Economic Analysis of Air Pollution Regulations: Portland Cement

Final Report

Submitted to

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U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Air Quality Strategies and Standards Division
Innovative Strategies and Economics Group
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This report contains portions of the economic impact analysis report that are related to the industry profile.

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

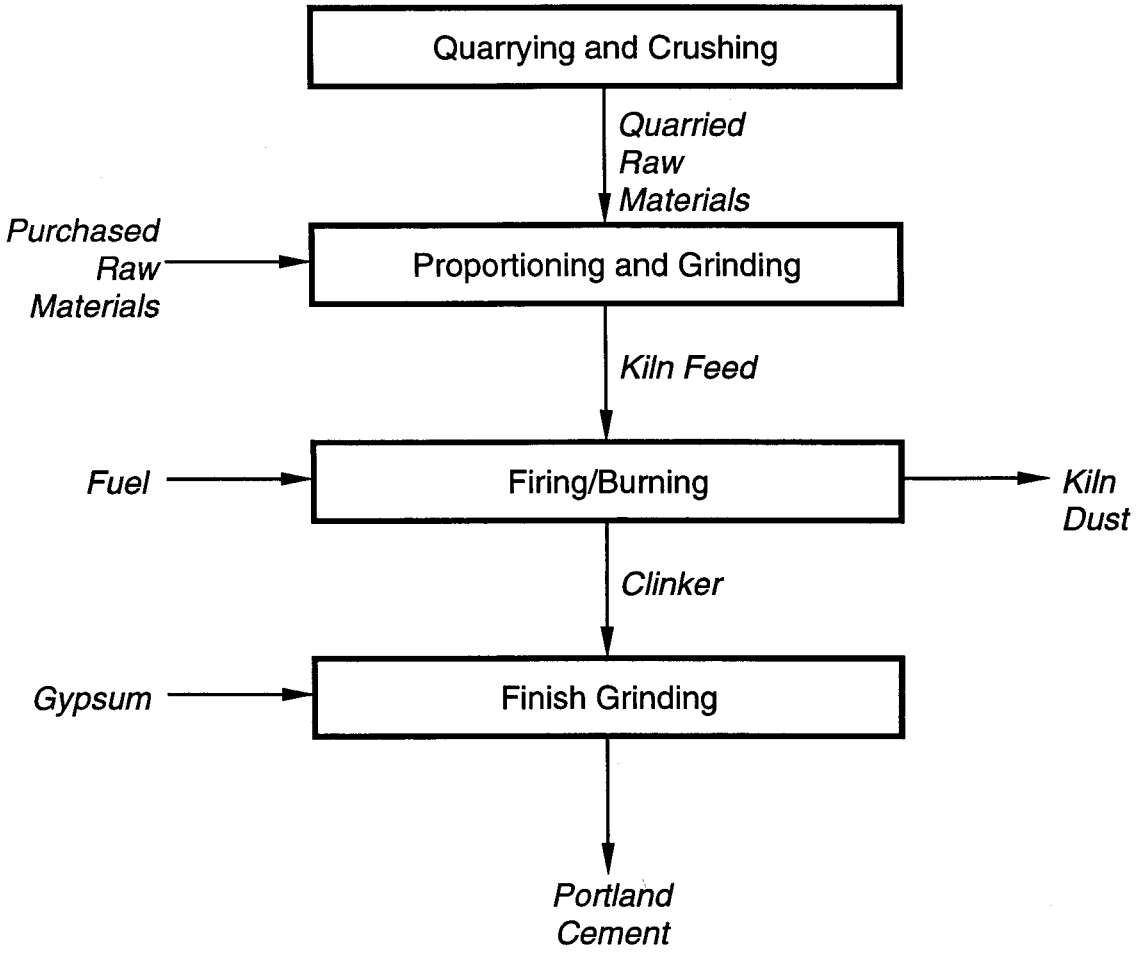

Figure 2-1. Basic flow diagram of the Portland cement manufacturing process.

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-

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.

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.

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 Location. 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.

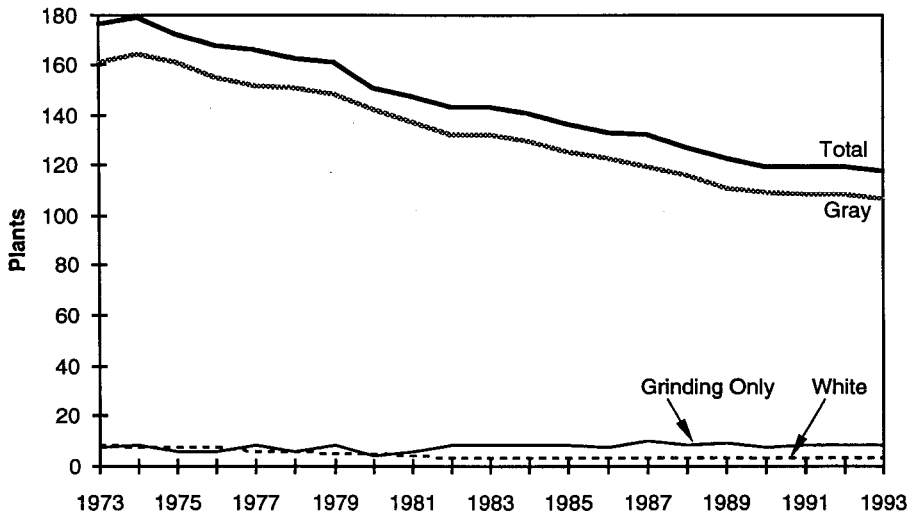

Figure 2-2. Number of U.S. cement plants by type of cement: 1973-1993.

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

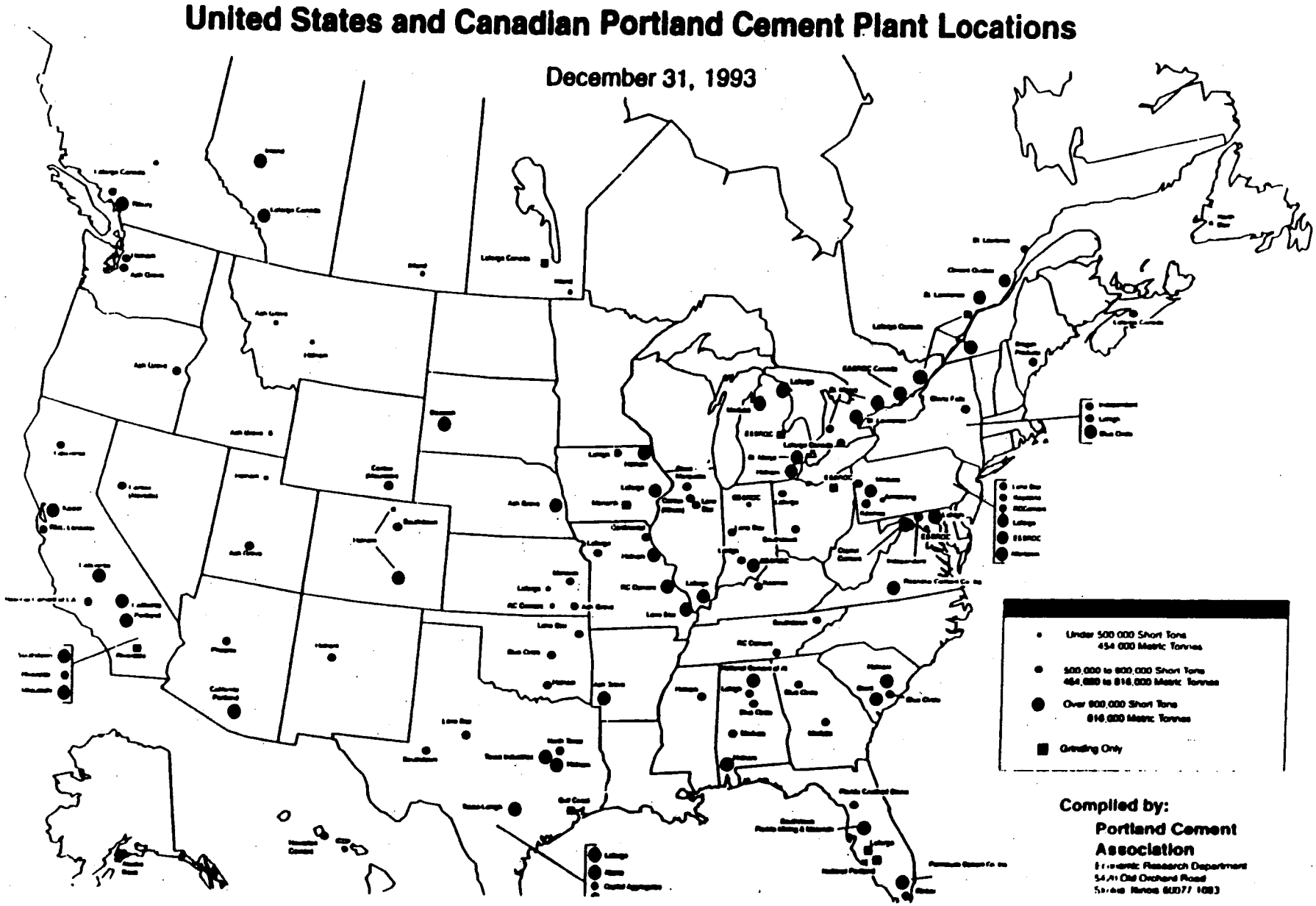

Figure 2-3. U.S. Portland cement plant locations, December 31, 1993.

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

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)

ID	Corporate name	City, state	No. of kilns			
			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)

ID	Corporate name	City, state	No. of kilns			
			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)

ID	Corporate name	City, state	No. of kilns			
			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.

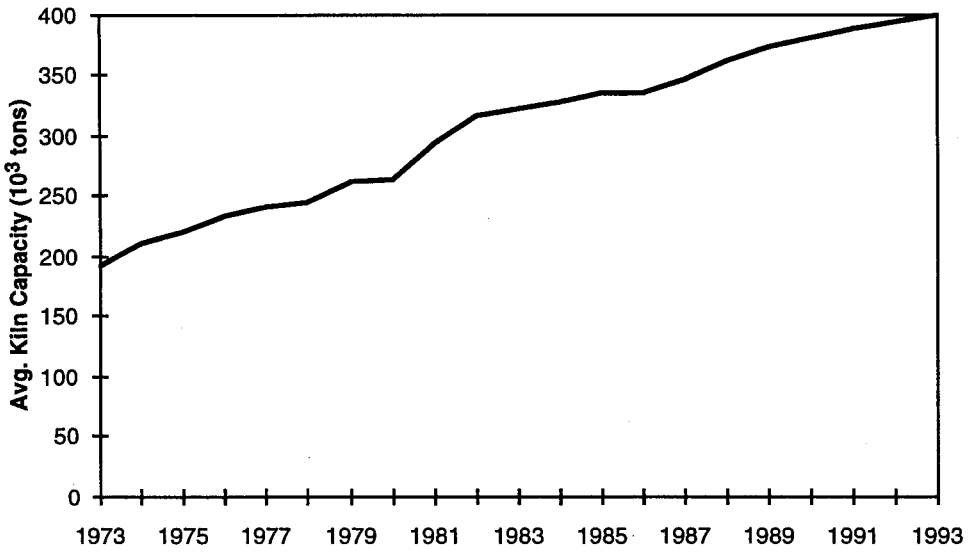

Figure 2-4. Average kilns capacity at U.S. cement plants: 1973-1993.

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

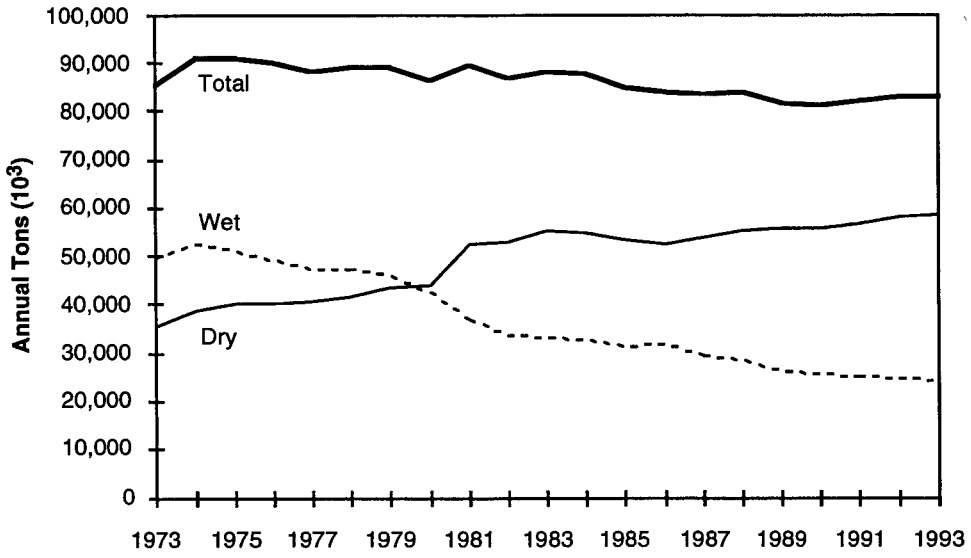

Figure 2-5. U.S. clinker capacity by type of process: 1973-1993.

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.
[d] 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.

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