
Florida	$0.98	1.65%	(229.0)	-7.44%	163.6	11.53%	(65.5)	-1.46%
Kansas City	$1.74	3.23%	(110.2)	-2.86%	0.0	0.00%	(110.2)	-2.86%
Los Angeles	$0.94	1.52%	(145.2)	-2.16%	48.6	10.66%	(96.6)	-1.35%
Minneapolis	$1.36	2.24%	(33.2)	-2.30%	1.1	0.61%	(32.1)	-1.98%
New York/Boston	$1.20	2.03%	(169.4)	-4.80%	94.3	14.18%	(75.1)	-1.79%
Phoenix	$1.60	2.46%	(63.0)	-2.18%	0.0	0.00%	(63.0)	-2.18%
Pittsburgh	$2.28	3.59%	(351.9)	-19.05%	260.4	25.14%	(91.6)	-3.17%
Salt Lake City	$1.96	2.56%	(96.8)	-6.32%	55.1	17.95%	(41.7)	-2.27%
San Antonio	$1.23	2.67%	(159.6)	-3.03%	31.4	18.68%	(128.2)	-2.36%
San Francisco	$0.88	1.71%	(89.0)	-2.89%	37.7	11.97%	(51.3)	-1.51%
Seattle	$0.40	0.64%	(64.5)	-5.72%	51.6	4.49%	(12.9)	-0.57%
St. Louis	$0.54	1.09%	(48.7)	-0.97%	0.0	0.00%	(48.7)	-0.97%
U.S. total/average	$1.29	2.32%	(2,741.2)	-3.63%	1,028.9	13.31%	(1,712.3)	-2.06%

TABLE F-6B. INDUSTRY IMPACTS ASSOCIATED WITH BTF OPTION 2 ON MAJOR SOURCES BY REGION: 1993

Market	Change in revenue ($10³)	Change in cost ($10³)			Change in pre-tax earnings ($10³)	Closures		Change in emp.
		Regulatory cost	Production cost	Total cost		Plants	Kilns	
Atlanta	($4,139.7)	$3,135.1	($10,532.8)	($7,397.7)	$3,258.0	0	2	(54)
Baltimore/Philadelphia	$1,030.6	$5,253.7	($10,795.2)	($5,541.5)	$6,572.1	0	2	(63)
Birmingham	($1,753.4)	$1,855.6	($5,193.6)	($3,338.0)	$1,584.5	0	0	(13)
Chicago	($713.9)	$1,929.3	($3,036.7)	($1,107.4)	$393.6	0	0	(18)
Cincinnati	$388.8	$2,172.5	($4,001.4)	($1,829.0)	$2,217.7	0	0	(17)
Dallas	$588.5	$1,979.8	($5,884.9)	($3,905.1)	$4,493.5	0	0	(28)
Denver	$533.3	$2,817.4	($6,033.1)	($3,215.7)	$3,749.0	0	1	(24)
Detroit	($9,680.4)	$2,404.2	($13,672.6)	($11,268.4)	$1,588.0	0	0	(10)
Florida	($10,919.4)	$2,608.9	($12,070.7)	($9,461.9)	($1,457.5)	0	1	(45)
Kansas City	$551.9	$2,570.7	($5,420.3)	($2,849.6)	$3,401.5	0	0	(22)
Los Angeles	($2,818.5)	$3,556.4	($8,743.4)	($5,187.0)	$2,368.6	0	1	(35)
Minneapolis	($133.2)	$968.1	($1,536.3)	($568.2)	$435.0	0	0	(8)
New York/Boston	($6,051.4)	$3,353.5	($8,121.3)	($4,767.8)	($1,283.6)	0	0	(19)
Phoenix	$384.9	$2,431.2	($3,353.3)	($922.0)	$1,306.9	0	1	(11)
Pittsburgh	($1,858.2)	$1,535.6	($5,059.1)	($3,523.6)	$1,665.4	0	0	(26)
Salt Lake City	($4,610.1)	$2,164.2	($5,960.1)	($3,795.8)	($814.2)	0	0	(16)
San Antonio	($1,161.9)	$3,097.2	($6,121.2)	($3,024.0)	$1,862.1	0	0	(12)
San Francisco	($1,992.9)	$1,718.8	($4,235.2)	($2,516.4)	$523.5	0	0	(23)
Seattle	($3,608.3)	$1,057.0	($3,420.7)	($2,363.7)	($1,244.6)	0	0	(6)
St. Louis	$277.0	$1,431.6	($2,386.1)	($954.5)	$1,231.5	0	0	0
U.S. total	($45,686.4)	$48,041.0	($125,578.1)	($77,537.1)	$31,850.7	0	8	(449)

TABLE F-6C. SOCIAL COSTS ASSOCIATED WITH BTF OPTION 2 ON MAJOR SOURCES BY REGION: 1993

Market	Change in consumer surplus ($10³)	Change in producer surplus ($10³)			Social cost ($10³)[a]
		Domestic	Foreign	Total	
Atlanta	($7,198.9)	$3,258.0	$649.6	$3,907.6	($3,291.3)
Baltimore/Philadelphia	($12,610.1)	$6,572.1	$0.0	$6,572.1	($6,038.0)
Birmingham	($4,532.0)	$1,584.5	$291.2	$1,875.8	($2,656.2)
Chicago	($2,797.4)	$393.6	$130.3	$523.8	($2,273.6)
Cincinnati	($4,997.4)	$2,217.7	$0.0	$2,217.7	($2,779.7)
Dallas	($7,249.0)	$4,493.5	$0.0	$4,493.5	($2,755.4)
Denver	($7,412.2)	$3,749.0	$0.0	$3,749.0	($3,663.2)
Detroit	($6,524.1)	$1,588.0	$1,368.8	$2,956.8	($3,567.4)
Florida	($4,382.7)	($1,457.5)	$1,491.7	$34.2	($4,348.5)
Kansas City	($6,591.4)	$3,401.5	$0.0	$3,401.5	($3,189.9)
Los Angeles	($6,705.9)	$2,368.6	$457.5	$2,826.0	($3,879.9)
Minneapolis	($2,244.8)	$435.0	$244.8	$679.9	($1,564.9)
New York/Boston	($4,970.9)	($1,283.6)	$869.1	($414.5)	($5,385.3)
Phoenix	($4,545.0)	$1,306.9	$0.0	$1,306.9	($3,238.1)
Pittsburgh	($6,440.4)	$1,665.4	$2,729.3	$4,394.7	($2,045.7)
Salt Lake City	($3,555.3)	($814.2)	$662.8	($151.4)	($3,706.7)
San Antonio	($6,582.3)	$1,862.1	$234.8	$2,096.8	($4,485.5)
San Francisco	($2,933.6)	$523.5	$303.9	$827.3	($2,106.3)
Seattle	($904.2)	($1,244.6)	$476.5	($768.1)	($1,672.3)
St. Louis	($2,763.9)	$1,231.5	$0.0	$1,231.5	($1,532.4)
U.S. total	($105,941.4)	$31,850.7	$9,910.4	$41,761.1	($64,180.2)

[a] Changes from baseline at the national-level reflect the sum of the mean observations across each of the 20 regions.

FIGURE F-7. U.S. SUMMARY OF ECONOMIC IMPACTS FOR MACT FLOOR ON MAJOR SOURCES AND D/F CONTROLS ON AREA SOURCES

Market Impacts	Baseline	With Regulation	Changes from baseline	
			Absolute	Percent
Portland Cement				
Market Price ($/ton)	$55.49	$56.08	$0.58	1.05%
Market Output (10^3 tpy)[a]	83,321.4	82,550.7	(770.7)	-0.92%
Domestic Production	75,592.3	74,333.1	(1,259.2)	-1.67%
ROW Production	3,775.3	3,996.7	221.4	5.86%
CAN Production	3,953.8	4,220.8	267.1	6.76%

Portland Cement Industry Impacts	Baseline	With Regulation	Changes from baseline	
			Absolute	Percent
Revenues ($\$10^3$)	$4,165,036	$4,145,563	($19,473)	-0.47%
Costs ($\$10^3$)	$3,514,212	$3,485,414	($28,798)	-0.82%
Post-reg. control costs	--	$28,828	--	
Cost of production adj.	$3,514,212	$3,456,586	($57,626)	-1.64%
Pre-tax Earnings ($\$10^3$)	$650,824	$660,149	$9,325	1.43%
Operating Entities				
Plants	105	105	0	0.00%
Kilns	201	199	-2	-1.15%
Employment	13603	13376	-227	-1.67%

Small Business Impacts	Baseline	With Regulation	Changes from baseline	
			Absolute	Percent
Revenues ($\$10^3$)	$387,053	$380,752	($6,301)	-1.63%
Costs ($\$10^3$)	$327,809	$321,628	($6,181)	-1.89%
Post-reg. control costs	--	$3,071	--	
Cost of production adj.	$327,809	$318,558	($9,252)	-2.82%
Pre-tax Earnings ($\$10^3$)	$59,244	$59,124	($120)	-0.20%
Operating Entities				
Plants	9	9	0	0.00%
Kilns	22	22	0	0.00%
Employment	1,199	1,156	-43	-3.63%
Cost Share as % of Revenues[b]	--	0.85%	--	--

Social Cost Impacts	Change in value ($\$10^3$)
Consumer Surplus	($48,369)
Producer Surplus	$13,860
Domestic Producers	$9,325
Foreign Producers	$4,534
Worker Dislocation Costs	($1,763)
Social Costs of Regulation[c]	($34,510)

[a] Portland cement quantity measured in short tons.
[b] Defined as engineering compliance cost divided by baseline revenues for facilities owned by small businesses.
[c] Social cost of regulation is the sum of consumer surplus and producer surplus.

TABLE F-7A. MARKET IMPACTS ASSOCIATED WITH MACT FLOOR ON MAJOR SOURCES AND D/F CONTROLS ON AREA SOURCES BY REGION: 1993

Market	Change in market price		Change in output					
			Domestic production		Imports		Market total	
	$/ton	Percent	10^3 tpy	Percent	10^3 tpy	Percent	10^3 tpy	Percent
Atlanta	$0.61	1.17%	(105.5)	-1.85%	41.3	8.22%	(64.3)	-1.04%
Baltimore/Philadelphia	$0.85	1.65%	(104.7)	-1.46%	0.0	0.00%	(104.7)	-1.46%
Birmingham	$0.32	0.63%	(36.8)	-0.86%	11.4	4.43%	(25.4)	-0.56%
Chicago	$0.36	0.68%	(29.3)	-0.84%	7.3	4.76%	(22.0)	-0.60%
Cincinnati	$0.92	1.71%	(43.5)	-1.51%	0.0	0.00%	(43.5)	-1.51%
Dallas	$0.50	1.04%	(47.5)	-0.92%	0.0	0.00%	(47.5)	-0.92%
Denver	$1.33	2.09%	(49.7)	-1.85%	0.0	0.00%	(49.7)	-1.85%
Detroit	$0.33	0.57%	(75.0)	-1.58%	45.2	4.02%	(29.8)	-0.51%
Florida	$0.60	1.01%	(140.2)	-4.56%	100.1	7.06%	(40.1)	-0.89%
Kansas City	$0.87	1.62%	(55.3)	-1.44%	0.0	0.00%	(55.3)	-1.44%
Los Angeles	$0.40	0.65%	(62.3)	-0.93%	20.9	4.58%	(41.5)	-0.58%
Minneapolis	$0.80	1.31%	(19.4)	-1.35%	0.6	0.36%	(18.8)	-1.16%
New York/Boston	$0.57	0.97%	(81.1)	-2.30%	45.1	6.79%	(36.0)	-0.86%
Phoenix	$0.57	0.88%	(22.5)	-0.78%	0.0	0.00%	(22.5)	-0.78%
Pittsburgh	$1.27	2.01%	(196.6)	-10.64%	145.4	14.04%	(51.1)	-1.77%
Salt Lake City	$1.02	1.34%	(50.4)	-3.29%	28.7	9.35%	(21.7)	-1.18%
San Antonio	$0.46	1.00%	(59.9)	-1.14%	11.8	7.01%	(48.1)	-0.89%
San Francisco	$0.29	0.57%	(29.7)	-0.97%	12.6	4.00%	(17.2)	-0.51%
Seattle	$0.14	0.23%	(22.6)	-2.01%	18.1	1.58%	(4.5)	-0.20%
St. Louis	$0.30	0.61%	(27.0)	-0.54%	0.0	0.00%	(27.0)	-0.54%
U.S. total/average	$0.58	1.05%	(1,259.2)	-1.67%	488.5	6.32%	(770.7)	-0.92%

TABLE F-7B. INDUSTRY IMPACTS ASSOCIATED WITH MACT FLOOR ON MAJOR SOURCES AND D/F CONTROL ON AREA SOURCES BY REGION: 1993

Market	Change in revenue ($10³)	Change in cost ($10³)			Change in pre-tax earnings ($10³)	Closures		Change in emp.
		Regulatory cost	Production cost	Total cost		Plants	Kilns	
Atlanta	($1,911.0)	$2,294.8	($5,412.6)	($3,117.8)	$1,206.8	0	1	(26)
Baltimore/Philadelphia	$616.1	$3,717.4	($5,287.2)	($1,569.8)	$2,185.9	0	1	(35)
Birmingham	($505.5)	$1,081.1	($1,673.3)	($592.2)	$86.7	0	0	(4)
Chicago	($303.6)	$1,018.4	($1,448.3)	($429.9)	$126.3	0	0	(9)
Cincinnati	$262.6	$1,213.2	($2,122.7)	($909.5)	$1,172.1	0	0	(8)
Dallas	$275.7	$1,380.1	($2,190.2)	($810.1)	$1,085.8	0	0	(12)
Denver	$344.6	$1,665.7	($3,033.2)	($1,367.5)	$1,712.1	0	0	(12)
Detroit	($2,733.4)	$1,304.6	($3,951.1)	($2,646.6)	($86.8)	0	0	(6)
Florida	($6,609.9)	$1,605.8	($7,917.9)	($6,312.1)	($297.7)	0	0	(28)
Kansas City	$339.6	$1,678.7	($2,747.4)	($1,068.7)	$1,408.3	0	0	(17)
Los Angeles	($1,164.2)	$2,008.0	($3,741.3)	($1,733.2)	$569.0	0	0	(15)
Minneapolis	($50.2)	$566.9	($913.7)	($346.8)	$296.6	0	0	(4)
New York/Boston	($2,822.4)	$1,977.5	($3,782.8)	($1,805.3)	($1,017.1)	0	0	(11)
Phoenix	$178.0	$1,014.2	($1,249.7)	($235.5)	$413.4	0	0	(4)
Pittsburgh	($961.6)	$1,206.1	($2,836.1)	($1,630.1)	$668.4	0	0	(14)
Salt Lake City	($2,347.4)	$1,363.9	($3,085.3)	($1,721.4)	($626.0)	0	0	(9)
San Antonio	($360.9)	$1,543.9	($2,285.5)	($741.6)	$380.7	0	0	(3)
San Francisco	($631.2)	$816.5	($1,424.7)	($608.2)	($23.0)	0	0	(8)
Seattle	($1,255.3)	$378.0	($1,232.5)	($854.5)	($400.8)	0	0	(2)
St. Louis	$167.2	$992.9	($1,290.1)	($297.2)	$464.4	0	0	(1)
U.S. total	($19,472.8)	$28,827.9	($57,625.8)	($28,798.0)	$9,325.1	0	2	(227)

TABLE F-7C. SOCIAL COSTS ASSOCIATED WITH MACT FLOOR ON MAJOR SOURCES AND D/F CONTROLS ON AREA SOURCES BY REGION: 1993

Market	Change in consumer surplus ($10^3)	Change in producer surplus ($10^3)			Social cost ($10^3)[a]
		Domestic	Foreign	Total	
Atlanta	($3,757.0)	$1,206.8	$320.6	$1,527.4	($2,229.6)
Baltimore/Philadelphia	($6,053.1)	$2,185.9	$0.0	$2,185.9	($3,867.2)
Birmingham	($1,467.6)	$86.7	$84.8	$171.5	($1,296.2)
Chicago	($1,328.5)	$126.3	$57.3	$183.6	($1,144.9)
Cincinnati	($2,622.6)	$1,172.1	$0.0	$1,172.1	($1,450.4)
Dallas	($2,580.3)	$1,085.8	$0.0	$1,085.8	($1,494.5)
Denver	($3,545.7)	$1,712.1	$0.0	$1,712.1	($1,833.6)
Detroit	($1,909.8)	($86.8)	$374.1	$287.3	($1,622.6)
Florida	($2,693.2)	($297.7)	$886.7	$589.0	($2,104.3)
Kansas City	($3,341.7)	$1,408.3	$0.0	$1,408.3	($1,933.4)
Los Angeles	($2,894.7)	$569.0	$188.7	$757.8	($2,137.0)
Minneapolis	($1,300.7)	$296.6	$142.9	$439.5	($861.3)
New York/Boston	($2,396.1)	($1,017.1)	$395.3	($621.7)	($3,017.8)
Phoenix	($1,643.3)	$413.4	$0.0	$413.4	($1,229.8)
Pittsburgh	($3,635.0)	$668.4	$1,416.5	$2,085.0	($1,550.1)
Salt Lake City	($1,864.7)	($626.0)	$329.7	($296.3)	($2,160.9)
San Antonio	($2,500.5)	$380.7	$80.7	$461.4	($2,039.1)
San Francisco	($990.5)	($23.0)	$94.2	$71.2	($919.3)
Seattle	($318.5)	($400.8)	$162.8	($238.1)	($556.5)
St. Louis	($1,525.6)	$464.4	$0.0	$464.4	($1,061.3)
U.S. total	($48,369.3)	$9,325.1	$4,534.4	$13,859.5	($34,509.8)

[a] Changes from baseline at the national-level reflect the sum of the mean observations across each of the 20 regions.

FIGURE F-8. U.S. SUMMARY OF ECONOMIC IMPACTS FOR BTF OPTION 1 ON MAJOR SOURCES AND D/F CONTROLS ON AREA SOURCES

Market Impacts	Baseline	With Regulation	Changes from baseline: Absolute	Percent
Portland Cement				
Market Price ($/ton)	$55.49	$56.90	$1.40	2.53%
Market Output (10^3 tpy)[a]	83,321.4	81,446.6	(1,874.8)	-2.25%
Domestic Production	75,592.3	72,611.5	(2,980.8)	-3.94%
ROW Production	3,775.3	4,319.1	543.8	14.40%
CAN Production	3,953.8	4,516.0	562.2	14.22%

Portland Cement Industry Impacts	Baseline	With Regulation	Changes from baseline: Absolute	Percent
Revenues ($\$10^3$)	$4,165,036	$4,111,167	($53,869)	-1.29%
Costs ($\$10^3$)	$3,514,212	$3,449,960	($64,252)	-1.83%
Post-reg. control costs	--	$73,600	--	
Cost of production adj.	$3,514,212	$3,376,360	($137,852)	-3.92%
Pre-tax Earnings ($\$10^3$)	$650,824	$661,207	$10,383	1.60%
Operating Entities				
Plants	105	105	0	0.00%
Kilns	201	196	-5	-2.57%
Employment	13603	13094	-509	-3.74%

Small Business Impacts	Baseline	With Regulation	Changes from baseline: Absolute	Percent
Revenues ($\$10^3$)	$387,053	$374,469	($12,585)	-3.25%
Costs ($\$10^3$)	$327,809	$317,469	($10,341)	-3.15%
Post-reg. control costs	--	$7,681	--	
Cost of production adj.	$327,809	$309,787	($18,022)	-5.50%
Pre-tax Earnings ($\$10^3$)	$59,244	$57,000	($2,244)	-3.79%
Operating Entities				
Plants	9	9	0	0.00%
Kilns	22	21	-1	-2.73%
Employment	1,199	1,123	-76	-6.36%
Cost Share as % of Revenues[b]	--	2.26%	--	--

Social Cost Impacts	Change in value ($\$10^3$)
Consumer Surplus	($114,498)
Producer Surplus	$21,385
Domestic Producers	$10,383
Foreign Producers	$11,002
Worker Dislocation Costs	($3,962)
Social Costs of Regulation[c]	($93,112)

[a] Portland cement quantity measured in short tons.
[b] Defined as engineering compliance cost divided by baseline revenues for facilities owned by small businesses.
[c] Social cost of regulation is the sum of consumer surplus and producer surplus.

TABLE F-8A. MARKET IMPACTS ASSOCIATED WITH BTF OPTION 1 ON MAJOR SOURCES AND D/F CONTROLS ON AREA SOURCES BY REGION: 1993

Market	Change in market price		Change in output: Domestic production		Change in output: Imports		Change in output: Market total	
	$/ton	Percent	10^3 tpy	Percent	10^3 tpy	Percent	10^3 tpy	Percent
Atlanta	$1.37	2.63%	(236.2)	-4.15%	92.4	18.40%	(143.9)	-2.32%
Baltimore/Philadelphia	$2.23	4.33%	(274.6)	-3.83%	0.0	0.00%	(274.6)	-3.83%
Birmingham	$1.20	2.37%	(137.6)	-3.21%	42.6	16.56%	(95.0)	-2.09%
Chicago	$1.14	2.12%	(91.3)	-2.61%	22.7	14.85%	(68.5)	-1.87%
Cincinnati	$1.73	3.22%	(82.0)	-2.85%	0.0	0.00%	(82.0)	-2.85%
Dallas	$0.96	1.98%	(91.0)	-1.75%	0.0	0.00%	(91.0)	-1.75%
Denver	$3.17	4.97%	(118.1)	-4.39%	0.0	0.00%	(118.1)	-4.39%
Detroit	$1.17	2.06%	(268.8)	-5.65%	161.9	14.39%	(106.9)	-1.82%
Florida	$1.11	1.87%	(259.5)	-8.43%	185.3	13.06%	(74.2)	-1.65%
Kansas City	$1.50	2.78%	(94.9)	-2.46%	0.0	0.00%	(94.9)	-2.46%
Los Angeles	$0.97	1.57%	(149.8)	-2.23%	50.1	11.00%	(99.7)	-1.39%
Minneapolis	$1.57	2.58%	(38.2)	-2.65%	1.3	0.71%	(37.0)	-2.28%
New York/Boston	$1.22	2.06%	(172.5)	-4.89%	96.0	14.44%	(76.5)	-1.82%
Phoenix	$1.45	2.24%	(57.3)	-1.98%	0.0	0.00%	(57.3)	-1.98%
Pittsburgh	$1.92	3.03%	(297.0)	-16.07%	219.7	21.22%	(77.3)	-2.68%
Salt Lake City	$2.03	2.66%	(100.5)	-6.56%	57.2	18.64%	(43.3)	-2.35%
San Antonio	$1.61	3.49%	(209.0)	-3.97%	41.1	24.46%	(167.9)	-3.09%
San Francisco	$1.73	3.38%	(175.8)	-5.71%	74.4	23.64%	(101.4)	-2.99%
Seattle	$0.47	0.76%	(76.6)	-6.80%	61.3	5.34%	(15.3)	-0.67%
St. Louis	$0.56	1.12%	(50.1)	-0.99%	0.0	0.00%	(50.1)	-0.99%
U.S. total/average	$1.40	2.53%	(2,980.8)	-3.94%	1,106.0	14.31%	(1,874.8)	-2.25%

TABLE F-8B. INDUSTRY IMPACTS ASSOCIATED WITH BTF OPTION 1 ON MAJOR SOURCES AND D/F CONTROLS ON AREA SOURCES BY REGION: 1993

Market	Change in revenue ($10^3)	Change in cost ($10^3)			Change in pre-tax earnings ($10^3)	Closures		Change in emp.
		Regulatory cost	Production cost	Total cost		Plants	Kilns	
Atlanta	($3,957.9)	$4,742.7	($11,065.5)	($6,322.8)	$2,364.9	0	2	(56)
Baltimore/Philadelphia	$845.4	$11,617.1	($13,727.1)	($2,110.1)	$2,955.5	0	2	(76)
Birmingham	($2,180.7)	$3,518.3	($6,149.3)	($2,631.0)	$450.3	0	0	(20)
Chicago	($1,139.6)	$2,605.1	($4,431.5)	($1,826.3)	$686.7	0	0	(24)
Cincinnati	$305.5	$2,163.0	($3,929.4)	($1,766.4)	$2,071.9	0	0	(17)
Dallas	$370.6	$2,203.7	($4,050.3)	($1,846.6)	$2,217.2	0	0	(20)
Denver	$425.3	$4,995.8	($6,754.4)	($1,758.6)	$2,183.9	0	0	(27)
Detroit	($10,336.0)	$3,702.5	($14,126.4)	($10,423.9)	$87.9	0	0	(22)
Florida	($12,529.1)	$4,089.0	($13,555.3)	($9,466.3)	($3,062.8)	0	0	(49)
Kansas City	$454.7	$3,165.3	($4,713.5)	($1,548.3)	$2,003.0	0	0	(22)
Los Angeles	($3,090.5)	$5,356.7	($8,479.7)	($3,123.0)	$32.5	0	0	(29)
Minneapolis	($227.1)	$1,104.7	($1,815.9)	($711.2)	$484.0	0	0	(9)
New York/Boston	($6,369.5)	$4,106.3	($8,176.6)	($4,070.3)	($2,299.1)	0	0	(26)
Phoenix	$308.9	$3,185.1	($3,132.8)	$52.3	$256.6	0	1	(9)
Pittsburgh	($1,587.0)	$1,877.8	($4,257.9)	($2,380.1)	$793.1	0	0	(21)
Salt Lake City	($4,893.6)	$2,896.7	($6,198.1)	($3,301.3)	($1,592.3)	0	0	(18)
San Antonio	($1,833.6)	$6,070.4	($8,247.5)	($2,177.1)	$343.5	0	0	(22)
San Francisco	($4,400.4)	$3,257.5	($8,508.5)	($5,250.9)	$850.6	0	0	(37)
Seattle	($4,316.5)	$1,247.8	($4,082.6)	($2,834.8)	($1,481.7)	0	0	(7)
St. Louis	$282.5	$1,694.2	($2,449.3)	($755.1)	$1,037.6	0	0	0
U.S. total	($53,868.6)	$73,599.6	($137,851.5)	($64,251.9)	$10,383.3	0	5	(509)

TABLE F-8C. SOCIAL COSTS ASSOCIATED WITH BTF OPTION 1 ON MAJOR SOURCES AND D/F CONTROLS ON AREA SOURCES BY REGION: 1993

Market	Change in consumer surplus ($$10^3$)	Change in producer surplus ($$10^3$)			Social cost ($$10^3$)[a]
		Domestic	Foreign	Total	
Atlanta	($8,290.4)	$2,364.9	$795.7	$3,160.6	($5,129.8)
Baltimore/Philadelphia	($15,494.8)	$2,955.5	$0.0	$2,955.5	($12,539.3)
Birmingham	($5,581.3)	$450.3	$361.9	$812.2	($4,769.1)
Chicago	($4,066.4)	$686.7	$202.6	$889.3	($3,177.2)
Cincinnati	($4,849.8)	$2,071.9	$0.0	$2,071.9	($2,777.9)
Dallas	($4,863.0)	$2,217.2	$0.0	$2,217.2	($2,645.8)
Denver	($8,229.0)	$2,183.9	$0.0	$2,183.9	($6,045.2)
Detroit	($6,735.9)	$87.9	$1,503.6	$1,591.5	($5,144.4)
Florida	($4,942.7)	($3,062.8)	$1,746.5	($1,316.3)	($6,259.0)
Kansas City	($5,668.1)	$2,003.0	$0.0	$2,003.0	($3,665.2)
Los Angeles	($6,858.0)	$32.5	$502.5	$535.1	($6,322.9)
Minneapolis	($2,625.2)	$484.0	$283.7	$767.7	($1,857.5)
New York/Boston	($5,018.0)	($2,299.1)	$942.4	($1,356.7)	($6,374.7)
Phoenix	($4,113.3)	$256.6	$0.0	$256.6	($3,856.7)
Pittsburgh	($5,424.9)	$793.1	$2,330.9	$3,124.1	($2,300.8)
Salt Lake City	($3,669.8)	($1,592.3)	$718.5	($873.8)	($4,543.6)
San Antonio	($8,494.1)	$343.5	$338.1	$681.6	($7,812.5)
San Francisco	($5,661.4)	$850.6	$698.3	$1,548.9	($4,112.5)
Seattle	($1,072.3)	($1,481.7)	$577.2	($904.6)	($1,976.8)
St. Louis	($2,839.1)	$1,037.6	$0.0	$1,037.6	($1,801.5)
U.S. total	($114,497.6)	$10,383.3	$11,001.9	$21,385.2	($93,112.4)

[a] Changes from baseline at the national-level reflect the sum of the mean observations across each of the 20 regions.

FIGURE F-9. U.S. SUMMARY OF ECONOMIC IMPACTS FOR BTF OPTION 2 ON MAJOR SOURCES AND D/F CONTROLS ON AREA SOURCES

Market Impacts	Baseline	With Regulation	Changes from baseline: Absolute	Changes from baseline: Percent
Portland Cement				
Market Price ($/ton)	$55.49	$56.87	$1.37	2.47%
Market Output (10^3 tpy)[a]	83,321.4	81,492.6	(1,828.8)	-2.19%
Domestic Production	75,592.3	72,655.1	(2,937.2)	-3.89%
ROW Production	3,775.3	4,246.1	470.8	12.47%
CAN Production	3,953.8	4,591.4	637.6	16.13%

Portland Cement Industry Impacts	Baseline	With Regulation	Changes from baseline: Absolute	Changes from baseline: Percent
Revenues ($\$10^3$)	$4,165,036	$4,116,304	($48,732)	-1.17%
Costs ($\$10^3$)	$3,514,212	$3,431,022	($83,190)	-2.37%
Post-reg. control costs	--	$50,043	--	
Cost of production adj.	$3,514,212	$3,380,979	($133,233)	-3.79%
Pre-tax Earnings ($\$10^3$)	$650,824	$685,282	$34,458	5.29%
Operating Entities				
Plants	105	105	0	-0.08%
Kilns	201	192	-9	-4.28%
Employment	13603	13144	-459	-3.38%

Small Business Impacts	Baseline		Absolute	Percent
Revenues ($\$10^3$)	$387,053	$378,829	($8,224)	-2.12%
Costs ($\$10^3$)	$327,809	$317,280	($10,529)	-3.21%
Post-reg. control costs	--	$5,031	--	
Cost of production adj.	$327,809	$312,249	($15,560)	-4.75%
Pre-tax Earnings ($\$10^3$)	$59,244	$61,549	$2,305	3.89%
Operating Entities				
Plants	9	9	0	0.00%
Kilns	22	21	-1	-5.71%
Employment	1,199	1,132	-67	-5.59%
Cost Share as % of Revenues[b]	--	1.70%	--	--

Social Cost Impacts	Change in value ($\$10^3$)
Consumer Surplus	($112,812)
Producer Surplus	$45,303
Domestic Producers	$34,458
Foreign Producers	$10,845
Worker Dislocation Costs	($3,574)
Social Costs of Regulation[c]	($67,509)

[a] Portland cement quantity measured in short tons.
[b] Defined as engineering compliance cost divided by baseline revenues for facilities owned by small businesses.
[c] Social cost of regulation is the sum of consumer surplus and producer surplus.

TABLE F-9A. MARKET IMPACTS ASSOCIATED WITH BTF OPTION 2 ON MAJOR SOURCES AND D/F CONTROLS ON AREA SOURCES BY REGION: 1993

	Change in market price		Change in output					
			Domestic production		Imports		Market total	
Market	$/ton	Percent	10^3 tpy	Percent	10^3 tpy	Percent	10^3 tpy	Percent
Atlanta	$0.87	1.67%	(150.0)	-2.64%	58.6	11.68%	(91.3)	-1.48%
Baltimore/Philadelphia	$2.12	4.11%	(261.0)	-3.64%	0.0	0.00%	(261.0)	-3.64%
Birmingham	$1.04	2.04%	(118.8)	-2.77%	36.8	14.30%	(82.0)	-1.81%
Chicago	$0.96	1.78%	(76.8)	-2.19%	19.1	12.49%	(57.6)	-1.58%
Cincinnati	$2.03	3.78%	(96.4)	-3.34%	0.0	0.00%	(96.4)	-3.34%
Dallas	$1.22	2.53%	(115.9)	-2.23%	0.0	0.00%	(115.9)	-2.23%
Denver	$2.55	4.01%	(95.2)	-3.54%	0.0	0.00%	(95.2)	-3.54%
Detroit	$1.17	2.06%	(269.4)	-5.66%	162.2	14.42%	(107.2)	-1.82%
Florida	$1.01	1.70%	(236.1)	-7.67%	168.6	11.89%	(67.5)	-1.50%
Kansas City	$1.59	2.96%	(101.0)	-2.62%	0.0	0.00%	(101.0)	-2.62%
Los Angeles	$1.04	1.68%	(160.3)	-2.38%	53.6	11.76%	(106.7)	-1.49%
Minneapolis	$1.93	3.17%	(47.0)	-3.26%	1.6	0.87%	(45.5)	-2.81%
New York/Boston	$1.42	2.40%	(200.2)	-5.67%	111.4	16.77%	(88.8)	-2.12%
Phoenix	$1.53	2.35%	(60.2)	-2.08%	0.0	0.00%	(60.2)	-2.08%
Pittsburgh	$2.54	4.01%	(392.5)	-21.24%	290.4	28.04%	(102.1)	-3.54%
Salt Lake City	$1.97	2.57%	(97.2)	-6.34%	55.3	18.02%	(41.8)	-2.28%
San Antonio	$1.54	3.34%	(200.1)	-3.80%	39.3	23.41%	(160.8)	-2.96%
San Francisco	$1.16	2.27%	(118.4)	-3.84%	50.1	15.92%	(68.3)	-2.01%
Seattle	$0.47	0.76%	(76.6)	-6.80%	61.3	5.34%	(15.3)	-0.67%
St. Louis	$0.72	1.44%	(64.2)	-1.27%	0.0	0.00%	(64.2)	-1.27%
U.S. total/average	$1.37	2.47%	(2,937.2)	-3.89%	1,108.5	14.34%	(1,828.8)	-2.19%

TABLE F-9B. INDUSTRY IMPACTS ASSOCIATED WITH BTF OPTION 2 ON MAJOR SOURCES AND D/F CONTROLS ON AREA SOURCES BY REGION: 1993

Market	Change in revenue ($10^3)	Change in cost ($10^3)			Change in pre-tax earnings ($10^3)	Closures		Change in emp.
		Regulatory cost	Production cost	Total cost		Plants	Kilns	
Atlanta	($2,653.8)	$3,125.2	($7,476.0)	($4,350.8)	$1,697.0	0	2	(38)
Baltimore/Philadelphia	$1,126.7	$6,103.8	($12,678.1)	($6,574.3)	$7,701.0	0	2	(64)
Birmingham	($1,751.3)	$2,262.3	($5,638.4)	($3,376.1)	$1,624.8	0	0	(20)
Chicago	($876.4)	$2,138.3	($3,633.3)	($1,495.0)	$618.6	0	0	(20)
Cincinnati	$431.0	$2,027.8	($4,661.4)	($2,633.6)	$3,064.6	0	0	(19)
Dallas	$505.0	$1,585.5	($5,204.6)	($3,619.2)	$4,124.1	0	0	(27)
Denver	$492.5	$2,939.9	($5,443.0)	($2,503.1)	$2,995.6	0	0	(23)
Detroit	($10,145.5)	$2,426.4	($14,298.9)	($11,872.5)	$1,727.1	0	0	(16)
Florida	($11,261.0)	$2,339.7	($12,644.7)	($10,304.9)	($956.1)	0	1	(50)
Kansas City	$517.7	$2,412.0	($4,907.5)	($2,495.5)	$3,013.2	0	0	(19)
Los Angeles	($3,109.6)	$3,887.0	($9,485.2)	($5,598.2)	$2,488.6	0	2	(34)
Minneapolis	($232.9)	$1,128.5	($2,217.0)	($1,088.5)	$855.6	0	0	(11)
New York/Boston	($7,202.3)	$3,897.6	($9,619.4)	($5,721.7)	($1,480.6)	0	0	(23)
Phoenix	$359.2	$2,111.0	($3,199.5)	($1,088.6)	$1,447.7	0	1	(10)
Pittsburgh	($2,102.0)	$1,901.5	($5,521.7)	($3,620.2)	$1,518.2	0	0	(24)
Salt Lake City	($4,620.5)	$2,146.2	($5,845.4)	($3,699.2)	($921.3)	0	0	(14)
San Antonio	($1,530.2)	$2,843.8	($7,754.9)	($4,911.2)	$3,380.9	0	1	(16)
San Francisco	($2,739.4)	$2,102.8	($5,677.9)	($3,575.0)	$835.7	0	0	(26)
Seattle	($4,292.8)	$1,099.7	($4,186.4)	($3,086.7)	($1,206.1)	0	0	(6)
St. Louis	$353.5	$1,563.9	($3,139.5)	($1,575.6)	$1,929.1	0	0	0
U.S. total	($48,732.2)	$50,042.8	($133,232.8)	($83,190.0)	$34,457.8	0	9	(459)

TABLE F-9C. SOCIAL COSTS ASSOCIATED WITH BTF OPTION 2 ON MAJOR SOURCES AND D/F CONTROLS ON AREA SOURCES BY REGION: 1993

Market	Change in consumer surplus ($10³)	Change in producer surplus ($10³)			Social cost ($10³)[a]
		Domestic	Foreign	Total	
Atlanta	($5,308.9)	$1,697.0	$475.2	$2,172.3	($3,136.7)
Baltimore/Philadelphia	($14,891.6)	$7,701.0	$0.0	$7,701.0	($7,190.6)
Birmingham	($4,773.1)	$1,624.8	$292.1	$1,916.9	($2,856.2)
Chicago	($3,451.1)	$618.6	$160.1	$778.7	($2,672.4)
Cincinnati	($5,734.7)	$3,064.6	$0.0	$3,064.6	($2,670.0)
Dallas	($6,210.6)	$4,124.1	$0.0	$4,124.1	($2,086.5)
Denver	($6,712.9)	$2,995.6	$0.0	$2,995.6	($3,717.2)
Detroit	($6,793.3)	$1,727.1	$1,442.6	$3,169.7	($3,623.6)
Florida	($4,518.4)	($956.1)	$1,539.0	$582.9	($3,935.4)
Kansas City	($6,045.2)	$3,013.2	$0.0	$3,013.2	($3,032.0)
Los Angeles	($7,402.1)	$2,488.6	$504.7	$2,993.4	($4,408.8)
Minneapolis	($3,204.6)	$855.6	$347.9	$1,203.5	($2,001.1)
New York/Boston	($5,866.5)	($1,480.6)	$1,040.9	($439.7)	($6,306.2)
Phoenix	($4,342.6)	$1,447.7	$0.0	$1,447.7	($2,894.9)
Pittsburgh	($7,167.0)	$1,518.2	$3,087.0	$4,605.3	($2,561.7)
Salt Lake City	($3,570.9)	($921.3)	$663.3	($258.1)	($3,829.0)
San Antonio	($8,222.2)	$3,380.9	$301.5	$3,682.5	($4,539.8)
San Francisco	($3,876.9)	$835.7	$422.9	$1,258.5	($2,618.3)
Seattle	($1,074.7)	($1,206.1)	$567.6	($638.5)	($1,713.2)
St. Louis	($3,644.2)	$1,929.1	$0.0	$1,929.1	($1,715.1)
U.S. total	($112,811.5)	$34,457.8	$10,845.1	$45,302.8	($67,508.7)

[a] Changes from baseline at the national-level reflect the sum of the mean observations across each of the 20 regions.