ENERGY-EFFICIENCY IMPROVEMENT TARGETS: Stone, Clay, and Glass Products (SIC 32)

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I. PURPOSE OF DOCUMENT

In accordance with Section 374 of the Energy Policy and Conservation Act (EPCA) (Pub. L. 94-163), the Federal Energy Administration (FEA) proposed industrial energy efficiency improvement targets for the ten most energy-consumptive manufacturing industries in the United States, and invited the oral and written presentation of views thereon by interested persons (41 FR 48169, November 2, 1976). Following public hearings on December 9, 1976, and review of the written comments which were submitted to FEA, the final target for "Stone, Clay, and Glass Products" (Standard Industrial Classification 32) has been developed and is described in this notice. It is intended to provide the basis for conservation activities undertaken in furtherance of the industrial energy conservation program.

A. Legislative

Part D of Title III of the EPCA requires that FEA establish a program to promote increased energy efficiency in American industry. This program includes the identification and ranking of major energy-consuming manufacturing industries, the establishment of energy efficiency improvement targets for at least the ten most energy-consumptive industries, and the identification of major energy-consuming corporations within targeted industries for the purpose of reporting industry progress in improving energy efficiency.

In accordance with Section 373 of the EPCA, FEA has identified the ten most energy-consumptive industries in the United States, to which energy efficiency improvement targets shall apply (41 FR 12766, March 26, 1976). These industries are as follows, based on the two-digit standard industrial classification (SIC):

RANKING	INDUSTRY	SIC NO.
1	Chemical and allied products	28
2	Primary metal industries	33
3	Petroleum and coal products	29
4	Stone, clay, and glass products	32
5	Paper and allied products	26
6	Food and kindred products	20
7	Fabricated metal products	34
8	Transportation equipment	37
9	Machinery, except electrical	35
10	Textile mill products	22

B. Technical

In accordance with Section 374 (a) (2), each energy efficiency improvement target is to be established at a level which represents the maximum feasible improvement in energy efficiency which the subject industry can achieve by January 1, 1980. Conceptually, each target represents the percentage reduction in energy consumed per unit of output or activity from the base year to the target year. The base year is calendar year 1972. The target year is defined as a projected year throughout which the industry would have in place the operating procedures and technologies determined to represent the maximum feasible improvement in energy efficiency as of January 1, 1980. While certain information on industry

progress in meeting the targets is required under the program, the EPCA specifically provides at Section 372 (2) that the targets are voluntary and further provides at Section 376 (f) that no sanctions shall attach for failure to meet them.

The targets for the ten industries, expressed in terms of an integer percentage, were developed in accordance with Section 374 (b) of the EPCA, which requires FEA to consider:

1. The objectives of the industrial energy conservation program;
2. The technological feasibility and economic practicability of utilizing alternative operating procedures and more energy efficient technologies in each identified industry;
3. Special circumstances or characteristics which pertain to any identified industry; and
4. Actions planned or implemented by any such industry to reduce its consumption of petroleum products or natural gas.

In general, the two-digit industry level targets were calculated by aggregating estimated energy efficiency improvement results derived for components of the two-digit industries. Technological feasibility and economic practicability of utilizing alternative operating procedures and more efficient technologies were considered at this level. These estimated "gross" two-digit targets were then reviewed in the light of special industry circumstances, characteristics and actions anticipated to reduce consumption of petroleum products and natural gas, and a "net" energy efficiency improvement determined.

The special industry circumstances include those over which industry has no control and which are expected to increase its energy consumption.

With regard to the factors required to be considered under Section 374 (b), the following criteria were applied in general:

1. Technological feasibility. The primary factors determining technological feasibility of utilizing alternative operating procedures and more efficient technologies are (a) the ability to implement measures identified by January 1, 1980, (b) the degree to which the measures represent proven practice, and (c) the compatibility of the measures with the products and processes of the industry.

2. Economic practicability. The economic practicability of various operating procedures and technologies reflected in the targets depends on the availability of capital for such procedures and technologies, and on the anticipated rate of return from investments in energy conservative options compared to rates of return on other options competing for the limited capital available.

3. Conversion from petroleum products and natural gas. Consideration was given in developing the targets to the effect of conversion from scarce energy forms such as natural gas and petroleum products. Any energy inefficiencies associated with conversion from these scarce energy forms were examined.

4. Special circumstances and considerations. The targets reflect necessary additional energy consumption associated with various requirements of law, such as certain pollution control requirements, which take effect between the base and target years and with various other changes beyond the control of industry, such as declining quality of raw materials and alterations in product mix, or changes in product characteristics.

Detailed analyses of each industry provide the bases for FEA's determinations of maximum feasible energy efficiency improvement, and these were made available for review by interested parties at the FEA Freedom of Information Reading Room, Washington, D.C., and at ten FEA Regional Offices throughout the country.

II. DRAFT TARGET AND DRAFT TARGET SUPPORT DOCUMENTS

A. Description

1. Documents

The draft target support document described the structure of the Stone, Clay, and Glass Products Industry (SIC 32), analyzed the technological feasibility and economic practicability of various appropriate energy efficiency improvement measures, presented the proposed target for SIC 32, and contained draft target support documentation. The report, "Draft Report on Development and Establishment of an Energy Efficiency Improvement Target for SIC 32: Stone, Clay, and Glass Products", was published June 25, 1976, in three volumes: the main report and two appendices.

The main report contained the following sections:

(a) Summary and conclusions

(b) Industry description, including a definition of the 27 component industries making up SIC 32, a description of the industry structure and of the products and manufacturing processes used by the individual industries, a discussion of the energy consumption patterns of SIC 32 and of the energy usage by the various components, and a review of the energy conservation achievements and programs undertaken by the industry during 1972 through 1975.

(c) Technological feasibility, including a discussion of the criteria for assessment, a description of all of the energy efficiency measures which could reasonably be adopted by January 1, 1980, and which would impact the target for SIC 32, an assessment of the energy efficiency improvement achievable by the adoption of individual measures and appropriate combinations of measures, an assessment of the extent to which such combinations of measures could be technically implemented by January 1, 1980, and a determination from those factors of the maximum technologically feasible energy reduction by 1980.

(d) Economic practicability, including a discussion of the criteria for assessment, a description of the return-on-investment analysis methods employed, a discussion of the results of the economic practicability evaluations of the various technologically feasible measures, and the development of an economically practicable level of energy efficiency improvement for each of the component industries.

(e) Conversion from scarce energy forms.

(f) Special circumstances/characteristics, covering a discussion of those special circumstances and characteristics of SIC 32 industries that had not been specifically taken into account in establishing the economically practicable energy conservation level.

(g) Target definition, including the analytical framework and assumptions inherent in developing the energy efficiency improvement potentials for the component industries and for aggregating these into an energy efficiency improvement target for SIC 32, the statement of the resultant target, and a discussion of the sensitivity of the target to key variables.

Volume 2 of the Draft Report contained the following Appendices:

Appendix A - Methodology

Appendix B - Conversion Factors

Appendix C - General Energy Conservation Measures

Appendix D - Industry Descriptions
- SIC 3211 - Flat Glass
- SIC 3221 - Glass Containers
- SIC 3229 - Pressed and Blown Glass, n.e.c.
- SIC 3231 - Products of Purchased Glass
- SIC 3241 - Hydraulic Cement
- SIC 3251 - Brick and Structural Clay Tile
- SIC 3253 - Ceramic Wall and Floor Tile
- SIC 3255 - Clay Refractories
- SIC 3259 - Structural Clay Products, n.e.c.

Volume 3 of the Draft Report was a continuation of Appendix D and contained the following industry descriptions:

- SIC 3261 - Vitreous Plumbing Fixtures and China and Earthenware Fittings, and Bathroom Accessories
- SIC 3262 - Vitreous China
- SIC 3263 - Fine Earthenware, Table, and Kitchen Articles
- SIC 3264 - Porcelain Electrical Supplies
- SIC 3269 - Pottery Products, n.e.c.
- SIC 3271 - Concrete Block and Brick
- SIC 3272 - Concrete Products
- SIC 3273 - Ready-Mixed Concrete
- SIC 3274 - Lime
- SIC 3275 - Gypsum
- SIC 3281 - Cut Stone and Stone Products
- SIC 3291 - Abrasive Products
- SIC 3292 - Asbestos Products
- SIC 3293 - Gaskets, Packings, and Sealing Devices
- SIC 3295 - Minerals and Earths, Ground or Otherwise Treated
- SIC 3296 - Mineral Wool
- SIC 3297 - Nonclay Refractories
- SIC 3299 - Nonmetallic Mineral Products, n.e.c.

Both the main report and the appendices were made available for public review as indicated previously.

2. Industry

The draft target support document represented a comprehensive evaluation of all segments of SIC 32, a heterogeneous grouping of 27 manufacturing industries (as categorized by four-digit SIC's within the Office of Management and Budget's Standard Industrial Classification (SIC) system). A wide diversity exists among both the products manufactured and the manufacturing processes used by this group of industries. For the purposes of this study, the 27 industries were grouped together into nine categories in the manner shown on Page 9, along with their relative energy usage and production for 1972.

The SIC 32 industries are well established segments of the American economy. The outlook for these industries is for modest growth, dominated in the nearer term by recovery of the construction industry. Over the longer term, the SIC 32 industries rate of growth can be expected to parallel or slightly surpass that of GNP calculated in constant 1972 dollars. In 1972, the estimated energy consumption was 1462×10^{12} Btu of fuel and electrical energy. The bulk of this energy was used to promote chemical reactions at high temperatures or to melt raw materials.

SIC 32 encompasses over 13,000 companies operating over 16,000 establishments and employing nearly 580,000 people. In 1972, shipments were valued at over $21 billion. A large portion of the

SIC 32 Industry Component	SIC	1972 Energy 10^{12} Btu	1972 Energy Percent	1972 Production 10^{6}	1972 Production Output Units	Consumption 10^{6} Btu/Unit of Output
Hydraulic Cement	3241	504.8	34.5	75.47	Tons produced	6.69
Glass Products						
Flat	3211	70.2	4.8	2.71	Tons produced	25.90
Container	3221	150.9	10.3	11.90	Tons produced	12.68
Pressed and Blown	3229	79.0	5.4	2.04	Tons produced	38.65
Mineral Wool	3296	51.3	3.5	1.64	Tons produced	31.20
Purchased Glass	3231	17.0	1.2	1.33	10^{3} $ shipped	12.84
Lime	3274	106.0	7.3	14.20	Tons produced	7.47
Structural Clay Products						
Brick and Tile	3251	92.9	6.4	9.46	10^{3} SBE* produced	9.82
Products, NEC	3259	27.9	1.9	2.44	Tons produced	11.44
Concrete Products						
Block and Brick	3271	19.5	1.3	0.86	10^{3} $ shipped	22.80
Products, NEC	3272	32.6	2.2	1.86	10^{3} $ shipped	17.46
Ready Mix Concrete	3273	82.0	5.6	208.50	Yds^{3} shipped	0.39
Gypsum	3275	49.2	3.4	19.08	10^{3} ft^{2} shipped	2.58
Refractories						
Clay	3255	25.5	1.7	3.54	Tons shipped	7.22
Nonclay	3291	13.6	0.9	0.89	10^{3} $ shipped	15.30
Abrasives	3297	37.3	2.6	2.74	Tons shipped	13.60
Whiteware Products						
Wall and Floor Tile	3253	7.2	0.5	0.18	10^{3} $ shipped	41.19
Plumbing Fixtures	3261	9.7	0.7	0.27	10^{3} $ shipped	36.00
Vitreous China	3262	3.3	0.2	0.07	10^{3} $ shipped	44.19
Earthenware	3263	3.0	0.2	0.08	10^{3} $ shipped	36.10
Electrical Porcelain	3264	7.4	0.5	0.28	10^{3} $ shipped	27.09
Pottery, NEC	3269	4.7	0.3	0.13	10^{3} $ shipped	35.00
Mineral Products						
Cut Stone	3281	6.1	0.4	0.30	10^{3} $ shipped	20.07
Asbestos	3292	15.5	1.1	0.76	10^{3} $ shipped	20.34
Gaskets	3293	7.4	0.5	0.38	10^{3} $ shipped	19.45
Minerals	3295	27.9	1.9	0.41	10^{3} $ shipped	67.44
Products, NEC	3299	9.9	0.7	0.17	10^{3} $ shipped	59.22

* SBE - Standard Brick Equivalent.

industry is privately owned. Companies averaged earnings of approximately 10 percent on investment capital and an estimated 5 percent on sales in 1974. Products made by these industries are used in construction or as components or supplies for other manufacturing sectors. On a value of shipments basis, other sectors affecting annual turnover of SIC 32 industries will be construction (60 percent), consumer durables (14 percent), industrial supplies (19 percent), and capital goods (7 percent).

The SIC 32 industries purchase essentially all fuels and more than 97 percent of their electricity. This study considered all energy as being purchased. Historical use patterns for energy are shown below:

	1962	1967	1972
Natural Gas	55%	52%	56%
Fuel Oil	8	7	10
Coal/Coke	29	25	18
Electricity	5	5	7
Other	3	11	9
	100%	100%	100%
Total Energy ($\times 10^{12}$ Btu)	1056	1229	1462

Since 1972, significant changes have occurred in the emphasis which energy planning and management is receiving by industry. In 1972, very few manufacturers had a detailed accounting of where energy was used. Energy audits are now becoming standard practice for many manufacturers. This, along with the unavailability of

natural gas, has resulted in some shifts in the pattern of energy consumption by SIC 32 industries. Reports submitted as part of an industrial voluntary energy conservation program and the survey of energy usage in 1974 by the Bureau of Census indicate that the relative use of natural gas is declining and the use of oil and electricity is rising. For instance

1. The Portland Cement Association showed a 6 percent decline in the relative gas usage between 1972 and 1975 with a corresponding increase in the use of coal.

2. The Refractories Institute showed a 6 percent decline in the relative gas usage between 1972 and 1974 with a corresponding increase in the use of fuel oil.

3. The flat glass and pressed and blown glass reporting groups showed a 6 percent decline in the relative gas usage between 1972 and 1975, with a corresponding increase in the use of fuel oil.

4. The Brick Institute of America showed a 5 percent decline in the relative use of gas between 1972 and 1975, with a corresponding increase in the use of fuel oil and coal.

5. The Bureau of Census figures for SIC 32 indicate a [2] percent decline in the relative use of natural gas between 1971 and 1974. Fuel oil usage increased 7 percent while coal usage decreased 4 percent.

For a majority of manufacturers in SIC 32, it is only feasible to substitute fuel oil or LPG fuels for natural gas. Replacement of existing processing equipment with electrically heated equipment is also technically feasible in some cases. Conversion to coal usually requires an ash-free (and sometimes sulfur-free) combustion product which will not affect product quality. It is not believed that such coal-firing technology will generally be

available on a commercial basis before 1980, and therefore conversion from natural gas and oil by a majority of the SIC 32 industries is not likely to occur, except as noted below.

A few SIC 32 industries do have the option of switching from natural gas or oil, and coal currently represents a higher percentage of the energy consumed in those industries than was the case in 1972. These are mainly the cement and portions of the lime, refractories, and mineral products industries, where the pyroprocessing equipment (e.g., rotary kiln) can utilize any fossil fuel and the product quality specifications can accept the impurities generated by the combustion of the coal or other less scarce fuel. The primary example is the cement industry which can use coal in its rotary kilns. This poses no difficult technical problems. Except for the relatively minor energy consumption in grinding the coal, overall energy consumption in cement manufacturing is essentially not affected. Similar conversions are possible for the lime industry, except where the sulfur specifications of the lime product require only the use of a low-sulfur coal. Portions of the refractories and mineral products industries also utilize rotary kilns which are convertible to coal. Again, specifications on product quality can preclude such conversions. In every case, the conversion is made primarily for business reasons, which may include the unavailability of natural gas. Securing reliable coal stocks of consistent quality and avoiding emissions which exceed ambient air quality standards are two additional barriers

which can prevent the decision to use coal over a scarce fuel, even though conversion to coal might otherwise appear to be an economically sound decision.

Coal or other less scarce fuels can also be substituted for natural gas or fuel oil to produce steam used in manufacturing plants for process heating or space conditioning needs. Again, reliability of coal stocks and environmental standards would be factors inhibiting such conversions.

The conversion to less scarce fuels (primarily coal) could increase the relative percentage of energy supplied by these less scarce fuels from the 18 percent level in 1972 to a maximum of about 40 percent in 1980. This would come about primarily through conversions in the cement and lime industries. In any case, conversion from scarce energy forms is not anticipated to result in any significant energy efficiency penalty associated with such conversions made by 1980.

B. Methodology

The study of the energy efficiency improvement for SIC 32 generally consisted of the collection and analysis of available technical and economic information and this was used to establish a draft target for SIC 32 by estimating the improvement which could be made by each of the component industries between 1972 - 1980. The draft target support document described the industries involved, identified the energy efficiency techn-

ologies which were found feasible for implementation by 1980, assessed the economic practicability and capital available for implementation, and considered conversion from scarce energy forms and special circumstances affecting the SIC 32 industries.

While all segments of SIC 32 were evaluated, primary emphasis was concentrated on those industries which consume a majority of the energy, since these can more significantly impact the target set for SIC 32.

1. Criteria for Assessing Technological Feasibility

The amount and quality of technical information available during this study varied widely. The information was obtained from domestic and foreign technical and trade publications, from government reports, and from contacts with industrial manufacturers, trade associations, and equipment suppliers. The general methodology consisted of developing a list of possible energy-efficiency improvement measures. Each measure was evaluated using the following general criteria which could positively affect adoption:

(a) Measure could be implemented to have an impact on the SIC 32 target by January 1, 1980.
(b) Measure could provide significant energy savings within an industry component and such savings could impact the SIC 32 target.
(c) Measure had been demonstrated commercially in the U.S. by 1975 (if it required significant process modifications or equipment additions), or the measure had been demonstrated commercially in a foreign country.

Additionally, criteria which could negatively affect the adoption were used. These are:

(a) Measure could lower the quality of the product produced to an unmarketable level.
(b) Measure could decrease production rates to a non-competitive level.
(c) Measure could cause an undesirable interaction with other measures.

A determination was made for each of the measures selected as to the extent to which the measure had already been adopted by industry and the extent to which it could be adopted; assuming only technical considerations.

The energy base for 1972 was established on an individual basis for each of the 27 components of SIC 32. The energy usage was initially calculated from Census of Manufacturers data for 1971 and modified, when appropriate, by data obtained from other sources. The 1972 energy usage was determined by deflating the 1972 costs of purchased fuels and electricity (given by Census of Manufacturers) to 1971 dollars, using wholesale price indexes published by the Bureau of Labor Statistics. The deflated 1972 costs were then divided by the 1971 cost per million Btu to determine the 1972 usage. Aside from the price increases for both fuel and electricity, the pattern of energy consumption that existed in 1971 was taken as appropriate for 1972, except where data from other sources showed otherwise.

2. Criteria for Assessing Economic Practicability

On the basis of discussions with/or information supplied by representatives of individual companies or trade associations within the various component industries making up SIC 32, an after-tax, discounted-cash-flow, return on investment analysis was considered to be appropriate in evaluating the economic feasibility of technically feasible measures. The following basic values were used in the analysis:

(a) Project Life - 10 years (with some exceptions).
(b) Capital Investment - One time at start of project.
(c) Depreciation Rate - Straight-line for life of project.
(d) Fuel Costs - Fossil - $2.50/million Btu
Electrical - $7.50/million Btu equivalent.
(e) Operating Cost Changes - Unless otherwise specifically identified as a substantial change, all changes in cost of labor, power, maintenance, and supplies were considered to largely offsetting and to result in negligible changes in operating costs in comparison with fuel cost changes.
(f) Tax Rate - 50 percent effective Federal and State tax rate.
(g) Hurdle Rate for ROI - Taken to be 15 percent on basis of industry practice.

Other assumptions implicit in the analysis included no change in production capacity and constant operating dollars. Other taxes and tax credits were assumed to be off-setting or negligible. The installed capital cost of a proposed project was based on costs of actual projects completed in the 1974-1975 period or engineering estimates of the installed costs where actual project data were not available. For most of the technically

feasible energy conservation measures considered, the calculated returns on investment were either substantially above 25 percent or were well below 5 percent. For the few situations where the calculated return on investment was close to 15 percent with the best estimate of installed cost, the sensitivity of the ROI to the assumed capital investment was examined and taken into account in the final judgement of the economic feasibility of a given energy conservation measure.

By applying the return on investment analysis, the technically feasible energy conservation measures and the various technically feasible combinations of such measures for the various component industries were sorted into an economically feasible set. The next question that was considered in arriving at an evaluation of the economic practicability of a given measure or combination of measures was the availability of the capital funds required to implement the various measures.

It must be recognized that industry regards energy-conserving investments as merely one of a number of alternative opportunities each of which makes demands on the available capital funds. If the proposed investment makes good business sense (among other things offers a sufficiently high return on investment to be included in the list of alternatives) it will be considered further and will be evaluated with respect to the

various current priorities and strategy of the business. Investments that are essential to the survival of the business, to meet new laws and regulations, to maintain market share, to assure supplies of essential raw materials or energy, or for expansion of production capacity to provide for anticipated growth generally have priority over cost-saving measures such as energy-conserving measures. Thus, energy-saving measures are usually in the deferrable category and the funds available are among the "discretionary" investment funds that are left after the "non-discretionary" funds have been budgeted.

The size of this discretionary bank of money was determined by first estimating the total amount of money available to the industry component for capital investments during the period 1972-1980. Data available from the Annual Survey of Manufacturers on historic investment levels were used as the indicator of the ability of the industry to generate and borrow capital for new plant and equipment*. From the resultant total financial capability number were subtracted the known or estimated amounts expended during 1972 through 1975 and the projected expenditures from 1975 to 1980

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* For SIC 32 the expenditures for new fixed assets ranged between about 7 to 9 percent of the gross book value of fixed assets during the period 1967-1973.

for capacity increases, to meet environmental and other regulations, to assure supplies of raw material and energy (including conversion to less scarce energy forms), and any other known high priority, non-discretionary capital expenditures*. The remaining funds were used as the basis for evaluating the extent to which the industry could implement the technically and economically feasible energy efficiency improvement measures.

3. Target Determination

The SIC 32 target is expressed as the percentage reduction in energy consumed per unit of output from the base year (1972) to the target year (1980). The reduction in energy was estimated for each of the SIC 32 components.

The procedure used in aggregating these component energy efficiency improvements into an energy efficiency improvement target for the entire stone, clay, and glass industry comprised in essence weighting the contribution of each component in terms of its relative total energy consumption. This involved determining for each of the 27 components:

(a) Energy per unit of output consumed in 1972.
(b) Technologically feasible means to improve energy utilization.

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* Where the individual data were insufficient for such detailed calculations, it was assumed that the funds available for energy-conserving measures represented 33 percent of the total available capital funds.

(c) What fraction of the above means would be implementable by January 1, 1980, based on economic practicability.
(d) A forecast of 1980 output.
(e) Energy consumption in 1980 at 1972 efficiency.
(f) Energy consumption in 1980 at 1980 efficiency.
(g) Energy savings in 1980 by implementation of 1980 efficiency improvement means.
(h) Item (g) divided by Item (e), expressed as a percentage.

The resulting percentage was rounded to the nearest integer percentage.

C. Resulting Draft Target

The draft target for energy efficiency improvement in SIC 32 which was determined to be technically and economically feasible was 17 percent. This was the percent reduction in energy consumed per unit of industrial output.

The target resulted from a weighted aggregation of the energy reductions expected to be achieved by the individual components which make up SIC 32. The values for the individual components ranged from a low of 0.46×10^{12} Btu to a high of 108.24×10^{12} Btu. The total for SIC 32 was 290.14×10^{12} Btu. The SIC 32 target was calculated by dividing 290.14×10^{12} Btu by the 1980 energy consumption at 1972 efficiencies (1752.60×10^{12} Btu) and rounding off to the nearest integer.

The draft target derived in this fashion represented the net energy efficiency improvement target which was the same as the gross target; those factors outside the control of the industry which might influence the ability of the industry to achieve the technically and economically feasible improvement were taken into account as an intrinsic part of evaluating the economically practicable level of energy efficiency improvement for the individual components of SIC 32.

For example, the significant capital investments that have already been made by the industry for pollution control equipment and the anticipated additional expenditure in the 1976-1980 period were taken into account in assessing the funds available to finance energy-saving capital projects.

The amount of energy consumed in operating pollution control equipment likewise was examined for the various component industries. On the basis of changes in electrical energy consumption per unit of production between 1972 and 1974 or comparison of 1974 consumption rates with typical electric power usage for the 1960-1970 period, it was concluded that the operation of pollution control equipment has caused negligible increases in energy consumption. It is judged that any future increases in energy consumption resulting from equipment installed to meet 1977 environmental standards will be more than off-set by gains in energy efficiency resulting from more efficient process equipment installed in connection with increases in capacity to meet growing markets.

One of the special characteristics of SIC 32 that has not been explicitly discussed previously is the relationship between fuel efficiency and operating rate as a function of percentage of rated capacity. The largest majority of energy consumption in SIC 32 is associated with high-temperature pyroprocessing steps in continuous furnaces, melting units, or kilns. It is known that for each continuous pyroprocessing system there is an optimum rate of production for fuel economy which is normally close to the design capacity. Operation above this point may result in a lower overall operating cost at some penalty in fuel economy. Operation below the optimum will penalize both fuel economy and overall cost per unit of production. Hence, where the demand for the product permits, operation is optimized for overall cost efficiency at an operating rate somewhat above the optimum fuel economy rate. Slight decreases below the economic optimum rate, thus, result in energy savings. Increases above the optimum economic rate to meet a temporary increase in demand or large decreases below the optimum to accommodate a falling demand will result in losses in energy efficiency. However, these relationships are not well quantified and assessment of the effect on the energy efficiency target of possible variations from the optimum operating rate has not been done.

If the market for the products of SIC 32 should decrease rather than grow as anticipated, the energy efficiency improvements that have been predicted will be more difficult to attain.

An offsetting factor is that a reduction in demand could result in the removal of less efficient furnaces, melting units, and kilns from the production stream, which would, in effect, contribute to an overall improvement in average energy efficiency.

The end result of the technical and economic analyses and consideration of special circumstances was a draft energy efficiency improvement target for SIC 32 of 17 percent; the reduction in energy consumed per unit of industrial output. The sensitivity of the target was tested against three sets of key variables: technical, economic, and the relative magnitude of energy consumption among industry components. This analysis showed the draft target to be relatively insensitive to variations in individual technical measures. For example, one of the most effective energy saving measures available to the cement industry, conversion of wet process to dry process, suspension preheater kilns, can halve the total energy consumed in making cement in some kilns. The measure is believed applicable to about 10 percent of the cement production, which represents about one-fourth of the total energy savings achievable in this industry. However, a variation of as much as $\pm$ 20 percent (judged to be larger than the uncertainty of the estimate) in the energy savings achievable with this single significant measure will produce a variation of only about 5 percent in the total energy savings for the cement industry or about $\pm$ 1 percentage point in the target for SIC 32.

Variation in the economic variables (e.g., assumed fuel costs or installed capital costs) impact the industry target only when they affect the calculated return on investment. Only a few measures are so affected.

The SIC 32 industry target is most sensitive to variations in the energy efficiency improvement potentials in the cement and glass product industries which jointly represent about 60 percent of the total energy consumption.

Overall, within the constraints of the study and the basic assumptions and provisions that are an intrinsic part of the target setting procedure, the target is judged to have a probable maximum error of no more than +1 and -2 percentage points.

III. FINAL TARGET AND UPDATE OF TARGET SUPPORT DOCUMENTS

A. Comments Received and Their Impact

Testimony was given at the Public Hearing on December 9, 1976, on behalf of the glass, cement, gypsum, lime, ceramic tile, refractories, and abrasives industries and additional written comments were supplied to FEA concerning the expanded minerals industry and supplementing the testimony on some of the other industries. This testimony and the written comments supplied to FEA by representatives of industry and by other government agencies has been thoroughly reviewed and the impact on the target has

been assessed. The comments fall into eight general categories as described below.

1. Energy Savings Achieved to Date and Achievable During 1976 - 1980

Three of the comments concerned the difficulty in achieving the energy efficiency improvement goals of certain component industries in view of the limited progress made toward those goals since 1972 and the short time remaining until January 1, 1980, to undertake the extensive capital equipment modernization program required. It was a basic premise of the target setting procedure (as indicated by the provisions of Section 374 (a) (2) of the EPCA that each target be established as the maximum feasible improvement which can be achieved by January 1, 1980), that the energy savings potential resulting from the modernization or replacement of inefficient plants and equipment is to be judged on the basis of the maximum improvement which can be implemented and put into effective operation over the period 1972-1980. Hence, these comments are deemed not to have merit and the suggestion that the component goals and the industry target be revised to reflect what is probable over the period 1976-1980 rather than what is possible over the period 1972-1980 is contrary to the requirements of the EPCA.

Seven comments (including two of the above three) concerned the progress made to date toward the voluntary energy conservation

goals of various industry components and in five of these it was stated that the component would strive to achieve the energy efficiency improvement potentials which were estimated for their industry component in establishing the target for SIC 32.

2. Base Year Data

The base year selected by FEA to be used as a bench mark in measuring energy efficiency improvement was 1972. Five comments disagreed with the base year energy consumption figures used in the study. These comments have been considered and no changes in the base year figures resulted. The data used are considered to be the best available industry-wide information and no revision is warranted. In those cases where revisions in the base year data were proposed, the comments were made by segments of the respective industry components. The data used in this study were derived from the U. S. Bureau of Census and other sources and more closely represented consumption used by the whole industry component.

3. Component Industry Structures and Boundaries

Three comments concerned the possible inclusion within a given 4-digit component industry of energy consumed by other components within SIC 32 or the attribution of energy saving potentials to one component that properly should be attributed

to another component industry. Two comments concerned the possible inclusion in SIC 32 component industries of energy consumed in captive production of SIC 32 products as raw materials by industries outside SIC 32. These comments were carefully considered and the data in question were re-examined. The energy consumption data were obtained from the U. S. Bureau of Census and are judged to be the best available data for the individual component industries and for SIC 32. No changes in the goals for the components nor for the target is warranted.

4. Inapplicability of Component Goals and Industry Target to Individual Companies

Eight of the comments either stated that or questioned whether the component goals and/or the industry target could not be achieved by all companies. This fact is fully recognized and was taken account of in the target setting procedure. Two comments pointed out that many of the energy efficiency improvement measures proposed for their industry had already been fully implemented by some companies prior to 1972 and that those companies would be unable to achieve as great an improvement over their 1972 energy consumption as was presumed by the goal. This also was taken account of in estimating the extent to which individual energy saving measures had been implemented by the industry as a whole prior to 1972 and the savings that could be achieved by wider implementation between 1972 and 1980.

5. Degree of Technological Applicability of Various Energy Conserving Options

A substantial area of disagreement expressed in the comments was the degree to which individual measures for improving energy efficiency are applicable throughout an industry component or the extent to which various combinations of measures can be applied within an individual plant or the plants in an individual company. Ten comments expressed various positions with respect to these questions. Four comments disagreed with the figures given in the Draft Report on the extent to which specific measures were applicable; the reasons stated for disagreement included (a) differing judgments concerning the extent to which the measure had been applied prior to 1972, (b) potential adverse effects on product quality for some markets, (c) potential increases in operating or maintenance costs, (d) potential decreases in production rate and (e) limitations on raw material choices imposed by the measure. Two comments questioned whether the energy savings achievable by a combination of measures had been properly evaluated and pointed out that the net savings from a combination could be significantly less than the sum of the individual savings. Four comments questioned whether the degree of energy savings postulated for specific measures was achievable throughout the industry component. These same points were an intrinsic part of the target setting

procedure. The questions raised had been carefully considered in arriving at the judgments made concerning the technical feasibility, the applicability of the technical measures alone, and in combination, and the average energy efficiency improvement attainable by the various measures. Hence, it was concluded that the postulated savings are achievable and are considered valid.

In many cases, the objections that were contained in the comments to the judgments arrived at in the target setting were based on the experience of an individual company or a segment of the industry component and are not considered to be representative of the entire component. No new factual information was presented that would justify a change in the conclusions previously reached concerning the degree of applicability nor the energy savings resulting from the application of the measures that were judged to be technologically feasible.

6. Economic Practicability of Various Options

The economic practicability of individual measures and the economically practicable level of implementation throughout an industry component of certain high capital cost energy efficient plant modifications was another area which generated comments expressing disagreement with the FEA findings. The comments covered the following aspects of economic practicability: the

estimates of the capital costs of the plant/equipment modifications, the level of fuel costs assumed, the ability of the industry component to generate the amount of capital needed at the level of implementation included in the target.

Three comments questioned the validity of the estimated capital cost figures used in the return on investment calculations for certain equipment modifications or replacements. The capital cost figures used were based on reports in the technical literature or data from individual companies concerning the costs of actual plant modernization projects completed during 1972-1975 and estimates by engineering firms, construction firms, and equipment suppliers of the costs of various modifications for which actual costs were not available. The higher cost figures stated in some of the comments represented the experience of a few companies or estimates of future construction costs and are not judged to be more reliable indicators of the probable costs for the entire industry than the figures used in the return on investment calculations employed to evaluate economic feasibility. On the basis of the significant extent to which modernization projects have been and are being implemented for which the capital cost estimates and calculated investment returns were questioned, it is judged that the economic feasibility of those projects was not overestimated.

The fuel costs used in developing the SIC 32 target were intended to represent average industry fuel costs during the period 1972 to 1980. Three comments questioned the accuracy of the fuel cost estimates used to develop the target. Consideration of the comments and the data presented on fuel costs by the cement industry resulted in the determination that the fuel cost estimate used was reasonable for all industry components except the cement industry. The cement industry, unlike most of SIC 32, has been able to make a substantial conversion to coal and to stabilize their fuel cost for 1972 - 1980 at about 1/2 that of the fuel cost used in developing the target. Thus, the economic motivation for capital investment by the cement industry is likely lower than was originally estimated and the maximum practicable rate of modification/ replacement involving high capital cost investments is lower than was originally estimated. The resultant reduction in the economically practicable level of energy efficiency improvement for the cement industry impacts the target for SIC 32 because of the substantial fraction of the energy consumption for SIC 32 that is represented by the cement industry.

Two comments questioned the ability of the component industry to generate sufficient capital funds to finance the energy efficiency improvement modifications in plant and equipment implicit in the economically practicable level determined for the industry component in the target setting activity. The reduction

in the anticipated investment in capital equipment modifications resulting from the revised evaluation of the economically practicable level for the cement industry substantially reduces the need for capital funds and the ability of the industry to generate sufficient funds at the lower level of investment is judged to be more than adequate on the basis of historic data for the industry. Careful consideration of the other comment concerning the potential lack of available capital for energy conserving plant and equipment modifications in another industry component reveals that the statement was based on faulty reasoning from a hypothetical future development and does not warrant any change in the goal for that component nor in the target.

7. Effects of Operating Rate on Energy Efficiency

Three comments questioned whether the potential decrease in efficiency with decrease in operating rate had been sufficiently accounted for in determining the energy efficiency improvement potential for their industry component. Consideration of those comments and a re-examination of the limited data available on the relationship between production rate and energy efficiency in SIC 32 industries did not result in a change from the original conclusions concerning the probable future impact of market conditions on production rates and energy efficiency in SIC 32.

However, the point is well taken that unanticipated future decreases in the demand for the products of the stone, clay, and glass industries could have a significant detrimental effect on the energy efficiency of the industry and negate much of the improvement achieved by measures already taken on the assumption of a continued growth in the economy. As provided for by the EPCA, the target may be modified by FEA if conditions warrant.

8. Special Industry Circumstances

Six comments concerned special circumstances or characteristics of industry components and questioned whether these had been adequately considered in determining the energy efficiency improvement potential for the component and in setting the industry target. Two comments concerned the increase in energy consumption resulting from the operation of pollution control equipment. The increases quoted represented the experience of an individual company or predictions of possible future requirements, are not judged to be valid with respect to the industry as a whole, and, accordingly, do not warrant revision in the target. Three comments questioned whether the lack of energy penalty associated with conversion to coal as a fuel was valid for their industry component. In setting the target, it was judged that significant conversion to coal firing would take place only in those industry components where such

conversions would not be detrimental to product quality nor production rate and would not impose an energy efficiency penalty - namely in the cement industry and portions of the lime, refractories, structural clay products, and expanded minerals industries. If conversions beyond those contemplated in the target setting procedure are required because of circumstances beyond the control of the industry, a decrease in energy efficiency could result. The EPCA provision for target modification allows for appropriate changes if this should prove to be the case in the future. One comment concerned the energy penalty associated with quality specifications that limited the application of a specific energy efficient equipment modification. This limitation had been properly accounted for in the judgments made in assessing the applicability of this equipment and in the resultant goal for that industry. The comment is without merit with respect to the target but does suggest a pathway for further improvements in energy efficiency for that industry. If the product specifications should be altered in the future, the effect on the goal for the industry component and its potential impact on the target would be appraised during the review of the target.

B. Support Document Update

A full revision of the 800 page draft target support document would include many changes to improve the clarity and completeness

of the document. Since a complete revision is not presently planned, corrections were made of those pages where an impact occurred which affected the SIC 32 target. Based upon a comprehensive review of the comments received before, during, and after the public hearings, the only change which affects the SIC 32 target was a lowering of the assumed cost of energy for the cement industry because of its ability to utilize coal as a fossil fuel in place of oil or natural gas. Accordingly, this reduced the economic incentive for this industry to implement energy saving measures requiring major conversion or replacement of existing processing equipment.

The revised pages from the original draft document have been corrected and are attached as an appendix to this report.

C. Final Target Values

The final target, rounded to the nearest integer, is 16 percent (15.7 percent). It is calculated by dividing the 1980 energy efficiency improvement of 274.77×10^{12} Btu by the 1980 energy consumption at 1972 efficiencies of 1752.60×10^{12} Btu. As was the case with the draft target, there is no offset to the final target (i.e., gross target = net target).

Two changes occurred in the estimated improvement in energy efficiency by the cement industry and these resulted in a 14 percent reduction in the expected improvement for this industry

component. These changes were (1) a reduction in the estimate for the maximum economically practicable rate of conversion/replacement of kilns due to a lower cost of fossil fuel (coal) than originally assumed, and (2) inclusion of energy savings resulting from the addition of new, more efficient capacity additions. These two changes reduced the SIC 32 draft target from 290.14×10^{12} Btu to its final value of 274.77×10^{12} Btu.

No other changes were made which impacted the SIC 32 target.

D. Basis and Justification

The target of 16 percent for the SIC 32 industries is based on the best information available. It represents the maximum feasible energy efficiency improvement which the industry can achieve by January 1, 1980, using 1972 as the base year, considering both technological feasibility and economic practicability.

The SIC 32 industries represent a composite of industries, which in the main utilize high temperature pyroprocessing furnaces in the manufacture of their products. Processing temperatures usually exceed 1500 F. Methods for improving the energy efficiency of these industries can be grouped into four general categories: (1) general energy conservation, sometimes referred to as "housekeeping", (2) improvement in the manufacturing processes, (3) changes in the materials used and/or changes in the composition or

character of the final products, and (4) improvement in the transportation of materials.

Improvement in the manufacturing process usually has the greatest impact on energy usage within this industry. This may be a replacement, modification, or change in the operation of the pyroprocessing equipment, which results in an energy reduction per unit of production. To a large extent, attainment of the target depends upon the actions taken by the major energy consuming industries (cement, glass, lime, and structural clay) within the 1972 to 1980 time period, primarily through capital investments which lead to energy reductions in their high temperature pyroprocessing equipment. Other changes can also be meaningful in the other three areas mentioned above, and for some industries may result in significant energy savings, and need to be diligently pursued. The target is not dependent upon just a few industries, but rather represents a combination of a large number of measures. As a consequence, attainment of the target for SIC 32 and its component industries depends upon a broad-based energy conservation program being developed and pursued by the large majority of these industries.

The number of measures considered as technically feasible, which could impact the industry target, ranged from 15 for cement to 3 for some of the industries consuming smaller amounts of energy.

Detailed descriptions of the measures for each of the 27 component industries comprising SIC 32 were given in the appendix to the draft target document. In addition to specific technology measures for each industry, energy reductions from general energy conservation measures (housekeeping) were considered. These general measures were considered to collectively produce an energy savings of 10 percent or more of the nonprocess energy. It was generally found that no one measure dominated the potential energy reduction by an industry. The application of specific energy saving measures within an industry required judgment as to the amount of production which could be affected by the measure. It is generally true that while a large number of energy saving measures may be applicable to an industry, not all measures could be utilized by a single plant.

Most technology measures considered had been evaluated in the U.S. or abroad by industry in a commercial facility. All of the measures selected can be available and be implemented by a significant portion of industry by January 1, 1980, so as to contribute to the net energy savings of SIC 32.

The availability of capital to implement feasible energy efficiency improvement measures was considered for each of the 27 components of SIC 32. Data was obtained from the Annual Survey of Manufacturers on historic investment levels and was used as the indicator of the ability of an industry component to generate and borrow capital for capital expenditures. Known or projected "non-

discretionary" capital expenditures were deducted from the total and the remaining funds used as basis for evaluating the extent to which the industry could implement the technically and economically feasible energy efficiency measures. The result was a final target for SIC 32 which represents the improvement which can be implemented and for which money can be raised.

All of the known special circumstances and characteristics of the SIC 32 industries that have a bearing on determination of the target were taken into account in establishing the energy efficiency improvement. It was concluded that these represented a minor perturbation in the ability of the SIC 32 industry to achieve its target.

Historically, the SIC 32 industries have been dependent upon the use of natural gas since the 1950's, which in 1972 provided 56 percent of the energy consumed. Usage of coal has generally declined up to 1972, while the percentage of other fuels and electricity remained relatively constant. Since 1972, there has been a slight shift toward the use of more coal and fuel oil, but, natural gas still represents the primary fuel. Some industries (e.g., cement) can readily substitute one fossil fuel for another in their pyroprocessing equipment and do so mainly on the basis of fuel cost. Most industries have optimized pyroprocessing system design and operation around the use of natural gas, making shifts to alternate fuels more difficult and often times costly.

Until the early 1970's, the SIC 32 industries depended heavily upon energy suppliers for fuels and electricity planning. Cost of fuel was the most important criteria. The reductions in natural gas availability, the oil embargo of 1973, and the significant increases in fuel cost were not anticipated by most manufacturers in 1972. Since then, significant changes have been noted in the emphasis which energy planning and management is receiving by industry. The limited availability of natural gas and the higher cost of energy have brought about an awareness on the part of many manufacturers which did not exist in the early 1970's, but which is now apparent.

APPENDIX A

REVISION OF PAGES 136 AND 137 OF DRAFT TARGET SUPPORT DOCUMENT ENTITLED "DEVELOPMENT AND ESTABLISHMENT OF AN ENERGY EFFICIENCY IMPROVEMENT TARGET FOR SIC 32: STONE, CLAY, AND GLASS PRODUCTS"

These high priority investments add up to:

Environmental Control	$ 500 million
Increased Capacity	1120 million
Assurance of raw materials and maintain market share	200 million
Conversion to coal firing	130 million
	$1950 million.

The remaining capital funds available for energy-conserving investments amount to $500 million or a little more than one-half that required for the mixture of economically feasible feasible measures. Thus, to arrive at an estimate of the maximum feasible improvement in energy-efficiency that is technically and economically achievable by the U.S. cement industry without special financial incentives or assistance, a choice must be made among the various measures to arrive at a set that represents a total investment of no more than $500 million and produces the greatest possible energy savings. The greatest savings in energy per dollar invested are associated with the measures that have the lowest capital cost per ton: housekeeping measures, replacement of faulty kiln seals, installation of improved refractories, cooling of kiln shell, optimal use of chains, use of slurry filters to reduce water content, use of energy-rich raw materials, and production of blended cements. This set of measures produces an industry-wide energy savings of 0.45 x 10^6 Btu/ton at a total capital cost of $27 x 10^6 for the 1972-1980 period. It is assumed

that these measures will be implemented first, leaving a balance available for the higher capital cost investments equal to about $473 million. The remaining energy conservation measures all involve substantial capital costs per ton of capacity and all produce about the same energy savings per dollar invested. The following distribution among the alternative methods of converting inefficient wet capacity to more efficient dry process kilns and the improvement of the efficiency of existing dry process kilns by converting to suspension preheater kilns is judged to be a reasonable allocation of the estimated remaining capital funds:

Energy Conservation Conversion Measure	Percent of 1972-1980 Production Converted	Capital Investment Required, 10^6 $	Energy Savings, 10^6 Btu/ton
Wet to Dry Preheater	10	225	0.32
Wet to Dry	5	5	0.08
Dry to Dry Preheater	12	240	0.36

The total reduction in energy consumption achievable within the estimated financial limits then equals 1.21×10^6 Btu/ton.