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INPUT-OUTPUT ANALYSIS OF INDUSTRIAL ENERGY CONSUMPTION: SOME EFFECTS OF CHANGING PRICES AND FEDERAL REGULATION

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Abstract

Input-output data are used to indicate some possible effects on the industrial sector of government options relating to energy, and some results of the industrial conservation program are examined.

1. INTRODUCTION

Since the Arab Embargo of 1973, several kinds of legislation relating to energy have been proposed that could have significant effects on the industrial sector. Others have been enacted that are meant to alter the patterns of industrial energy consumption. The former group includes the rash of bills redesigning the corporate structure of Big Oil (an apparent reaction to the felt threat of monopoly and collusion among the major oil companies), a heavy tax on domestic crude oil to bring the controlled U.S. price into line with foreign prices. and alterations in the pricing of natural gas, both inter- and intrastate. The latter group includes the Energy Supply and Environmental Coordination Act of 1974, which authorized the FEA to order major energy users to convert from oil or gas to coal, and the Energy Policy and Conservation Act of 1975, which ordered energy-intensive manufacturing industries to report annually on their progress toward "energy efficiency improvement targets" set by the FEA. The first group could affect energy prices in a number of ways, causing reverberations throughout the industrial sector; the second adds the complications of legislated shifts in fuel source and reductions in consumption.

Whatever changes may come about, it is obvious that any alterations in the price structure of the various energy sources will affect some industries more than others. By examining input-output tables using two energy use configurations--current account and capital account--we will try to give some insight into those particular industries most likely to be affected by price changes. Then we will look at some of the results of industry's efforts to lower energy consumption in response both to "legislated conservation" and to rising prices.

2. EFFECTS OF ALTERED PRICE MECHANISMS

Breaking up Big Oil or otherwise altering price mechanisms in the energy-producing industries might work in either one of two ways: increased competition might increase the availability of oil and lower prices, or decreased production efficiency might raise prices. Lowered prices could cause a shift to oil out of other energy sources, tending also to lower their prices and increase their availability. In this connection, Kim has estimated the price elasticity of demand for crude oil by the top 20 crude-using manufacturing industries as ranging from -.0419 (new construction) to -1.1904 (radio, television, and communication equipment), suggesting in some industries a high degree of substitutibility between crude oil and other fuels. (A coefficient of -1.19, for example, suggests a 119% decrease in the quantity of crude oil purchased for every 100% increase in its price.) (9) Berndt and Wood have estimated the price elasticity of demand for energy in general as -.47. (2) Whatever the price elasticity of demand might be, it is assumed that any increase in competition would benefit energy-intensive industries as well as those conbuting substantial input either to oil or to energy-

intensive industries and that this benefit would be translatable into profits and from there into higher security prices and/or credit rating. Increased prices, on the other hand, would tend to cause other fuels (mainly coal at this stage of our technology) to gain at the expense of oil, of the industries contributing to oil production, and (in the short run) of energy-intensive industries. The fulfillment of these expectations, of course, would depend largely upon the operational effectiveness of the market mechanism.

2.1 CURRENT ACCOUNT

In order to estimate how various industrial sectors might be affected financially by divestiture, a set of ordinal comparisons were tabulated from the Department of Commerce 83-entry input-output matrix, using the Department of Commerce industrial classifications listed in Table 1. (17) The top 11 energy-intensive industries, ranked according to energy use on the basis of FEA data, are #27, #37, #38, #31, #35, #36, #24, #25, #14, #41, and #42. Those qualifying as closely energy-related are #7, #8, #65 (by virtue of its contribution to the coal industry), #68, and #71 (by virtue of its contribution to both #8 and #31).

TABLE 1

INPUT-OUTPUT CLASSIFICATIONS

1. Livestock and livestock products
2. Other agricultural products
3. Forestry and fishery products
4. Agricultural, forestry and fishery services
5. Iron and ferroalloy ores mining
6. Nonferrous metal ores mining
7. Coal mining
8. Crude petroleum and natural gas
9. Stone and clay mining and quarrying
10. Chemical and fertilizer mineral mining
11. New construction
12. Maintenance and repair construction
13. Ordnance and accessories
14. Food and kindred products
15. Tobacco manufactures
16. Broad and narrow fabrics, yarn and thread mills
17. Miscellaneous textile goods and floor coverings
18. Apparel
19. Miscellaneous fabricated textile products
20. Lumber and wood products, except containers
21. Wooden containers
22. Household furniture
23. Other furniture and fixtures
24. Paper and allied products, except containers
25. Paperboard containers and boxes
26. Printing and publishing
27. Chemicals and selected chemical products
28. Plastics and synthetic materials
29. Drugs, cleaning and toilet preparations
30. Paints and allied products
31. Petroleum refining and related industries
32. Rubber and miscellaneous plastics products
33. Leather tanning and industrial leather products
34. Footwear and other leather products
35. Glass and glass products
36. Stone and clay products
37. Primary iron and steel manufacturing
38. Primary nonferrous metal manufacturing
39. Metal containers
40. Heating, plumbing and structural metal products
41. Stampings, screw machine products and bolts
42. Other fabricated metal products
43. Engines and turbines
44. Farm machinery and equipment
45. Construction, mining and oil field machinery
46. Materials handling machinery and equipment
47. Metalworking machinery and equipment
48. Special industry machinery and equipment
49. General industrial machinery and equipment
50. Machine shop products
51. Office, computing and accounting machines
52. Service industry machines
53. Electric industrial equipment and apparatus
54. Household appliances
55. Electric lighting and wiring equipment
56. Radio, television and communication equipment
57. Electronic components and accessories
58. Miscellaneous electrical machinery, equipment and supplies
59. Motor vehicles and equipment
60. Aircraft and parts
61. Other transportation equipment
62. Scientific and controlling instruments
63. Optical, ophthalmic and photographic equipment
64. Miscellaneous manufacturing
65. Transportation and warehousing
66. Communications except radio and TV broadcasting
67. Radio and TV broadcasting
68. Electric, gas, water and sanitary services
69. Wholesale and retail trade
70. Finance and insurance
71. Real estate and rental
72. Hotels; personal and repair services except auto
73. Business services
75. Automobile repair and services
76. Amusements
77. Medical, educational services and nonprofit organizations
78. Federal Government enterprises
79. State and local government enterprises
80A. Directly allocated imports
80B. Transferred imports
81. Business travel, entertainment and gifts
82. Office supplies
83. Scrap, used and secondhand goods

Next, those industries contributing at least 2 cents input per dollar of final demand were ranked according to their aggregate direct and indirect input to energy-intensive industries. These contributing industries were weighted to show that for any given input, the smaller the contributor, the greater the impact of a change in any energy-intensive industry's production level on the revenue, profits, and stock prices of the contributing industry.

Then the same ranking procedure was followed, without weighting, for the aggregate direct and

indirect receipt by different industries of input from energy-intensive industries.

Table 2 integrates the results of those two steps, ranking industries by a composite score reflecting both their contribution to and receipt of input from energy-intensive industries. This ranking was done by adding each industry's input contribution percentile to that industry's input receipt percentile. (In many cases industries that contributed did not receive input from the energy-intensive industries.)

Last, in Tables 3 and 4, the same procedures were followed for industries contributing input to and receiving input from the energy-related industries individually.

TABLE 2

COMPOSITE INDUSTRY RANKING ACCORDING TO INPUT TO ENERGY-INTENSIVE SECTOR AND RECEIPT OF INPUT FROM ENERGY-INTENSIVE SECTOR

Industry Code	Composite Score	Industry Code	Composite Score
9	136.8	63	61.6
25	129.8	64	61.2
38	127.7	60	60.0
28	127.4	29	59.6
1	118.8	16	58.4
24	106.2	11	58.0
5	100.5	13	56.8
39	98.4	50	56.4
37	97.4	17	55.2
40	95.2	23	54.8
41	93.5	62	52.0
82	91.9	32	50.4
42	90.3	83	48.8
8	88.8	35	47.1
52	88.7	27	45.5
59	87.1	20	44.0
81	85.5	22	43.9
54	83.8	51	42.3
43	82.2	75	40.7
58	80.6	33	39.0
44	79.0	73	38.4
45	77.4	19	35.8
46	75.8	24	34.2
49	74.2	31	33.8
62	72.6	18	32.6
26	70.9	56	29.4
55	67.6	6	24.4
53	66.0	12	21.7
47	64.4	10	21.2
57	63.2	2	17.9
48	62.8	34	14.5

TABLE 3

INDUSTRY RANKING ACCORDING TO INPUT CONTRIBUTED TO ENERGY-RELATED INDUSTRIES

Energy-Related Industries	Contributing Industry	Score	Weighted Ranking
#65	12	.047	2
	31	.052	1
	69	.052	3
	80	.064	Unranked
#68	65	.046	4
	7	.049	3
	79	.156	1
	8	.098	2
#71	70	056	
#8	12	.048	2
	71	.196	1
	80	.114	Unranked

TABLE 4

INDUSTRY RANKING ACCORDING TO INPUT RECEIVED FROM ENERGY-RELATED INDUSTRIES

Industry #65

Code	Score	Code	Score
81	.531	35	.058
78	.186	82	.056
36	.101	6	.056
25	.094	18	.056
15	.093	52	.056
31	.091	41	.055
30	.084	44	.053
37	.084	64	.052
39	.083	42	.051
24	.083	23	.051
5	.083	51	.050
28	.081	75	.049
27	.080	43	.048
38	.069	2	.046
1	.067	49	.046
17	.065	68	.046
40	.065	53	.046
11	.064	55	.046
61	.062	45	.045
22	.062	46	.044
32	.060	62	.044
29	.060	58	.044
13	.059	34	.043
19	.059	3	.042
59	.058	48	.041
54	.058	67	.041
33	.058		

Industry #68

Code	Score	Code	Score
79	.150	9	.054
10	.085	5	.052
24	.071	38	.052
28	.075	35	.055
29	.068	26	.055
25	.065	37	.050
23	.064	6	.045
36	.059	31	.042
27	.059		

Industry #71

Code	Score	Code	Score
8	.196	4	.064
31	.138	70	.064
5	.118	9	.064
76	.114	54	.052
66	.105	7	.049
72	.095	25	.048
51	.081	75	.048
1	.079	5	.047
29	.078	3	.047
10	.078	6	.047
26	.077	57	.045
27	.075	63	.044
73	.072	55	.044
28	.072	24	.044
77	.070	62	.043
69	.070	60	.043
30	.067	52	.043
82	.064	58	.042
		78	.041

Industry #8

Code	Score
31	.509
68	.098
8	.064

Although a detailed projection of possible changes in stock prices and/or borrowing costs is impracticable because of the many factors involved, these tables do serve to suggest some significant points. In Table 4, for example, of the ten industries that would seem to be most affected by any policy change by virtue of contributing to or receiving input from the energy-intensive industries, four are themselves energy-intensive--#25, #38, #24, and #37. From Tables 3 and 4 it appears that #31, #12, and #69 contribute relatively greatly to #65, while that industry itself contributes substantially to #81, #78, #36, and #25--the last two of which are energy-intensive industries. Tables 3 and 4 also indicate those industries that would be most greatly affected by any changes in the energy-related industries. It is assumed that if a particular policy increased competition, the profits of #68 and #71 would benefit, whereas the opposite effect could come about if the policy created too much confusion, decreasing efficiency and thereby increasing prices. The effects on #8 are assumed to move roughly in the same direction as #68 and #71 because of the energy input into the production of electricity and the involvement of Big Oil in many phases of natural gas production and marketing. It is also assumed that higher oil prices and/or lower oil supply would benefit both energy-related industries #7 and #65 (the latter because of the increased need for coal transport). Coal mining is not entered in Tables 3 and 4 because there is only one industry (#71) to which coal contributes substantially and only one (#68) receiving substantial input from coal. Finally, the effects of increased competition in the oil industry itself are probably indeterminate. Paradoxically, the reduction of oil monopoly, while reducing oil profits, would tend to increase profits of associated industries.

These estimates of the effects of changing policies must be qualified in several ways. For example, #65, which includes railroad coal transport for hire, also includes a number of other activities that may not be so closely affected by the energy situation, such as public warehousing, air transportation, and passenger transportation. Furthermore, inputs to a consuming industry represent transactions on current account only: capital purchases are not shown as inputs but are aggregated elsewhere as gross private domestic investment. Unfortunately, oil extraction and coal mining equipment are contained within the same industry classification--#45. Although it may be impossible to tell how a particular policy might affect oil as compared with coal in regard to capital requirements, it is interesting to note that in 1972 petroleum capital expenditures were about 7 times those of coal and that the capital intensity of their operations appeared to be quite similar. A factor that might alleviate the effect of this current account constraint is the capability of many industries to increase production without increasing capital expenditure. This is especially the case now when many businesses operate at substantially less than capacity due to deficient but growing aggregate demand.

For a more detailed breakdown, data from the Department of Commerce 360-entry matrix is used in Table 5 to give an unweighted ranking of the top 20 industries receiving input from energy-intensive industries, while Table 6 itemizes the top 20 contributors to energy-intensive industries.

TABLE 5

INDUSTRIES RECEIVING INPUT FROM ENERGY-INTENSIVE INDUSTRIES

Industry			Receipt
	26.04	Misc. publishing	1.0589
E-I	14.32	Food preparations n.e.c.	.9362
E-I	38.14	Nonferrous forgings	.9264
E-I	17.07	Tire cord and fabric	.9150
E-I	42.10	Metal foil and heat	.8856
	19.01	Curtains and draperies	.8680
E-I	17.04	Paddings and upholstery fillings	.8370
E-I	18.03	Knit fabric mills	.8273
E-I	18.04	Apparel made from purchased materials	.8011
E-I	38.08	Aluminum rolling and drawing	.7906
E-I	17.06	Coated fabrics, not rubberized	.7825
E-I	27.03	Agricultural chemicals	.7765
	19.03	Fabricated textile products n.e.c.	.7675
E-I	38.10	Nonferrous wire drawing and insulating	.7362
E-I	38.07	Copper rolling and drawing	.7360
E-I	40.09	Miscellaneous metal work	.7322
E-I	42.11	Fabricated metal products	.7302
E-I	60.03	Aircraft propellors and parts	.7222
	54.01	Electric measuring instruments	.7107
E-I	59.02	Truck trailers	.7142

TABLE 6

INDUSTRIES CONTRIBUTING INPUT TO ENERGY-INTENSIVE INDUSTRIES

Industry			Contribution
E-I	37.01	Blast furnaces and basic steel products	11.7162
	80.02	Transferred imports	11.7002
	69.01	Retail trade	9.0434
E-R	71.02	Real estate	6.8559
	26.08	Miscellaneous printing svcs.	6.2481
	73.01	Miscellaneous business svcs	4.9795
E-R	65.03	Motor freight transport and warehousing	3.4731
E-R	65.01	Railroads and related svcs.	2.3503
E-I	28.04	Organic fibers, noncellulosic	2.3485
E-I	38.04	Primary aluminum	2.1031
	73.02	Advertising	1.8669
E-I	24.02	Paper mills except building paper	1.7960
E-I	31.01	Petroleum refining and related products	1.7358
E-I	38.01	Primary copper	1.6572
E-I	38.06	Secondary nonferrous metals	1.4907
	2.06	Oil bearing crops	1.4819

TABLE 6: CONTINUED

	9.00	Stone and clay mining and quarrying	1.4441
E-I	25.00	Paperboard containers and boxes	1.4112
E-I	16.03	Yarn mills and finishing of textiles n.e.c.	1.3195
E-I	59.02	Truck trailers	1.2736

2.2 CAPITAL ACCOUNT

The current account account tables 2, 3, and 4 show inter-industry transactions in goods and services. Capital account tables 7 and 8 show relationships of transactions between producers and users of new capital goods. For purposes of this paper, Tables 2, 3, and 4 indicate industrial expenditures connected with increased output with given capital equipment, whereas Tables 7 and 8 indicate the industrial reverberations associated with changes in production involving increased expenditures on plant and equipment.

TABLE 7

CAPITAL GOODS CONTRIBUTION BY ENERGY-INTENSIVE AND ENERGY-RELATED INDUSTRIES TO OTHER INDUSTRIES*

	Using Industries	E-I Industries Producing Capital Goods		E-R Industries Producing Capital Goods	
		38	42	65	71
	2			9	
	11			6	
	20		4		
E-I	24		10		
E-I	27		34		
E-I	37		22		
E-R	65			9	
	66	100			
E-R	68			6	
	69		4		
	70		15	19	
E-R	71				97
	72				
	75			4	

*As percentages of total capital expenditures. Amounts lower than 4% are not entered.

Source: Survey of Current Business, September 1975, pp. 10-14.

Of the 10 E-I and 5 E-R industries, 4 industries (#38, #42, #65, and #71) are producers of new capital goods. Two of these are energy-intensive (#38 and #42) and two are energy-related (#65 and #71). Table 7 shows the relationship, in percentage of total dollar output, between these producing industries and their using counterparts. For example, industry #38's entire production of new capital goods is purchased by industry #66, whereas industry #42 contributes its production to 6 industries (#20, #24, #27, #37, #69, and #70). Table 8 illustrates transactions between energy-intensive and energy-related industries (vertical columns), in percentage of total dollar expenditures, and industries contributing new capital goods (horizontal rows). For example, energy-related industry #8 purchases 78% of its total capital expenditures from industry #11 and 9% from industry #45.

In summary, E-I and E-R industries' contribution to other industries' capital goods is greater than E-I and E-R industries' expenditure on capital goods. That is, Tables 7 and 8 reveal that the E-I industries (#38 and #42) and E-R industries (#65 and #71) which produce capital goods are dependent on the user E-I industries (#24, #27, #37) and E-R industries (#68 and #71) for purchases of their capital goods, more so than the E-I industries (#14, #24, #27, #31, #35, #36, #37, #38, #41, #42) and E-R industries (#7, #8, #65, #68, #71) are dependent on the E-I industries (#65 and #71) as suppliers of their capital goods.

2.3 SUMMARY

We must examine both capital (Tables 7 and 8) and current (Tables 2, 3, and 4) accounts to see which industries are most vulnerable to changes in energy costs. On current account, those industries most vulnerable to energy source price change seem to be #9, #25, #38, #28, #1, #24, and #5. On capital account E-I and E-R expenditures on capital will not be greatly affected by energy price change. E-I (#42) and E-R (#65 and #71) industries are affected as capital goods contributors. Of these three, only one (#42) is high on the list of price vulnerability on both capital and current accounts.

3. INDUSTRIAL ENERGY CONSERVATION

Shortly after the Arab Embargo, Warren G. Magnuson, Chairman of the Senate Commerce Committee, sent a letter to the heads of the nation's 100 largest industrial corporations, asking them to describe the steps they were taking to reduce energy waste and improve efficiency. Their replies describe energy awareness programs for employees, coordinating committees and reporting mechanisms, and innovative conservation practices. Some striking savings were reported, and many corporations set savings goals of 10% to 20% over 1973. (15)

Such conservation efforts were not short-lived phenomena. In 1975, manufacturers consumed 10% less energy in the form of purchased fuels and electricity than in 1974, while costs continued to climb: the 3.54 trillion kwh of 1975 cost $23.3 billion, while the 3.95 trillion kwh of 1974 cost $19.5 billion. (5, #191, 7 April 1977, p. 31)

TABLE 8

CAPITAL GOODS EXPENDITURES BY ENERGY-INTENSIVE AND ENERGY-RELATED INDUSTRIES*

E-I and E-R Investing Industries	Contributing Industries																	
	11	40	42	43	45	46	47	48	49	51	52	53	56	59	60	61	62	69
7	23				51									6				7
8	78				9													
14	28					7		23		5	5			10				7
24	22	6				4		35	4			6						4
27	24	21	7					5	13								4	6
31	64	7						7										
35	30					12	15	17	4	4				4				4
36	27				5	8	4	19	5	4		6		10				6
37	27	4					21	6	13			6						6
38	34						20	6	13	4		5						5
41	20					10	43		5					4				5
42	25					4	36	5	7			5		5				5
65	14													13	27	28		5
68	66			6								16						
71	92																	

*As percentages of total capital expenditures. Amounts lower than 4% are not entered.

Source: Survey of Current Business, September 1975, pp. 10-14.

Apparently not content to let industry's cost-consciousness dictate the extent of energy savings, Congress included in the Energy Supply and Environmental Coordination Act of 1974 a directive to the FEA to conduct a conservation study into (among other things) ways to increase industrial recycling and resource recovery so as to reduce energy demand and ways to increase efficiency of the industrial use of energy. (14)

3.1 THE ENERGY POLICY AND CONSERVATION ACT OF 1975

In December 1975, Congress enacted Title III Part D of the Energy Policy and Conservation Act to "promote increased energy efficiency by American industry" and to "establish voluntary energy efficiency improvement targets for at least the 10 most energy consumptive major energy-consuming industries." (13) Under its provisions, the FEA was first ordered to rank the major energy consuming manufacturing industries in the U.S. (identified by their Standard Industrial Classification two-digit code numbers) on the basis of their "respective total annual energy consumption." Within each of these industries, the FEA would then name each corporation which "(1) consumes at least one trillion British thermal units of energy per year, and (2) is among the corporations identified by the Administrator as the 50 most energy-consumptive corporations in such industry." Finally, the Administrator was given one year to set an "industrial energy efficiency improvement target for each of the 10 most energy-consumptive industries," with the option of setting targets for any other "major energy-consuming industry" in the interest of promoting increased energy efficiency.

The Act requires each of the pinpointed corporations to report annually on the progress it has made towards its goal, unless it is in an industrial group (corresponding to the 3- and 4-digit SIC subclassifications) which has an adequate voluntary reporting program, whereby a trade association or other agent reports for the group as a whole such information as has been collected from the individual members.

There is no penalty for failing to meet a target, but failure to report may result in a citation for contempt of court. "Energy efficiency" is defined as "the amount of industrial output or activity per unit of energy consumed therein." Changes in energy efficiency are measured in relation to 1972 as the base year. Consumption as defined here excludes feedstocks.

After the enactment of this legislation, the industrial conservation program took shape in the Federal Register in the following sequence:

1. On 2 November 1976, proposed targets for the top 10 industries were published, along with a schedule of public hearings on each industry's target.

2. On 24 November 1976, criteria for establishing voluntary reporting programs were announced.

3. On 16 December 1976, the major energy consuming corporations within each industrial classification were identified.

4. On 4 May 1977, the proposed reporting form appeared.

5. On 9 May 1977, those corporations eligible to report through a trade association or other agent were identified within their respective reporting agencies.

6. On 9 June 1977, the final targets were published.

7. On 28 June 1977, the final reporting form appeared.

The top 10 industries in rank order, along with (1) the proposed targets, (2) the final net targets to be reached by 1 January 1980, and (3) an offset figure representing a reduction from an original gross target based on special circumstances peculiar to the specific industry (such as the energy costs of pollution controls) are given below:

SIC	(1)	(2)	(3)
28 Chemicals & allied products	16	14	3
33 Primary metal industries	10	9	5
29 Petroleum & coal products	12	12	8
32 Stone, clay, & glass	17	16	0
26 Paper & allied products	12	20	3
20 Food & kindred products	14	12	1
34 Fabricated metal products	24	24	1
37 Transportation equipment	16	16	2
35 Machinery excluding electronic	15	15	2
22 Textile mill products	27	22	3

To recapitulate, each target represents what the FEA judged on 9 June 1977 to be the maximum feasible (both technologically and economically) percentage reduction in energy consumed per unit of output or activity that could be achieved by 1 January 1980, based on calendar year 1972.

3.2 CONSERVATION MEASURES AND RESULTS

While the FEA was setting targets, compiling lists, formulating criteria, and designing forms, industries were cutting down on energy consumption. A report issued by DOE in the spring of 1978 for the first half of 1977 showed overall savings of 9.2% by the industries reporting under the voluntary program. This group consists of over 3000 firms using more than 50% of total industrial energy, reporting through 48 trade associations and other agents. (18, 12 May 1978, p. 3) Individually reporting corporations showed for the same period an average reduction of 8%. (18, 23 June 1978, p. 1)

Savings varied widely among the 3- and 4-digit subclassifications participating in the voluntary program. Three industries showed reductions of over 30%, nine fell in the 20%-30% range, twelve in the 10%-20% range, and four reported losses. Savings among the individually reporting corporations ranged from 2% to 24%.

To help industries reach their goals, the federal government engages in a number of activities--workshops, publications for specific industries, energy audit guidelines to identify opportunities for improvement (such audits being required for industry as part of the supplemental state energy conservation grants program of the Energy Conservation and Production Act of 1976 [12]), and the funding of studies and projects.

Both with and without government assistance, savings are being realized from a wide variety of applications. The simplest measures include relatively minor alterations in HVAC standards, reduced lighting, and careful monitoring and maintenance of equipment. A DOE/Industrial Heating Equipment Association manual, for example, describes how the proper adjustment and maintenance of large heating units can save 10%-30% on fuel. (18)

Other belt-tightening measures call for special equipment with variable payback periods. Computer systems can regulate the use of electricity throughout a facility. Automatic shut-off timers cut demand. According to an item in Energy Users Report (5, #254, 22 June 1978, p. 17), a power factor controller for induction motors developed by a NASA engineer saved 33% in a test at an Alabama textile mill. The installation of ceramic fiber insulation in furnaces of the Cameron Iron Works reportedly cut gas consumption by about 20%. At $30,000 per furnace, the payback is two years. (4, 18 September p978, p. 8)

Different kinds of waste that can be used to save "new" energy include industrial refuse, the used and discarded products themselves, and several forms of heat. Sawdust and scraps from lumber and paper mills and from furniture factories are salvaged for fuel. The recycling of used paper and metal requires less energy than the original processing. Ceiling ducts are used to capture and recycle heat from office machines and workers.

One of the most promising--and controversial--ways to minimize the waste of process heat is in cogeneration, the successive generation of electrical or mechanical energy and useful heat from the same fuel. DOE is actively involved in a number of cogeneration studies and projects and recently invited proposals for "demonstrating the technical and economic feasibility of cogeneration systems at existing facilities in several energy-intensive industries, including petroleum-refining, pulp and paper, chemical, textiles, and food processing." (18, 11 August 1978, p. 1) Cogeneration systems would also appear feasible in other energy-intensive industries--such as steel and cement--which expel waste heat of high enough temperatures. Problems arise from difficulties of financing, from real and imagined threats to electric utilities, and from the spectre of government involvement in a number of areas--pollution control, utility regulation (if a plant sells its excess steam to another facility), and the possibility of forced conversion of an oil- or gas-fired system to coal.

Many industries have adopted new processes to cut energy consumption. Kaiser Aluminum and Chemical Corporation's plant in Norco, Louisiana, reportedly cut its per unit consumption of energy by 69% from 1972 to 1977, largely by installing a kiln process that uses formerly wasted volatiles to help fuel its coke production. Burning the volatiles reduced Norco's 1977 natural gas consumption by 119 billion Btu's from 1976 levels. The coke is used to make carbon anodes for Kaiser's aluminum reduction process; excess coke is sold to other aluminum, graphite, and steel industries. (4, 18 September 1978, p. 8.) The same publication describes a 25% reduction in fossil fuel consumption and projected savings of $2 million per year by the Spreckels Sugar Division of Amstar Corporation after a $6 million replacement of most of its antiquated steam generating equipment. Spreckels was once listed as the nation's largest natural-gas-consuming food processing facility. (4, 18 September 1978, p. 8)

3.3 THE ENERGY SUPPLY AND ENVIRONMENTAL COORDINATION ACT OF 1974

Industrial efforts to conserve energy have been complicated by the effects of the Energy Supply and Environmental Coordination Act passed in June 1974, a year and a half before the Energy Policy and Conservation Act. The intent of the earlier Act was to promote the use of coal in preference to presumably scarce natural gas and the problems and uncertainties of foreign oil. Under its provisions, power plants and "other major fuel-burning installations" may be ordered to convert to coal and new facilities must be designed to allow the burning of coal. Cooperation with the Environmental Protection Agency to minimize air pollution is required. Proposed incentives to spur conversion have included a surcharge on nonprocess use of natural gas and taxes on domestic crude oil production.

Since the energy-intensive industries include many "major fuel-burning installations," any financial savings from equipment installed or other changes made to cut natural gas and oil consumption are potentially threatened by ESECA. In May 1978, for example, the Economic Regulatory Administration issued a "Notice of Intention to Issue Prohibition Orders" for four facilities in the paper, textile, and cement industries. (18, 19 May 1978, pp. 2-3)

Even without this threat, switching to coal is by no means a simple solution to the oil and natural gas problem. The difficulties of expanding production, transportation, and storage; the capital costs of conversion and of pollution control; and technical problems of temperature control and thermal efficiency all combine to lessen the apparent advantage of abundance.

According to Energy Users Report (#192, 14 April 1977, pp. 8-9), some of these difficulties appear to be moderated by on-site coal gasification: the low-Btu gas produced from coal is cheaper than imported oil, an existing gas system could be retained, gasification is inherently less polluting than direct burning, and emission control is easier when pollution is confined to a single central source.

Among the major energy-consuming corporations, Burlington Industries reported in Energy User News its current plans to convert to coal for more than 50% of its steam requirements, while Monsanto reported a hesitation to use more coal without "some economic justification," complaining of high conversion costs and poor service from coal producers. (4, 18 September 1978, pp. 1 and 6)

4. CONCLUSION

The effectiveness of federal involvement in industrial conservation is debated. Hesitant to impose further mandated programs, yet apparently dissatisfied with current progress, the DOE in March 1978 announced its intention of offering incentives to selected members of industry privately before presenting all available options to the public. Industry spokesmen replied that "cost-effectiveness balanced against spiralling fuel prices would continue to dictate conservation measures in the industrial sector to a greater extent than government regulation." (5, #240, 16 March 1978, p. 19) In contrast to these attitudes and in what might be seen as an excess of zeal, a GAO report of 30 June 1978 entitled The Federal Government Should Establish and Meet Energy Conservation Goals proposes that goals be set for all consumption sectors with continuous monitoring and evaluation. (5, #256, 6 July 1978, pp. 4-5)

For whatever reasons, industrial energy consumption has decreased in the 5 years since the Embargo. On 7 September 1978, a front-page article in the Wall Street Journal, citing the OECD as its source, reported a reduction in total energy consumption of 13% between 1973 and 1976, production remaining about steady. (10) With the costs of new energy climbing steadily, continuing conservation efforts seem guaranteed, as more and more industries come to realize the significant savings that can be gained even from apparently costly new equipment. Whether such efforts will be sufficient to avert mandatory reduction goals and to offset any adverse effects of altered price mechanisms remains to be seen.

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