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IMPACT OF RECENT ENERGY AND ENVIRONMENTAL LEGISLATION ON THE INDUSTRIAL SECTOR: THE STONE, CLAY AND GLASS INDUSTRY

FIRST INTERIM REPORT

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IMPACT OF RECENT ENERGY AND ENVIRONMENTAL LEGISLATION ON THE INDUSTRIAL SECTOR: THE STONE, CLAY AND GLASS INDUSTRY (SIC 32)

First Interim Report

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I. INTRODUCTION

This report describes the results of LBL's initial examination of the impacts of recent energy and environmental legislation on the stone, clay and glass industry group.

In the larger multi-industry study of which this work is a part, a heavy emphasis has been placed on the analysis of the impact of the Fuel Use Act (FUA). However, our initial inquires indicate that the FUA will have little impact on SIC 32 because fuel use in that industry group is dominated by direct heat applications and relatively little fuel is consumed in boilers. Thus, our attention has been drawn to other issues — in particular, the problems and opportunities associated with fuel switching and increased energy efficiency.

The remainder of this report is divided into two sections. The first of these gives a brief description of energy use patterns in the industry group and explains our decision to focus on two sectors of the group: hydraulic cement and glass. The second section describes the issues that we have identified as having the greatest environmental significance for cement and glass.

II. ENERGY USE PATTERNS

Energy consumption in the components of the stone, clay and glass industry group is available for 1976 from the Annual Survey of Manufacturers. The nationwide consumption figures for this industry group are reproduced as Table 1. Data for 1977 are rapidly becoming available with the publication of the Census of Manufacturers. During 1976, SIC 32 consumed a total 1.22×10^{12} Btu of fuels and electric energy at a cost of $2.16 billion. This was a five percent increase in energy consumption over 1975, and represents about ten percent of all energy consumed for heat and power in manufacturing. SIC 32 is the fifth largest energy consuming sector.

The largest energy consumer in the group is hydraulic cement (SIC 324), which used 36 percent of the purchased fuel (403×10^9 Btu) and 31 percent of the purchased electricity (9140 MWh). Almost all of the purchased fuel is used in burning raw materials in rotary kilns to produce cement clinker. Most of the electricity is consumed in grinding raw materials for the kiln and grinding the clinker to produce the finished product.

Table 1

Fuels and Electricity Used for Heat and Power, 1976

SIC CODE	INDUSTRY	TOTAL FUEL AND ELECTRICITY Btu (Trillion)	TOTAL FUEL AND ELECTRICITY (Million Dollars)	PURCHASED FUELS Btu (Trillion)	DISTILLATE FUEL OIL (1,000 Barrels)	RESIDUAL FUEL OIL (1,000 Barrels)	COAL (1,000 Short Tons)	COKE AND BREEZE (1,000 Short Tons)	NATURAL GAS (Billion Cubic Ft.)	PURCHASED (Million kWh)	LESS SOLD (Million kWh)
32	Stone, Clay and Glass Products	1,219.6	2,162.0	1,119.8	12,847.1	10,847.0	11,020.5	470.4	586.8	29,236.3	514.8
3211	Flat Glass	53.5	99.5	49.3	521.6	(D)	(D)	-	41.3	1,244.6	(D)
322	Glass, Pressed or Blown	214.9	425.5	192.7	3,513.3	1,866.9	(D)	-	152.7	6,497.8	(D)
3221	Glass Containers	147.2	291.4	132.2	2,852.0	1,590.9	(D)	-	100.8	4,389.4	(S)
3229	Pressed and Blown Glass, NEC	67.7	134.1	60.5	661.3	275.9	-	-	51.9	2,108.5	(D)
3231	Products of Purchased Glass	17.3	38.8	14.4	48.9	(D)	-	-	10.9	842.6	(D)
3241	Cement, Hydraulic	434.4	617.7	403.2	803.0	4,942.3	8,584.8	(D)	130.2	9,140.4	392.9
325	Structural Clay Products	104.0	179.1	98.9	1,697.7	260.9	49.8	(Z)	74.4	1,491.8	(D)
3251	Brick and Structural Clay Tile	57.2	95.5	54.3	741.1	(D)	(D)	-	41.6	840.0	(S)
3253	Ceramic Wall and Floor Tile	7.1	13.3	6.6	(D)	(D)	-	-	5.5	157.9	(D)
3255	Clay Refractories	23.1	45.0	21.9	806.7	(D)	(D)	(Z)	13.8	349.6	(Z)
3259	Structural Clay Products NEC	16.6	25.2	16.1	(D)	(D)	(D)	-	13.5	144.4	-
326	Pottery and Related Products	23.0	47.5	21.0	189.2	(D)	(D)	-	16.4	601.2	(D)
3261	Vitreous Plumbing Fixtures	8.3	17.0	7.7	51.3	(D)	-	-	6.1	190.7	(D)
3262	Vitreous China Food Utensils	2.4	5.0	2.2	(D)	(D)	(D)	-	(S)	48.7	(Z)
3263	Fine Earthenware Food Utensils	1.3	3.1	1.2	(D)	(D)	(D)	-	0.9	32.6	(S)
3264	Porcelain Electrical Supplies	5.7	12.6	5.0	55.2	(D)	(D)	-	3.8	227.7	-
3269	Pottery Products, NEC	5.3	9.7	4.9	(D)	(D)	-	-	3.6	101.4	-
327	Concrete, Gypsum, Plaster Products	222.8	417.8	210.0	4,639.3	1,542.8	2,041.2	(D)	74.4	3,748.3	(S)
3271	Concrete Block and Brick	17.2	37.9	15.9	453.3	140.1	(D)	-	6.4	394.9	(D)
3272	Concrete Products, NEC	20.4	46.9	18.3	445.9	157.8	(D)	-	8.4	624.9	(D)
3273	Ready Mixed Concrete	49.9	170.2	46.1	2,224.1	137.7	(D)	(D)	6.2	1,120.9	(S)
3274	Lime	94.3	137.7	91.5	645.3	875.8	1,993.2	(D)	24.8	800.8	-
3275	Gypsum Products	41.0	75.0	38.3	870.8	231.3	41.1	-	28.5	806.8	(D)
3281	Cut Stone and Stone Products	4.2	13.1	3.2	72.1	(D)	(D)	(D)	0.3	293.8	(D)
329	Misc. Non-metallic Mineral Products	145.4	323.1	127.1	1,362.0	1,491.8	328.4	141.9	86.1	5,375.8	44.5
3291	Abrasive Products	10.6	33.3	8.1	119.3	(D)	(D)	(D)	3.9	725.3	(D)
3292	Asbestos Products	10.7	30.7	8.7	152.6	358.5	(D)	(D)	4.2	583.9	(D)
3293	Gaskets, Packing, Sealing Devices	5.6	17.2	4.2	41.1	(D)	(D)	-	1.9	415.2	(D)
3295	Minerals, Ground or Treated	38.5	70.1	35.5	499.0	(D)	(D)	(D)	25.7	898.6	(D)
3296	Mineral Wool	53.0	119.5	45.8	329.4	113.3	(D)	135.0	34.7	2,104.4	(D)
3297	Non- Clay Refractories	19.3	37.0	17.7	186.3	158.6	(D)	-	9.6	453.9	(D)
3299	Non-metallic Mineral Products, NEC	7.8	15.3	7.1	34.2	(D)	-	-	6.1	194.3	(D)

NOTES: (D) Withheld to avoid disclosing figures for individual companies.

(S) Withheld because the estimate did not meet publication standards.

(Z) Less than 0.05.

Source: Annual Survey of Manufactures 1976, Fuels and Electric Energy Consumed

Two glass industries, flat glass (SIC 321) and pressed or blown glass (SIC 322) consume 22 percent of the purchased fuel (242 x 10^9 Btu) and 27 percent of the purchased electricity (7740 MWh). About 70 percent of the purchased fuel used in these industries is for melting glass; a second major use is for annealing glass products in ovens which are called lehrs. Electricity is used for grinding raw materials and for operating the machines which form the molten glass into finished products.

Concrete, gypsum and plaster products (SIC 327) use 19 percent of the purchased fuels and 13 percent of the purchased electricity. Energy use in the largest consumer in this industry, lime (SIC 3274), involves processes similar to those used in the cement industry. Consumption of the second largest energy user, ready-mixed concrete (SIC 3273), appears to be associated largely with fuel for cement trucks.

Structural clay products (SIC 325) and pottery and related products (SIC 326) consume 11 percent of the purchased fuels and 7 percent of the purchased electricity. The major use of purchased fuel in these industries is for firing their products in kilns. The balance of energy consumption in SIC 32 is accounted for by products of purchased glass (SIC 323), cut stone and stone products (SIC 328) and miscellaneous non-metallic products (SIC 329).

In order to make the best use of the resources available for this study, we have decided to concentrate our efforts on glass and hydraulic cement. The two industries account for about 60 percent of the energy consumed in SIC 32. Two of the three major energy consuming types of equipment used in SIC 32, rotary klins and glass melting tanks, are found in these industries. Thus, information learned from the study of these industries will be, to some extent, transferable to other industries, especially lime and mineral wool. The third type of major energy consuming equipment, kilns for firing clay products, will not be examined in this study except for a brief survey of the literature.

III. ISSUES

Our initial study has identified a number of issues related to cement and glass that appear to have environmental significance. Roughly, these issues can be divided into the following categories: energy conserving technology — issues raised by technologies that may reduce energy use; materials — issues

related to possible changes in non-fuel inputs and/or outputs; fuel switching — issues related to the use of fuels other than oil and gas; legislation — the impact of specific legislation on issues in the above categories.

A. Cement

1. Energy Conserving Technology

Two new types of equipment, the suspension preheater (SP) and the flash precalciner (PC), can have a major impact on energy use in the cement industry. This equipment is widely used in Europe and Japan, but is not common in the U.S. Cement kilns with SP and PC use about 3×10^6 Btu for the production of a ton of cement; this compares with the U.S. average of about 6×10^6 Btu/ton. It is likely that SP and PC will be included in all new plants built in the U.S.

SP and PC are not retrofit technologies and cannot be added to existing plants without major modifications of other equipment. However, since this technology is so much more efficient, it may cause the early retirement of existing plants. One issue to be examined is what will be the impacts of the advent of SP + PC on the economic life of existing plants and how might environmental legislation affect these impacts.

The much greater efficiency of SP + PC also raises some methodological issues. In particular, if the marginal cement plant is much more efficient that the average plant, how can this be dealt with in the framework of input-output analysis?

2. Fuel Switching

Switching from oil and gas does not present major problems for the cement industry. The air pollution and solid waste problems usually associated with the burning of coal are much reduced by the fact that SO_2 is absorbed by the materials in the kiln feed (more than 80 percent limestone) and fly ash can be incorporated in the product without affecting the quality. Kilns can also be adapted to burn wood wastes and have even been used to incinerate toxic wastes such as PCB in mixtures of other fuels. The only drawback to coal use is that it does increase the fine particle loading of the kiln exhaust.

The cement industry has been switching to coal fairly rapidly for economic reasons. The only issue here appears to be whether there are any barriers which might prevent complete conversion away from oil and gas.

3. Materials

A major materials issue is the possible role of pozzolanic cement in reducing energy consumption. Pozzolanic cement is a blend of portland cement and other materials, such as fly ash, that do not require kiln processing but still contribute strength, albeit less than that provided by portland cement, to the finished product. Energy required for the production of pozzolanic cements may be as much as 30 percent less than is required for portland cement. Barriers to the increased production of pozzolanic cements include difficulties in obtaining low cost raw materials and construction specifications which may exclude the use of pozzolanic cements, even though they are suitable. Raw materials difficulties may be reduced with increased coal consumption since fly ash is suitable for making pozzolanic cements.

4. Legislation

The Fuel Use Act will have very little or no impact on the cement industry. No other legislative issues have been identified thus far.

B. Glass

1. Energy Conserving Technology

There are no innovations comparable to SP + PC ready for adoption in the glass industry. For the immediate future, increases in energy efficiency will come largely from "tuning up" existing processes. For the longer term, increased efficiency is likely to result from two approaches: improvements in the utilization of waste heat from glass melting tanks and improvements in glass forming processes which increase the yield of finsihed products. One waste heat utilization scheme now under development involves preheating the raw materials before they are fed to the melting tank. This would result in an approximate 15 percent reduction in fuel used for melting. Cogeneration may be another possibility for waste heat use. The float glass process for making plate glass is an example of increasing the yield of finished product. In older processes, the plate has to be ground with a resulting loss of 15 - 20 percent of the glass; the float process requies no grinding. In the past 10 years, the industry has converted almost completely to this process, so little further impact on energy consumption can be expected. Possibilities for future increases in yield include improved operating practices, increased computer control of operations, and improved designs for forming equipment.

The need to increase energy efficiency will require increasing technical sophistication in the glass industry and may tend to increase the scale of operations (large melting tanks are usually more efficient than small ones). One issue to be examined is to what extent these factors will change the structure of the industry, especially pressed and blown glass, which is at present much less concentrated than flat glass.

The rapid adoption of the float process in the flat glass industry raises an issue related to data for input-output anlaysis. Coefficients derived from data for the late sixties or early seventies will not reflect the transformation that has occurred in the industry. Care must be taken here to insure that up-to-date information is used in developing coefficients.

2. Fuel Switching

There have been some experiments with burning coal in glass melting tanks, but there are serious technical difficulties with this approach. The main alternatives to oil and natural gas appear to be electricity or producer gas made from coal. Electricity is already in fairly common use for booster heaters — electrodes are inserted into the melt to increase the capacity of the tank and to aid in "fining." The technology for all-electric glass melting is available. Producer gas was widely used in glass factories before inexpensive natural gas became available, but few, if any, plants use it today. The technology can probably be revived and improved.

The choice between electricity and producer gas raises a key issue for this study. At the plant site, electricity is environmentally superior since there are no combustion products. However, producer gas is more energy efficient--the thermal efficiency of electric melting is twice that of producer gas melting but losses at the power plant make the gas superior in terms of primary energy consumption. A study of how environmental regulations might affect the choice between these two fuels may provide consdierable insight into problems relating to trade-offs between energy and the environment.

3. Materials

a. Recycling

Glass containers and especially glass beverage containers have a high potential for recycling. Increased recycling would have the environmental benefit of reducing litter and possibly energy consumption. The existence of

the latter benefit is contested by the container manufacturers who argue that energy consumption would only be shifted to other sectors, especially transportation. There is no question that increased recycling of whole containers would have profound effects on the industry.

Broken glass (called cullet) can also be recycled. This is done by mixing it with virgin raw materials and remelting. This probably saves energy as well as raw materials since some of the raw materials must be calcined, while the cullet does not undergo any chemical reactions. Most melting operations use some cullet, but the primary source of this is home scrap.

The advisability of increased recycling of glass containers has been much debated, but we are not concerned here with the merits of this question. The issues for this study relate only to the impacts on the glass industry. Questions of interest include: 1) will increased recycling tend to increase concentration in the glass container industry? 2) what is the energy conservation potential associated with the increased use of cullet?

b. Impacts from Changes in the Construction Industry

Parts of the glass industry are very closely coupled with activities in the construction industry. Building energy perfromance standards (BEPS) may have a significant impact on the flat glass industry. On the one hand, BEPS are likely to result in a reduction of the areas used for glazing; on the other hand, BEPS will probably also result in the increased use of multiple glazing (i.e., double and triple glazing). The net effect of these contrary trends is an issue to be investigated.

The cyclical nature of the construction industry imparts a cyclical character to parts of the glass industry and this raises a data issue for input-output analysis. Coefficients based on the results of a single year are likely to show biases due to cyclical variations; care shold be taken to avoid this problem, either by establishing that such biases are not present, or by using the results of more than one year.

4. Legislation

The Fuel Use Act will have little impact on the glass industry. Steam is used in some glass forming operations such as in the manufacture of fiberglass where the steam attenuates streams of glass into fibers. But the use of fuel for direct heat applications far and away exceeds its use in boilers.

A major legislative issue for the glass industry concerns the enactment of "bottle bills" in a number of states. This legislation requires a deposit on beverage containers which is repaid when the container is returned for recycling. Indications of the impact of more widespread enactment of bottle bills on the glass industry can probably be obtained by studying the consequences for the industry in states where this legislation is already in force.

C. Summary

The issues identified above are summarized in Table 2.

Table 2

Issues for the Stone, Clay and Glass Industry Group

	CEMENT	GLASS
Energy Conserving Technology	Impacts of SP & PC on economic life of existing plants Marginal vs. Average coefficients for I/O analysis	Impacts of technical requirements on industry structure Effect of Float Glass Process on I/O coefficients for flat glass industry
Fuel Switching	Barriers to complete coal conversion	Energy-environment trade-offs in the choice between electricity and producer gas for melting
Materials	Barriers to increased use of pozzolanic cements Effects of increased availability of fly ash for use of pozzolanic cements	Impacts of increased recycling Impacts of BEPS Cyclical variations in I/O coefficients
Legislation	None	Bottle bills

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