259
9/19/80

MASTER

MEASURES TO REDUCE INDUSTRIAL
CONSUMPTION OF PETROLEUM
UNDER A SHORT-TERM ENERGY EMERGENCY

RAYMOND G. TESSMER, JR., JOHN D'ACIERNO, AND DAVID A. PILATI

February 1979

NATIONAL CENTER FOR ANALYSIS OF ENERGY SYSTEMS
DEPARTMENT OF ENERGY AND ENVIRONMENT

BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK 11973

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

MEASURES TO REDUCE INDUSTRIAL CONSUMPTION OF PETROLEUM UNDER A SHORT-TERM ENERGY EMERGENCY

RAYMOND G. TESSMER, JR., JOHN D'ACIERNO, AND DAVID A. PILATI

DISCLAIMER

This book was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

February 1979

Prepared for the
ECONOMIC REGULATORY ADMINISTRATION
UNITED STATES DEPARTMENT OF ENERGY

by the
NATIONAL CENTER FOR ANALYSIS OF ENERGY SYSTEMS
DEPARTMENT OF ENERGY AND ENVIRONMENT
BROOKHAVEN NATIONAL LABORATORY
ASSOCIATED UNIVERSITIES, INC.

UNDER CONTRACT NO. DE-AC02-76CH00016 WITH THE
UNITED STATES DEPARTMENT OF ENERGY

DISCLAIMER

This book was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

Printed in the United States of America
Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161
Price: Printed Copy ~~\$4.50~~ 5.00, Microfiche ~~\$3.00~~ 5.00

CONTENTS

I. Introduction	1
II. Options and Supportive Governmental Measures	2
A. Recommended Options	2
B. Supportive Governmental Measures	12
C. Options Not Recommended	14
III. Characteristics of Industrial Petroleum Consumption	15
A. Chemical Industry	17
B. Steel Industry	18
C. Cement Industry	19
D. Paper Industry	20
IV. Recommendations for Further Research	21

TABLES

1. Energy Content of Exported Goods by Sector	6
2. Major U.S. Exports, 1977	8
3. 1976 Industrial Oil Purchases, 10 MMbbl.....	16

SUMMARY

There are significant opportunities for petroleum conservation in the industrial sector in the event of an energy emergency. The major governmental options which could be adopted and preliminary estimates of potential petroleum product savings are as follows:

- Remove institutional barriers to fuel switching in industrial boilers and burners: 384 to 407 Mbbl/day.
- Rescind certain air pollution regulations: 19 to 100 Mbbl/day.
- Restrict export of energy-intensive goods: 20 to 60 Mbbl/day.
- Rescind thermal pollution regulations for power plants: 16 to 27 Mbbl/day.
- Remove trade barriers on certain imports.
- Restrict electricity production by industry.
- Restrict export of recyclable materials.

A number of supportive governmental measures are also identified which will indirectly reduce industrial energy consumption and set examples for industrial reaction to an emergency.

I. INTRODUCTION

Brookhaven National Laboratory has undertaken to identify and assess a set of emergency conservation plans to reduce industrial petroleum consumption in the event of an energy emergency. Options for residential, commercial, and commercial transportation energy use are being developed by Oak Ridge National Laboratory, while the Massachusetts Institute of Technology is considering all other forms of transportation.

These emergency conservation plans are required under the Energy Policy and Conservation Act of 1975. "Emergency" is defined as severe supply interruption of imported fuel, sabotage, or act of God. The plans are to be directed toward demand reduction, not increased supply. Most significantly, the plans cannot impose taxes or user fees, cannot price petroleum, and cannot provide tax rebates.

The most feasible government options identified in this program are presented in Section II. Their intended objectives, possible energy savings, constraints on adoption and implementation, and economic impacts are briefly discussed. Because the federal government can undertake a leadership role in energy conservation during an emergency, a set of supportive actions at the federal level is also presented and discussed. Additional options identified in this work, but not recommended, are presented in Section II along with reasons for not giving them further consideration.

The bases for many of the recommended options are presented in Section III. An examination of historical industrial patterns of oil consumption identifies the largest users of petroleum products and, thus, where the largest potential for conservation lies. This is followed with industry-specific information which was obtained from trade associations and several large manufacturers.

This report provides an initial identification of emergency conservation options with a rough analysis of potential costs and benefits. Section IV therefore presents recommendations for further analysis of these options and for the necessary preplanning among federal government agencies and industry.

II. RECOMMENDED OPTIONS AND SUPPORTIVE GOVERNMENTAL MEASURES

A. Recommended Options

Option #1. Remove institutional barriers to fuel switching in industrial boilers and burners.

a. Objective. Substitute natural gas, coal, and LPG for petroleum fuels in industrial boilers and burners.

b. Energy Savings.

Up to 160 Mbbl/day distillate oil	- by switching to NG
+ 210 Mbbl/day residual oil	
+ 10-22 Mbbl/day oil	- by switching to coal
+ 7-15 Mbbl/day oil	- by switching to LPG

These savings are taken from estimates in a 1978 report by Evaluation Research Corp.* Fuel switching capability data are from the Major Fuel Burning Installations File. Switching capability to natural gas (NG) and liquefied petroleum gas (LPG) is probably understated if one takes into account multifuel capability in small boilers and other combustion processes and if the current industrial trend to increased multifuel capability continues. Potential oil savings are of course limited to actual availability of additional natural gas and LPG at the time an actual energy emergency occurs. Switching capability to coal is probably greatly overstated. Because of favorable economics, it is probable that coal is already the overwhelming fuel choice in boilers with coal/oil capability.

c. Constraints and Economic Impacts. The major constraints which would inhibit industrial fuel switching to NG and LPG are:

1. Limits on excess gas production capacity above the rate of consumption and any necessary additions to storage at the time of the emergency.

2. The amount of gas in storage necessary for peak and winter use.

* A Study of Several Factors Which Bear Upon the Potential Capability of the Private Sector To Cope With an Interruption in Oil Imports, Evaluation Research Corp., Vienna, VA (October 27, 1978 Draft Report).

3. Federal Energy Regulatory Commission rules and regulations concerning the natural gas production and pipeline companies.

4. The governmental review and approval process for imports of natural gas by pipeline and LNG.

5. Pipeline capacities.

The only constraints which could be relaxed in the short run are 3 and 4, but their effects could be highly significant under an energy emergency. In February 1979, for example, the American Gas Association publicly stated that there was excess gas available equivalent to 700,000 bbl/day of oil, while industrial representatives asserted that they could not purchase additional gas because of certain federal rules and regulations in effect.* There is thus a need for the federal government to ascertain, prior to an energy emergency, just what regulations could be rescinded for the duration of the emergency or what alternative set of regulations could be quickly implemented to facilitate increased supply and consumption of natural gas in lieu of petroleum products. Likewise, there is a need to have mechanisms in place for quickly facilitating increased NG and LNG imports in accordance with availability from foreign sources. Attention should be primarily addressed to regulations covering wellhead and resale prices and pipeline curtailments in effect.

Economic impacts associated with fuel switching would be small and probably limited to any increased price that firms would have to pay for NG and LPG versus residual or distillate oil. Additional costs to NG pipeline companies which might arise if traditional geographical shipping patterns were altered would probably be offset by increased sales.

Option #2. Rescind air pollution regulations except during air quality warning or alert.

a. Objectives.

1. Promote fuel switching to coal and wood by-products.

* MacNeil/Lehrer Report, Public Broadcasting System, February 21, 1979.

2. Permit use of coal and wood by-product boiler capacity now idle because of air pollution regulations.

3. Increase efficiency of industrial steam and electric generating plants by bypassing pollution control equipment and thereby saving this energy consumption.

4. Enable fuel switching by increasing the available supply of electricity.

b. Energy Savings.

Three (at present) and 16 (in 1983) Mbbl/day residual oil - by burning available wood by-products.

Nine (at present) and 48 (in 1983) Mbbl/day residual oil - by burning more coal.

Seven to 21 (at present) and 12 to 36 (in 1983) Mbbl/day residual oil - by bypassing pollution control equipment.

Energy savings from increased use of wood by-products are estimated by the American Paper Institute. Power would be generated in hogged-fuel boilers now sitting idle and by burning 100% wood in boilers now burning a combination of wood and oil in order to meet air emission standards. Industrial data on excess coal-burning boiler capacity were not collected; so a very rough estimate of three times the available wood-burning capacity is listed in order to reflect the much larger installed coal-fired capacity in industrial plants.

Energy required to operate industrial air pollution equipment has been estimated by Development Sciences, Inc.* No interviews were made to determine which specific pieces of equipment could be bypassed without violating ambient air pollution emergency levels; a conservative assumption is that it would be possible to save only 5 to 15% of total energy consumed by air pollution equipment. It is also assumed that only

* U.S. Environmental Protection Agency, First Order Estimates of Energy Requirements for Pollution Control, pp. 33-40, Washington, DC, October 1977.

50% of this saving would result from a direct reduction in industrial oil consumption. The other 50%, not included above, would come from decreased use of coal in industrial boilers.

Given today's environmental control technology, feasible energy savings with this option will no doubt increase over time as environmental regulations become more stringent.

c. Constraints and Economic Impacts. The major constraint on this option is the complicated political process needed to obtain agreement on a set of modified air pollution regulations which would be implemented in the event of an emergency. Cooperation would be necessary between DOE, EPA, and state environmental control authorities, with more detailed study required of changes in particular regulations, their impact on petroleum savings (by type and grade of petroleum product), and resultant increases in ambient pollutant levels. As for industry itself, certain firms might be unwilling to disconnect control equipment, start up idle boiler capacity, or switch to coal and wood by-products unless continued operation in that mode were guaranteed for some minimum length of time. And unless there are guarantees on the maximum amount of permissible emissions or curtailment in the event of air quality warnings and alerts, there may be considerable opposition to this option.

Economic start-up costs of idle boiler capacity and disconnection of in-place pollution control equipment would in general be more than balanced by improved boiler efficiency and use of cheaper fuel (coal and wood by-products). Additional consultation is required for a more realistic assessment of the practical extent to which emission levels could be increased and the resultant energy savings by fuel type.

Option #3. Restrict exports of energy-intensive goods.

a. Objectives.

1. Reduce consumption of petroleum products by restricting export of energy-intensive goods.

2. Reduce consumption of transportation fuels by switching from air to water mode and by delaying large bulk export shipments until energy emergency is over.

3. Reduce export of petroleum products. Reduce export of other fuels to increase the domestic supply available for fuel switching.

b. Energy Savings. Twenty to 60 Mbbbl/day residual oil and kerosene (assuming reduction in transportation energy requirements of 5 to 15%).

Total energy content (direct plus indirect) of selected export goods and services in either 1967 or 1972 are listed in Table 1.

Table 1*
Energy Content of Exported Goods by Sector

Export sector	Energy content, 10 ¹² Btu	
Energy		2319
Coal mining	1322	
Refined oil products	596	
Crude oil and gas	252	
Gas utilities	93	
Electric utilities	56	
Transportation of final goods/services for export		862
Water transport	576	
Air transport	156	
Rail transport	130	
Chemicals & fertilizer		735
Aluminum, steel, machinery products		354
Motor vehicles & aircraft		196
Grains & cotton		162
Pulp & paper products		146
Wholesale trade		120

*Source: R.N. Herdendeen and C.W. Bullard III, U.S. energy balance of trade, 1963-1967, Energy Systems and Policy, Vol. 1, No. 4, pp. 383-390 (1976).

Since annual fluctuations can be great, the larger of either 1967 or 1972 energy content is listed for the most energy-intensive sectors. The figures include all energy forms (fuel, feedstock, and electricity) embodied in the raw materials of production, in transportation of productive inputs, and in the production process.

As discussed below, the most feasible method for reducing energy use in connection with exported goods is to exhort shippers to delay or stretch out overseas shipments of large volume and bulk materials and to substitute ship for air transport. An immediate energy-saving goal might lie in the range of 5 to 15% of transportation energy requirement (primarily by ships), or .02 to .06 MMbbl/day.

c. Constraints and Economic Impacts. Federal policies directed toward objectives 1 and 3 - restricting exports of fuels and energy-intensive goods - could encounter severe legal problems, especially those designed to stop delivery under contracts already signed. For contracts signed during the emergency, the time lag between placement of orders and an actual effect on oil consumption at the manufacturing plant is likely to be quite long. This would reduce the effectiveness of such policies during a short-term emergency. Shortages of particular goods caused by decreased petroleum availability will probably vary considerably, according to the nature of the emergency and differential impacts across industries and regions. In view of this, it might be more efficient for the private market to ration those particular goods in short supply.

On the other hand, policies directed toward objective 2 - switching transportation modes and delaying large bulk shipments by ship - might be politically feasible. The federal government could play a leadership role by suspending or delaying approval of shipments over which it has direct control, e.g., foreign aid (particularly food, feed grains, and arms) and trade with communist countries. Along with an executive order requiring federal agencies to transport goods by ship except under emergency situations, such actions would be a powerful political lever in encouraging similar practices by private concerns. Economic costs would be incurred through such delays in trade, but they

are likely to be small, especially where large quantities of stocks are maintained at consuming locations (e.g., grain, cotton, coal, paper pulp, linerboard, steel scrap, timber and wood products, ores) which can be drawn down over the course of the emergency. Waterborne and airborne exports with the greatest 1977 tonnage levels are listed in Table 2.

Table 2
Major U.S. Exports, 1977*

Waterborne, 10 ⁹ pounds		Airborne, 10 ⁶ pounds	
Coal	107.8	Office machines	115.7
Corn	88.3	Motor vehicle & tractor	
Wheat	52.5	parts	104.2
Soybeans	35.6	Instruments & app.	76.1
Crude fertilizers	28.0	Telecommunications	
Rough wood	25.0	equipment	50.2
Pitch, asphalt, etc.	17.3	Aircraft parts	45.0
Animal feed	17.1	Nonelectric generating	
Wood manufactures	16.8	machinery	44.8
Mfd. fertilizers	14.6	Live animals	42.0
Other cereals	13.4	Clothing & accessories	41.4
Iron & steel scrap	10.4	Meat	39.3
Inorganic chemicals	10.0	Const., mining machinery	38.8
Organic chemicals	9.1	Electric power machinery	38.6
Stone, sand, gravel	8.9	Printed matter	32.3
Oilseed cake, meal	8.8	Records, musical	
Pulp & waste paper	7.0	instruments	31.7
Rice	5.0	Paper board & manufactures	29.5
		Pumps, compressors	29.1
		Syn. resins, plastic	
		materials	27.8
		Electric meters	27.7
		I-C engines	26.9

*U.S. Dept. of Commerce, U.S. Exports; Commodity Groupings by World Area, 1977; Washington, DC, June 1978.

Option #4. Repeal thermal pollution regulations for power plants.

a. Objective. Substitute non-petroleum-based electricity generation for petroleum-based generation.

b. Energy Savings.

Sixteen (at present) to 27 (in 1983) Mbb1/day residual oil.

Savings are assumed to be achieved by bypassing mechanical draft cooling towers and discharging higher temperature condenser cooling water into a nearby water body, where this is physically possible. Current and projected cooling tower capacity and their associated energy requirements are taken from a Development Sciences, Inc. report.* Electrical capacity with cooling towers is estimated at 73.5 GW in 1977 and 120.1 GW in 1983. It is assumed that plant factors average 0.6 and that one-third of the potential energy savings can feasibly be substituted for oil-fired generation. It is assumed that the location of plants with cooling towers that can be bypassed versus oil-fired plants, and differing temporal profiles of electricity demand, limit feasible substitution to one-third of the potential energy savings.

c. Constraints and Economic Impacts. The primary constraints are federal and state regulations concerning allowable temperature rise in rivers and other bodies of water used for cooling purposes. Such regulations would have to be relaxed for the duration of the energy emergency.

While cost savings would accrue to companies bypassing their cooling towers, this would be offset to an extent by intercompany distribution charges to utilities purchasing this electricity as a replacement for their own oil-fired capacity.

Option #5. Remove trade barriers on certain imports.

a. Objectives.

1. Promote fuel switching to natural gas through increased NG, LPG, and LNG imports.

2. Substitute imports for domestic production of energy-intensive goods - particularly steel, pulp, and paper products.

* U.S. Environmental Protection Agency, First Order Estimates of Energy Requirements for Pollution Control, pp. 15-18, Washington, DC, October 1977.

b. Energy Savings.

Direct oil equivalent to additional natural gas, LPG, and LNG available from Canada, Latin America, Algeria, and Indonesia.

1.6 MMbbl oil per 1 MM tons newsprint imports.

0.3 MMbbl oil per 1 MM tons steel imports.

Increased imports of natural gas, liquefied natural gas, and liquefied petroleum gas can be directly substituted for oil because of the multifuel capacity of many industrial boilers. The limitations present are the available stocks of natural gas (Canada and, within a few years, Mexico), of propane and butane (primarily Canada), and of LNG (primarily Algeria, Indonesia, and the Middle East).

Imports of certain energy-intensive goods can be substituted for domestic production and, thus, will serve to reduce oil consumption in the affected industries. Examples of the oil required per unit for U.S. production of steel products and newsprint are shown above. The data are taken from two A.D. Little, Inc. studies.*

c. Constraints and Economic Impacts. Constraints on the use of this option appear at the federal and foreign government and individual firm levels. Governmental constraints include tariffs, duties, quotas, the trigger price mechanism for steel products, the lengthy review and approval processes for NG and LNG imports, and the export policies of foreign governments. The U.S. duty on imported groundwood paper, for example, is a major factor in limiting its import to an insignificant level. For natural gas, normal procedures of both U.S. and Canadian regulatory authorities are very time consuming. It would therefore be beneficial for both governments to put in place mechanisms for expediting increased sales prior to an actual energy emergency. It is possible that

* Industrial Environmental Research Laboratory, U.S.E.P.A., Environmental Considerations of Selected Energy Conserving Manufacturing Process Options: Vol. V, Pulp and Paper Industry Report, Cincinnati, OH, December 1976.
Arthur D. Little, Inc., Research, Development, and Demonstration for Energy Conservation: Preliminary Identification of Opportunities in Iron and Steelmaking, Cambridge, MA, January 1978.

additional foreign supplies of energy would be available in the event of an emergency. For example, Canadian exports of NG in 1978 were below allowable levels, and Canadian authorities are presently considering an increase in permissible levels through 1990 because of recent natural gas finds. A significant fraction of our LPG now comes from foreign countries; it is possible that additional supplies would be available at various times. However, if advance arrangements are not made with foreign governments, their reaction during an emergency may be to decrease energy exports to the U.S.

Reaction of industrial firms to increased imports of certain goods is likely to be highly negative, for this would mean a reduction in production levels at U.S. mills. It could be argued that, for capital-intensive goods, the major impact would be on company profits and not on employment. In view of this it might be feasible for federal officials to obtain prior agreement with trade associations and company executives about import measures that would have a large impact on industrial oil consumption, but minimal impact on employment. The impact on cyclical industries would also be smaller because of their established procedures for dealing with a fall in demand.

Option #6. Restrict industrial electricity generation where fueled by petroleum products.

a. Objective. Substitute non-oil-generated utility electricity for oil-fired electricity generation by industry.

b. Energy Savings. Seventeen Mbbl/day distillate and residual oil.

Electricity production by industry was 87×10^9 kWh in 1976. It is assumed that 20% of this was oil fired and substitution of purchased electricity (non-oil fired) is only feasible for 20% of the oil-fired industrial generation.

c. Constraints and Economic Impacts. Complete substitution of purchased for industrial-generated electricity is not feasible because of cogeneration requirements for process steam and the fact that certain utilities may also be burning oil. Improved estimates of feasible substitution will have to be obtained from industry, as relevant data are not published.

The primary economic impact will be the higher cost of purchased electricity.

Option #7. Restrict export of recyclable materials.

a. Objective. Reduce energy consumption in steel and paper industries from that required for production of virgin pulp and steel by increased domestic usage of scrap iron and steel and waste paper.

b. Energy Savings. Not estimated.

c. Constraints and Economic Impacts. The potential for energy savings with this option is great. In 1977 waste paper exports totaled 1.3 million tons and iron and steel scrap exports totaled 5.9 million tons. Actual energy savings would not be immediate, however, because of time delays in transportation and in gradual buildup in use of steel scrap in production processes.

Objections can be expected from scrap dealers because of possible price declines. On the other hand, paper and steel producers would probably favor this option because the drop in export demand would lower the cost of scrap and waste paper to them. In early 1979, for example, steel producers requested export quotas on iron and steel scrap from the Commerce Department because of high world market prices for scrap.

B. Supportive Governmental Measures

Regulatory and approval actions of the federal government have significant impact on industrial fuel mix and levels of usage. Government purchases, trade and tariff policies, foreign aid shipments, and many other areas of governmental responsibility also directly influence domestic production and levels of energy consumption. Because of large feedbacks to the level of industrial activity, a variety of measures are listed below by which the federal government can effect petroleum conservation in the private sector. The government can additionally set examples which, by drawing upon public relations programs to generate popular support, induce private firms to react in similar fashion even at the expense of short-term company profits.

1. Recommend and institute fiscal and monetary measures designed to slow the growth rate of the economy. If the energy emergency indeed proves to be great enough to affect the general level of economic activity, this is probably the most equitable policy which the federal government could adopt.

2. Establish an emergency governmental office to handle requests and questions from industry, business, and lower governmental units. Measures needed to alleviate local or firm-specific problems may necessitate coordination of emergency decisions among governmental agencies and offices. An emergency office could enable the necessary coordination as well as serve as a central source of information for the private sector and for state and local governments.

3. Permit pass-through of higher costs where prices of industrial/utility outputs are regulated. Given our experience with the Arab oil embargo and the Iranian crisis, oil price rises in the short term will no doubt occur with the onset of an energy emergency. If governmental regulators at the federal and state level do not inhibit quick pass-through of higher costs, this will enhance economic incentives on the supply side and, at the same time, provide price signals to reduce consumption on the demand side. Affected prices include wage/price guidelines or controls as well as energy prices per se.

4. Encourage conservation of other energy forms. To facilitate industrial fuel switching, business and the public must conserve natural gas, LPG, and non-oil-generated electricity, and a public awareness program emphasizing the need for and reasons for such conservation is necessary. The advertising portion of such a program can emphasize conservation of energy-intensive goods and services as well as fuel conservation. Increased recycling of iron, steel, aluminum, copper, paper, tires, and glass should also be promoted.

5. Restrict uranium enrichment and other nonessential (in the short term) energy-intensive operations such as production of military explosives and ammunition.

6. Recognize and support implementation of state level energy emergency plans. Many states now have such plans and means for their implementation. Their use can in many instances be more efficient than action at the federal level and more responsive to particular local problems.

7. Shift governmental goods shipment from air and truck to rail and ship modes.

C. Options Not Recommended

Option #8. Close down energy-inefficient plants.

Reason: This would be highly disruptive to the communities in which they are located. Decisions on individual plant closings are probably better left to the individual firms. Maintaining production and local employment can then be weighed against the penalty of higher energy consumption per unit of output.

Option #9. Decrease amounts of oil products that distributors can supply to large customers by specified percentage from previous year.

Reason: This more properly belongs in an allocation plan, which is already assumed to be in effect.

Option #10. Prohibit buildup of consumer oil inventories over the amounts in inventory in prior year, and progressively decrease allowable inventory levels.

Reason: Administrative cost of implementation is likely to be very large. Further, during the Arab oil embargo inventories actually increased, and the State of Ohio's action during the 1979 Iranian crisis was to urge industries to maintain their oil stocks at maximum levels.

Option #11. Ban certain types of packaging, and prohibit sale of small package sizes.

Reason: Packaging lines at plants generally have limited flexibility in the type of packaging material that can be run. Also, prohibition on production of small package sizes would reduce plant capacity - proba-

bly disproportionately across different firms. These actions could, however, be included as part of a public information program telling consumers how they could help reduce energy consumption.

Option #12. Prohibit production of certain energy intensive goods, e.g., plastics and synthetic fibers.

Reason: The particular goods which become scarce might vary considerably according to the nature of the energy emergency. It is doubtful that good guesses could be made beforehand, and it is probable that resultant plant closings would concentrate the employment and economic impacts in a few communities.

Option #13. Reduce quality standards on final products, e.g., coatings on paper stock (brightness and printing quality), paper strength.

Reason: It would be difficult to identify specific actions which would significantly reduce petroleum consumption. Quality reduction would probably affect material properties such as strength, stiffness, or printing quality and create problems with the automatic machinery used to handle reduced-quality materials or problems in the end use of the material.

Option #14. Restrict road construction and repair.

Reason: Although this would reduce consumption of asphalt, this petroleum product is not likely to become scarce during an energy emergency. Asphalt exports are large - particularly to Western Europe - and export restrictions might be preferable if there indeed were a shortage. Limiting road construction and repair is likely to be unpopular with the construction industry. In addition to causing unemployment, this restriction would result in vehicular congestion and damage to vehicles.

III. CHARACTERISTICS OF INDUSTRIAL PETROLEUM CONSUMPTION

Oil consumption varies widely across the industrial sectors of the economy. Table 3, which lists 1976 sectoral purchases of distillate and residual oil at the 3-digit SIC code level, shows this vividly. The

Table 3
1976 Industrial Oil Purchases, 10 MMbbl*

SIC	Industry group	Distillate oil	Residual oil	Total
331	Blast furnace, basic steel products	6.63	35.21	41.84
263	Paperboard mills	3.03	32.14	35.17
262	Papermills	2.89	28.98	31.87
286	Industrial organic chemicals	3.36**	14.05**	17.41**
282	Plastic materials, synthetics	2.49**	10.69**	13.10**
291	Petroleum refining		11.29	11.29**
281	Industrial inorganic chemicals	4.42	4.63	9.05
327	Concrete, gypsum, plaster products	4.64	1.54	6.18
206	Sugar, confectionery products	1.55	4.40	5.95
324	Hydraulic cement	.80	4.94	5.74
287	Agricultural chemicals	3.15	2.32	5.47
322	Glass, pressed or blown	3.51	1.87	5.38
203	Preserved fruits & vegetables	1.91	2.58	4.49
283	Drugs	.81	3.66	4.47
226	Textile finishing	1.08	3.18	4.26
307	Misc. plastics products	1.09	2.84	3.93
371	Motor vehicles & equipment	1.26	2.59	3.85
301	Tires & inner tubes	.72	3.12	3.84
207	Fats & oils	1.73	1.95	3.68
204	Grain mill products	1.53	2.03	3.58
333	Primary nonferrous metals	.98	2.38	3.36
208	Beverages	1.82	1.47	3.29
225	Knitting mills	1.34	1.84	3.18
335	Nonferrous rolling & drawing	1.78	1.31	3.09

*U.S. Dept. of Commerce, 1976 Annual Survey of Manufacturers; Fuels & Electric Energy Consumed; Industry Group & Industries, March 1978.

**Data are incomplete.

major consumers are, in decreasing order of importance, paper and paper-board mills, basic iron and steel production, chemicals, food and beverages, building products, and plastics. The greatest impact on reducing industrial oil consumption can thus be gained through measures directed at these largest users.

The particular characteristics of a future energy emergency may result in shortages of certain specific petroleum products, and not in an across-the-board shortage of all products. It is therefore important to know the composition of industrial oil purchases. For example, 78% of the purchases shown in Table 3 are for residual oil and only 22% are for distillate oil. Emergency measures directed toward these industries would have much more impact on residual oil use than on use of distillate. It would be instructive to further examine oil use by grade and sulfur content and to assemble corresponding data for other petroleum products such as diesel oil, kerosene, gasoline, LPG, etc.

Since energy-intensive production processes and the potential for energy conservation and fuel switching vary across industries and individual plants, a sample of trade associations and manufacturers has been contacted in order to ascertain the potential for petroleum conservation. Information obtained from the chemical, iron and steel, cement, and paper industries is presented below. This information forms part of the basis for the recommendation of particular energy saving options described in Section II of this report.

A. Chemical Industry*

Recent trends in energy consumption show a drop in the use of natural gas as the primary fuel. From 1972 to 1977, natural gas as a percentage of total fuel use dropped from 47 to 40% as the industry shifted to increased oil usage. In an energy emergency it is felt that the industry could easily revert to a gas consumption level of 47% and even as much as 60% of energy consumed (if available).

*Information sources: (1) Manufacturing Chemists Association, November 1978. (2) U.S. Department of Energy, Voluntary Business Energy Conservation Plan, Progress Report No. 6, pp. 4-6, DOE/CS-0018/6, April 1978. (3) Dick Barnes, U.S. DOE at ORNL, formerly with Dow Chemical and Shell Oil, personal communication, November 1978.

Petroleum products are used chiefly as feedstocks and natural gas is used as fuel for process heat. The data for 1975 reflect this:

	<u>Feedstock</u>	<u>Fuel</u>	<u>Total, 10¹⁵ Btu</u>
Natural Gas	20%	80%	2.0
Petroleum Products	71%	29%	1.4

Natural gas use for feedstock cannot be increased easily in a petroleum energy emergency. However, if natural gas were available, petroleum consumption could be lessened by up to 29% by switching power plants to gas. The industry does not have a plan to shut down production lines which use petroleum feedstocks in an emergency. There may be plans in individual plants to shut down some processes which consume oil, but only when production can be made up easily at a later date.

The chemical industry's voluntary plan to reduce energy consumption has been successful. Since 1972, energy consumption per unit of output has dropped 12%, equivalent to a reduction of 206 Mbbl/day. It is felt that there is little room to conserve energy under a short-term emergency, especially petroleum products, through improved maintenance or other such conservation efforts.

Many of the chemical plants are along the Gulf and California coasts where there has been a glut of domestic oil. The industry could keep these plants on stream without major cutbacks during an energy emergency, assuming that domestic oil is not rationed to other areas.

In summary, the best way the industry could save without sacrifice in production and employment is to switch away from oil to natural gas fuel for power plants. By cutting back oil consumption 15 and 29% the savings would correspond to 93 and 180 Mbbl/day, based on 1975 data.

B. Steel Industry*

Since 1972 the steel industry has cut back natural gas consumption by switching to petroleum fuels. Data show a drop in gas use from 21.8

*Information Sources: (1) Bill Gray, AISI Energy Committee Chairman, Inland Steel Co., November 1978. (2) U.S. Department of Energy, Voluntary Business Energy Conservation Program, Progress Report #6, DOE/CS-0018/6, April 1978.

to 19.2% of total energy demand, and a rise in oil use from 6.6 to 8.9% between 1972 and 1976. Coal and coke have continued to supply the principal energy needs at around 66%. It is felt that oil consumption could be curtailed to the 1972 level or lower, assuming natural gas is available as a replacement. However, a simultaneous drop in both oil and gas usage will effect a roughly proportional drop in production up to some threshold level of oil curtailment of about 15 to 20%. Fuel switching is the only effective short-term conservation method for the industry.

The greatest amount of oil is used as fuel in reheating furnaces which serve to heat up semifinished shapes of steel prior to rolling and other processing. The blast furnace which is fueled primarily by coke, and the open hearth furnace which can also use natural gas, coke oven gas, or coal tar, both consume residual fuel oil, but to a much lesser extent than the reheating furnace.

In summary, the impact on residual fuel consumption resulting from a 15 to 20% curtailment corresponds to 15 to 20 Mbbl/day residual fuel oil. (Total consumption = 100 Mbbl/day, 1976.)

C. Cement Industry*

The trend in energy consumption for the cement industry between 1972 and 1976 has been away from natural gas and towards coal as the primary fuel type. Usage of the two fuels has reversed in this period: natural gas dropped from 45 to 32% of total energy consumption, and coal increased from 36 to 51%. Oil demand has dropped only marginally from 12 to 10%. The bulk of the oil used is bunker C oil for kilns in several plants.

The kiln is the energy intensive processing step in cement production. Currently, only 2% of total clinker (product from the kiln) capacity relies on oil. Six plants located in Hawaii, Maine, Pennsylvania, and New York consume about 118 Mbbl/day of oil. Data for the entire industry are:

*Information Sources: (1) Personal Communication, John Wilson, Martin-Marett Cement, Bethesda, MD., November 1978; (2) Don Peterson, Martin-Marietta Cement, Martinsburg, WV, November 1978. (3) Portland Cement Association, in Voluntary Business Energy Conservation Program, Progress Report #6, DOE/CS-0018/6, April 1978.

<u>Fuel Capacity</u>	<u>No. of Plants</u>	<u>% Total Capacity</u>
Coal	44	29
Coal/gas	41	23
Coal/oil/gas	23	17
Oil/gas	18	13
Coal/oil	16	13
Gas	10	3
Oil	6	2
	<u>158</u>	<u>100</u>

Shutting down oil-fueled kiln plants would not severely affect supply, except in Hawaii where there are no other plants.

A wet process concrete plant consumes 5.5 to 6.0 MMBtu/ton of finished product. Energy is one of the biggest costs in the manufacture of cement, accounting for 25 to 38% of the selling price. Fuel for the coal-fired kiln comprises 88% of total energy use with the remainder composed of electricity, 10%, and diesel fuel oil, 2%. Electricity is used chiefly for power grinding equipment, and the industry has done as much as it can to shift electrical consumption to off-peak hours. Any further shift will result in a drop in production rate and, most important, poor-quality product caused by discontinuity in product shape when the finish grind is performed intermittently. Diesel fuel oil is necessary in drilling for blasting and in quarrying the rock (raw material).

In summary, the most effective way to reduce petroleum consumption (bunker C oil) in the industry is for all plants which currently consume oil to shift to coal- or gas-fired kilns, and then to cut back or shut down the six additional plants which rely on crude oil only for the kiln. The potential savings is 118 Mbbl/day.

D. Paper Industry*

Oil fuels are used in three primary boiler types plus the lime kiln. Together they account for most of the demand in this industry:

- Hogged-fuel boiler (combination wood by-products and oil),
- Power boiler,
- Recovery boiler.

*Information Sources: (1) Personal Communication, Jeffrey Duke, American Paper Institute, November 1978. (2) Personal Communication, Bob Jameson, Weyerhaeuser, November 1978.

The lime kiln and power boiler are the two biggest consumers. As a rough estimate, 10 to 40% of oil use in these processes could be switched to natural gas without side effects.

Although hogged-fuel boiler use is small, the energy produced here and in the recovery boilers which recover energy from lignin account for 44% of total energy requirements in the industry. This amount could increase if emission controls were slackened. The present standard is 1/10 lb particulate emission/MMBtu fuel heat value, corresponding to 0.2 grains/ft³ stack gas. This is accomplished by using one or two cyclones to scrub stack gases. To meet this EPA air emission standard, much of the excess wood by-products is now used for land fill instead of power generation with an energy equivalent of 1 MMbbl/year oil. The proposed standard in 6 months is .04 grains/ft³, which would result in a 25-30% cutback in hogged-fuel boiler capacity. Under this standard Weyerhaeuser alone will need to purchase additional electricity equivalent to 6 MMbbl oil/year, assuming generation is from oil-fired power plants. In addition, the company would have to install medium-efficiency wet scrubbers.

IV. RECOMMENDATIONS FOR FURTHER RESEARCH

This study represents a preliminary identification of significant opportunities for petroleum conservation in the industrial sector in the event of an energy emergency. It is recommended that more detailed analyses of energy savings, economic impacts, and likely acceptance of the measures by industry be performed through additional consultation with trade associations and large manufacturers. Additional input and cooperation from federal and state governmental agencies are required in those areas for which regulations and rules would have to be relaxed or changed. Changes in existing government regulations and procedures should be identified and agreed upon in advance of an actual emergency so that reaction can be swift and flexible, depending on the particular nature of the emergency. Flexibility and confidence in the value (in terms of energy saved) of particular options can also be increased by improving the detail of successive analyses in regard to specific types and grades (i.e., sulfur content of residual oil consumed) of specific petroleum products, transportation requirements for industrial fuels (including location of sources of supply), locational patterns of fuel demand, and disproportionate economic impacts across different firms.