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BY THE COMPTROLLER GENERAL

Report To The Congress

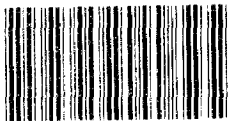
OF THE UNITED STATES

How The Petroleum Refining Industry Approaches Energy Conservation-- A Case Study

The U.S. petroleum refining industry accounts for about 4 percent of total domestic energy consumption and over 10 percent of all energy consumed by the industrial sector. The Department of Energy reports that the industry has made significant strides in increasing its energy efficiency--reducing its energy requirements to refine a barrel of crude oil by 19.5 percent between 1972 and the end of 1978.

Federal energy policies designed to raise domestic energy prices will have a large impact on refining industry efforts to improve its energy efficiency. Federal programs aimed at improving energy efficiency in industry have had little impact on the refining industry, but there are ways to improve these programs.

Federal programs to increase substitution of coal for oil and natural gas also have had little impact on the refining industry and in some cases may actually be hampering efforts to improve energy efficiency. More must be done to demonstrate the feasibility of using coal gasification technology in refineries.



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To the President of the Senate and the
Speaker of the House of Representatives

This report examines conservation achievements in the petroleum refining industry, and assesses the impact existing Federal energy conservation and fuel-switching programs have had in furthering conservation gains and encouraging switching to coal.

The refining industry was selected to be a case study for evaluating the effect of Federal energy policies and programs on the industrial sector, because it is one of the most energy-intensive industries and is heavily dependent on scarce oil and natural gas resources.

Copies of the report are being sent to the Director, Office of Management and Budget, and the Secretary of Energy.

Comptroller General
of the United States

COMPTROLLER GENERAL'S
REPORT TO THE CONGRESS

HOW THE PETROLEUM REFINING INDUSTRY APPROACHES ENERGY CONSERVATION--A CASE STUDY

D I G E S T

The U.S. petroleum refining industry accounts for about 4 percent of total domestic energy consumption and over 10 percent of all energy consumed by the industrial sector. In 1978 refineries consumed the equivalent of 1.4 million barrels per day of crude oil in producing refined petroleum products, or about 1 barrel of crude oil for every 10 barrels refined.

The refining industry has achieved significant improvements in efficiency in the past, and expects continued improvements. The Department of Energy reported that the industry reduced its energy requirements to refine a barrel of crude oil by 19.5 percent between 1972 and the end of 1978.

This report examines conservation achievements in the refining industry, and assesses the impact existing Federal energy conservation programs have had in furthering conservation gains. While the report looks only at the refining industry, GAO believes sufficient parallels exist between the industry and industry as a whole to enable the report to make recommendations having general industrial application.

The definition of "conservation" used in this report includes both increased energy efficiency and fuel substitution. GAO visited 29 refiners to learn about their conservation programs, and to get their views about future conservation opportunities.

FEDERAL EFFORTS TO IMPROVE EFFICIENCY

Federal programs designed to promote improved industrial energy efficiency have had little impact to date in improving refinery efficiency. However, Government

policies and programs, particularly those affecting energy prices, can speed up or hinder the rate at which future gains are achieved. (See ch. 2.)

The current Federal policy of moving toward decontrol of domestic crude oil and natural gas prices should help achieve greater energy savings by making additional conservation projects cost effective.

The Department of Energy's industrial energy conservation reporting program--the Government's most visible program designed to improve energy efficiency in industry--has had some positive impact on refiners' energy conservation efforts. However, the program's 1980 voluntary efficiency improvement target of 20 percent for the refining industry would probably have been achieved anyway.

The National Energy Conservation Policy Act extended the reporting program beyond 1980, but did not give the Department of Energy legislative authority to set new efficiency improvement targets. A periodic reporting program with an efficiency improvement goal can be useful for measuring progress and maintaining visibility for industrial conservation efforts. (See pp. 11 to 15.)

The 10-percent tax credit for certain conservation investments, contained in the Energy Tax Act of 1978, is not expected to have much impact on refinery conservation efforts. Refiners stated that the credit is too small and the 1982 expiration date too soon. However, the new Windfall Profits Tax Act has extended the deadline for long-term conservation projects to 1990, which should make the tax credit more attractive. (See pp. 17 and 18.)

FUEL SUBSTITUTION

Over 90 percent of the refining industry's fuel needs are met by scarce fossil fuels--oil and natural gas. Instead of using scarce fossil fuels to generate the process heat,

steam, and electricity refineries need, it may be possible to use as substitutes coal or synthetic fuels derived from coal.

Federal programs to increase substitution of coal for oil and natural gas have had little impact on the refining industry, and in some cases may actually be hampering efforts to improve energy efficiency. While increasing oil and natural gas prices will be a key determinant in any refiner's decision to use coal, greater Federal efforts will be needed in the coal gasification area to demonstrate its feasibility in refinery applications. (See ch. 3.)

DIRECT USE OF COAL

The direct burning of coal in refineries has limited potential because most refinery facilities either are not technically able to burn coal, or would require extensive modifications to do so. (See pp. 27 to 32.)

The most potential for coal use lies with future refinery boiler expansions and replacements, but refiners told GAO they were reluctant to adopt coal-fired boilers for economic, technical, and environmental reasons. Thus, the Department of Energy's coal-switching program, designed to force increased industrial coal use, may have little impact on the refining industry. GAO found several refiners that planned to continue using old, inefficient boilers rather than modernizing and risk having to use coal. (See pp. 32 and 33.)

COAL GASIFICATION

Synthetic gas produced from coal offers an alternative potentially more attractive than direct burning of coal. According to one study, this fuel could supply up to 25 percent of refinery energy needs in certain parts of the country, by the year 2000. (See pp. 33 and 34.)

Tear Sheet

Federal coal gasification activities to date have not been directed toward demonstrating the use of coal gas in a refinery since the refining industry has not shown much interest. However, since coal gas could potentially displace a significant amount of oil and natural gas burned in refineries, the industry should not be ignored as a possible coal gas user. (See pp. 35 to 37.)

RECOMMENDATIONS

The Secretary of Energy should

--Request legislative authority to develop new voluntary industrial energy efficiency improvement targets in order to maintain industry-wide visibility of effort in the conservation area, and to provide a yardstick by which to measure industry's progress.

--Monitor industrial energy usage and progress towards achieving the new improvement targets, and develop additional programs, if needed, to assure that conservation goals are met.

--Examine the extent to which companies in all industries are neglecting to replace old energy-inefficient equipment because of the coal-switching program, and take appropriate measures if a significant problem seems to exist.

--Take further steps to demonstrate coal gasification technologies in industrial applications, including the refining industry if appropriate.

The Congress should take the initiative to require the Department of Energy to set new voluntary industrial energy efficiency improvement targets if the Department fails to request the authority. (See pp. 55 and 56.)

AGENCY COMMENTS

The Department of Energy agreed with GAO's assessment that gas produced from coal may become more attractive to refiners than direct

burning of coal. However, the Department disagreed with the report in several areas. It said the evaluations appeared to have been made from a limited viewpoint, and it had problems with the logic of the recommendation pertaining to developing new efficiency improvement targets.

The Department of Energy stated that the report appeared to evaluate Federal programs from the industry's viewpoint rather than from the broader, more objective perspective of national energy considerations. GAO believes the report objectively portrays the impact of Federal energy conservation policies and programs on the refining industry. Certainly any appraisal of industrial conservation programs must consider the views and reactions of those affected.

The Department stated that the recommendation to establish new industrial efficiency improvement targets was illogical since GAO had concluded that the old targets were largely ineffective. The report recognizes that new targets may not result in greater energy savings than would have occurred without the targets. However, GAO believes that new targets can be useful in terms of being a reference point against which industry's progress can be measured, providing visibility to industrial conservation activities, and helping prevent possible future deemphasis on conservation by industry.
(See pp. 58 to 60.)

Contents

		Page
DIGEST		i
CHAPTER		
1	INTRODUCTION	1
	Petroleum refining processes	1
	Refining industry energy requirements	2
	Energy conservation in the refining industry	4
	Scope	4
2	REFINERY ENERGY EFFICIENCY: STATUS AND POTENTIAL FOR FUTURE IMPROVEMENT	7
	Factors affecting refinery fuel use	7
	Complexity	8
	Technological advances	8
	Fuel availability	8
	Federal activities designed to improve refinery efficiency	10
	Industrial energy conservation reporting program	11
	Development of the efficiency improvement targets	11
	Industry views on the program	13
	Future of the industrial energy conservation reporting program	14
	Industrial process efficiency program	15
	Ten-percent investment tax credit	17
	Refining industry conservation efforts	18
	Conservation project investment criteria	19
	Opportunities for improved efficiency	20
	Constraints to future efficiency increases	21

3	OPPORTUNITIES FOR FUEL SUBSTITUTION IN REFINERIES	26
	Direct use of coal	27
	Federal coal-switching program	27
	Limitations on the direct use of coal	29
	Environmental limitations	30
	Physical limitations	30
	Economic limitations	31
	Potential for greater direct use of coal	32
	Use of synthetic fuels derived from coal	33
	Federal low- and medium-Btu coal gasification programs	35
	Research and development	35
	Demonstration	36
	Commercial applications	36
	Coal gasification commercialization prospects	37
	Privately financed coal gasification effort	39
	Coal gasification applications in refineries	40
	Constraints to use of synthetic fuels from coal	42
	Refining industry's comments	42
4	THE FEDERAL ROLE IN HELPING ACHIEVE GREATER ENERGY SAVINGS IN REFINERIES	46
	Increasing energy efficiency	46
	Increasing use of coal	49
5	CONCLUSIONS AND RECOMMENDATIONS	52
	Improving energy efficiency	52
	Increasing coal use	53
	Direct use of coal	53
	Coal gasification	54
	Recommendations to the Secretary of Energy	55
	Recommendation to the Congress	56
	Agency Comments	56
APPENDIX		
I	Department of Energy Comments	58

ABBREVIATIONS

B/D	42-gallon barrels per day
Btu	British thermal unit
DOE	Department of Energy
EPA	Environmental Protection Agency
EPCA	Energy Policy and Conservation Act
ESECA	Energy Supply and Environmental Coordination Act
GAO	General Accounting Office
MMB/D	millions of 42-gallon barrels per day

CHAPTER 1

INTRODUCTION

Petroleum is the primary source of energy in the United States, accounting for nearly half of the energy domestically consumed. However, crude oil, as it is extracted from the ground, must be altered and separated--or refined--before it can be used. The refining process itself consumes energy. U.S. refineries use the equivalent of about 1 barrel of crude oil for every 10 barrels refined.

The U.S. refining industry accounts for about 4 percent of total domestic energy consumption and over 10 percent of all energy used by the industrial sector of the economy. Only two other industries--chemicals and primary metals--consume more energy than the refining industry. In 1978 the industry consumed the equivalent of 1.4 million barrels per day (MMB/D) of crude oil in the production of refined petroleum products.

According to the Department of Energy (DOE), as of January 1, 1979, there were 301 operating refineries in the United States with a total operable capacity of 17.4 MMB/D. These refineries ranged in size from less than 1,000 barrels per day (B/D) to 640,000 B/D. During 1978, U.S. refineries processed about 14.7 MMB/D of crude oil.

PETROLEUM REFINING PROCESSES

Of the several known refining processes, the major types are separation, conversion, and treating. 1/

Separation involves boiling the crude oil and permitting it to vaporize and condense at different temperatures. This process yields petroleum products that are more or less determined depending on the types of crude.

The conversion process alters the chemical structure of crude oil and results in an increased yield and quality of certain products, such as gasoline. There are several conversion processes, but the basic ones are cracking, reforming, and alkylation. Cracking is the process of breaking down large complex molecules into smaller ones, while reforming changes straight molecules into higher octane rings. Alkylation--generally the reverse of cracking--consists of linking two or more small molecules together. By using cracking conversion methods, refineries can obtain 25 to 60 percent more gasoline than with separation methods. 2/

Treating crude oil essentially removes undesirable impurities such as sulfur, vanadium, nickel, iron, oxygen components, and nitrogen compounds. Sulfur and sulfur compounds, the most significant contaminants, are usually removed through various processes known as hydroprocessing. This involves mixing the petroleum with hydrogen and heating it in the presence of a catalyst to produce hydrogen sulfide. The hydrogen sulfide is later separated from the "sweet" petroleum and sent to a sulfur recovery unit, and the unused hydrogen is separated and recycled. 3/

U.S. refineries produce gasoline, jet fuels, kerosene, diesel fuel, and fuel oils as their principal products. They also produce lubricants, waxes, solvents, asphalt oil, and petrochemical raw materials for products such as plastics, synthetic rubber, and synthetic fibers. The proportions of the principal products vary with the refining design, location, crude oil source, and time of year. For example, refineries may maximize gasoline production during the summer and heating oil production during the winter to meet seasonal consumer demand. 4/

REFINING INDUSTRY ENERGY REQUIREMENTS

The energy used in a refinery is generally process heat, steam, or electricity. The breakdown for these energy uses within a typical refinery is as follows: 5/

Process heat	65%
Steam generation	25%
Electricity	10%
	100%

Process heat is needed to operate furnaces and heaters that are used to process crude oil. Steam is used as a stripping agent, in heat exchangers, and in powering turbines and pumps, while electricity is used primarily for pumping.

Refineries use a variety of energy sources to meet their energy needs. They are in a somewhat unique position, compared to many other industries, relative to the availability of fuel. Since refineries are themselves producers of fuel, they can use these fuels, if needed, to replace other purchased fuels.

Roughly two-thirds of the refining industry's energy requirements are provided by energy sources obtained internally as a raw material (crude oil), finished product (residual and distillate fuel oil, and liquid petroleum gas) or by-product (refinery gas and petroleum coke). The remaining refinery energy requirements (natural gas, purchased electricity and steam, and coal) must be purchased. Also, many large refineries employ cogeneration to efficiently supply their own electric power needs.

The following table shows the various fuels used in the refining industry, and the reliance placed on each of them.

Refining Industry Fuel Use--1978

Energy source	10^{12} Btu's	Percent
Refinery gas	1291.7	42.2
Natural gas	820.6	26.8
Petroleum coke	394.8	12.9
Residual fuel oil	314.6	10.3
Purchased electricity	94.8	3.1
Liquid petroleum gas	57.1	1.9
Distillate fuel oil	51.7	1.7
Purchased steam	32.9	1.0
Coal	3.2	.1
Crude oil	2.6	0
	3064.0	100.0

Source: "Crude Petroleum, Petroleum, and Natural Gas Liquids: 1978," U.S. Department of Energy, DOE/EIA-0108/78.

Refinery gas is by far the largest single source of energy in refineries today. This gas is a mixture of the gases produced as by-products of various refining processes. It is normally collected from a processing unit and used either as a fuel for that unit or piped through the refinery to fire other units. Refinery gas has a fluctuating heating value ranging generally from 700 to 1,400 British thermal units (Btu's) per cubic foot 6/ compared to about 1,000 Btu's per cubic foot for natural gas.

Additional significant energy sources include natural gas, petroleum coke--the residue remaining after the refining processes are completed--residual fuel oil, and purchased electricity.

ENERGY CONSERVATION IN THE REFINING INDUSTRY

This report is an analysis of the role energy conservation plays in the refining industry. We have examined what conservation achievements have been accomplished and what the future is likely to hold in store. Our primary focus has been on the impact that existing Federal energy conservation programs have had in furthering conservation gains by the industry and what impact these programs can be expected to have in future years.

We are using a broad definition of "conservation" in this report. It includes both increased energy efficiency (use of more efficient equipment and operating practices) and measures to reduce the use of scarce fossil fuels--petroleum and natural gas--by substituting a more abundant fossil fuel, coal.

SCOPE

In determining the current extent and future potential of energy conservation in the refining industry, we contacted the following organizations:

--Within DOE--the Economic Regulatory Administration, Energy Information Administration, Offices of the Assistant Secretaries for Conservation and Solar Energy, Resource Applications, Fossil Energy, and Office of Energy Research. 7/

--Twenty-nine refining companies, representing about 57 percent of domestic refining capacity.

--A number of developers of low- and medium-Btu coal gasification technologies.

--The American Petroleum Institute.

At each of these organizations, discussions were held with officials and pertinent information and documents were obtained. In addition, we analyzed numerous studies, articles, and periodicals covering industrial energy conservation and fuel substitution. We discussed a draft of this report with representatives of the American Petroleum Institute, and have made some technical corrections based on their comments.

A significant portion of our review consisted of visits to 29 individual refiners to learn first-hand about their conservation activities. These companies range in size from less than 10,000 B/D to over 1.5 MMB/D and have a combined crude oil distillation capacity of approximately 10 MMB/D.

In addition to visiting large, medium, and small refiners, we sought geographic diversity as well, visiting refiners along the East, West, and Gulf Coasts, and in the Midwest. To avoid the possibility of disclosing proprietary company information, we have not linked to company names any of the information we received during our visits, unless the information was already in the public domain.

NOTES

CHAPTER 1

1/American Petroleum Institute, Facts About Oil (Washington: American Petroleum Institute, 1977), p. 23.

2/Ibid., p. 24.

3/U.S. Department of Energy, Trends in Desulfurization Capabilities, Processing Technologies, and the Availability of Crude Oils (Washington: U.S. Department of Energy, 1977), p. 10.

4/Science and Public Policy Program, University of Oklahoma, Energy Alternatives: A Comparative Analysis (Washington: U.S. Government Printing Office, 1975), pp. 3 to 25.

5/U.S. Department of Energy, Five Year Program Plan for Petroleum Refining Energy Conservation Research and Development (Washington: U.S. Department of Energy, 1978), p. 8.

6/SRI International, for U.S. Department of Energy, Market Opportunities for Low-and Intermediate-Btu Gas from Coal in Selected Areas of Industrial Concentration (Washington: U.S. Department of Energy, 1978), p. 81.

7/The Department of Energy Organization Act (P.L. 95-91) transferred the functions of the Federal Energy Administration, Energy Research and Development Administration, Federal Power Commission, and certain energy related activities of other agencies to DOE. This was effective on Oct. 1, 1977. For simplicity, statements made and data published under the former agency name are attributed to DOE.

CHAPTER 2

REFINERY ENERGY EFFICIENCY:

STATUS AND POTENTIAL FOR FUTURE IMPROVEMENT

The refining industry has a record over the years of steady improvements in efficiency of energy use, and is likely to continue to progress in the foreseeable future despite potentially constraining circumstances. Federal activities designed to promote industrial energy efficiency, however, have so far had little impact on refinery efficiency, and are not likely to have a large impact in the future. Nevertheless, other Federal energy programs and policies can influence the rate at which future refinery efficiency gains are achieved. For instance, the cost of fuel is the largest factor influencing refinery fuel use, so Federal energy policies affecting pricing are likely to have a large impact on future efficiency increases.

FACTORS AFFECTING REFINERY FUEL USE

There has always been an awareness within the refining industry of the need to use fuel efficiently because conservation of fuel used for internal processing often represented a gain in saleable energy products. Nonetheless, until 1973, minimizing energy requirements was rarely a decisive factor in minimizing product costs because energy was relatively cheap and abundant. 1/ However, the increasing cost of fuel has led, and will continue to lead, to more efficient use of energy in refineries.

Currently, the cost of energy consumed in the refining process represents the largest single cost element in operating a refinery. 2/ This was not always the case. For example, one large refiner reported that in 1970, labor costs were the greatest expense, followed by energy costs and then material costs. By 1977, energy costs were substantially greater than labor and material costs combined. Those refiners willing to provide the information to us stated that energy costs are typically close to 50 percent of current operating expenses. (Operating expenses do not include the cost of the crude oil processed through the refinery.)

Other significant factors affecting energy use are refinery complexity, technological advances, and availability of fuels.

Complexity

As a general rule, the greater the number or complexity of processing steps required, the greater the amounts of energy required. In 1975, a refinery considered simple in complexity and processing severity consumed in production the equivalent of 2.8 percent of the crude oil processed, whereas a more complex refinery used 12.4 percent. 3/

Complexity is likely to increase in the future due to such factors as increased unleaded gasoline production, increased dependence on high sulfur, lower quality crude oil, and compliance with environmental emission standards.

Technological advances

The refining industry has had substantial technological advancement due to increased demand for better petroleum products, such as increased quantities of higher quality gasoline and petrochemical feedstocks. These advancements have improved both product quality and process efficiency. These savings have more than offset the increases in energy use due to the more complex refining operations. For example, in 1955 a complex refinery used as energy the equivalent of 22.8 percent of the crude oil processed, while 20 years later a similar complex refinery needed only 12.4 percent. 4/

Because of technological advances, estimates are that a new refinery could be as much as 30 percent more energy efficient than an existing refinery. 5/ Retrofitting an existing refinery could improve its energy efficiency by as much as 20 percent. 6/

Fuel availability

Substantial regional variations exist within the United States in kinds of fuels used in refineries and amounts of energy consumed per barrel of crude oil processed, as the following table shows.

Table 1

Regional U.S. Refinery Energy Use - 1978

Type of Energy Used	Approximate Percentage of Use					
	East Coast	Mid-West	Gulf Coast	Rocky Mountain	West Coast	U.S. Total
Crude Oil	0	0	0	0	.3	0
Distillate Fuel Oil	1.8	1.3	2.3	.4	.7	1.7
Residual Fuel Oil	28.5	15.8	4.0	16.4	7.0	10.3
Liquefied Petroleum Gas	1.9	3.1	.8	1.7	3.0	1.9
Natural Gas	7.4	13.8	39.0	21.4	24.6	26.8
Refinery Gas	37.2	47.7	39.4	42.0	45.4	42.2
Petroleum Coke	14.8	15.0	11.2	14.9	13.0	12.9
Coal	1.0	0	0	0	0	.1
Purchased Electricity	3.0	3.3	2.4	3.2	4.8	3.1
Purchased Steam	4.4	0	.9	0	1.2	1.0
Totals	100	100	100	100	100	100
Total Btu's Used (10^9)	331,433	725,644	1,429,138	90,406	487,308	3,063,929
Btu per barrel of crude oil refined (10^3 Btu)	528.7	522.0	608.1	508.0	583.6	569.5

Source: "Crude Petroleum, Petroleum Products, and Natural Gas Liquids: 1978," U.S. Department of Energy, DOE/EIA-0108/78.

Use of natural gas fluctuates the most among regions, from a low of 7.4 percent on the East Coast to a high of 39.0 percent on the Gulf Coast. On the East Coast, and in the Midwest and Rocky Mountain areas, lower-than-average reliance on natural gas is largely offset by higher-than-average use of residual fuel oil. Gulf Coast refineries use considerably more natural gas than other refiners and also rank highest in energy used per barrel, partially because of past fuel usage decisions based on abundant and cheap natural gas. 7/

Reliance by refiners on natural gas has been declining in recent years. In 1974 over 36 percent of the energy used came from natural gas, while table 1 shows that this figure had dropped to 26.8 percent in 1978. Most of the refiners we interviewed indicated that natural gas use would continue to decline in the future. Such a decline would be consistent with past Federal energy policies designed to discourage industrial use of natural gas. However, the future of natural gas in refinery usage has been clouded somewhat, with new Federal policies encouraging short-term industrial use of natural gas as a means of reducing U.S. dependence on imported oil. 8/ Government allocation and pricing of fuels has, and probably will continue to have, great influence over refinery consumption of particular fuels.

FEDERAL ACTIVITIES DESIGNED TO IMPROVE REFINERY EFFICIENCY

We examined three Federal activities which are specifically aimed at promoting increased energy efficiency within the industrial sector

--Industrial energy conservation reporting program.

--Industrial process efficiency program.

--10-percent investment tax credit.

These activities were designed with all industry in mind. However, our examination of how they have affected the refining industry revealed that little conservation savings can be attributed to them. Further, these three activities, as they are presently operating, are not likely to have a large impact in the future.

Industrial energy conservation reporting program

DOE's industrial energy conservation reporting program has been the most visible Federal program designed to promote energy efficiency by industry in general and by the refining industry in particular. The program was established by the Energy Policy and Conservation Act of 1975 (EPCA) (P.L. 94-163) which required DOE to

--rank the major energy-consuming industries,

--establish efficiency improvement targets to be achieved by January 1, 1980 for at least the 10 highest energy-consuming industries,

--identify the major energy-consuming corporations within the 10 industries; and

--establish a system for reporting the progress by each industry in improving its energy efficiency.

The act also specified that technological feasibility and economic practicability be considered when establishing the improvement targets.

In 1979, 54 refiners which represent over 90 percent of the refining capacity in the United States and Puerto Rico reported their energy consumption data to DOE. For the period from July through December 1978, the most recent period for which DOE has published data, these companies reported an improvement in efficiency of 19.5 percent compared to their energy efficiency in the base year, 1972, after taking into account any operational changes that may have occurred. On an adjusted basis, 54 companies were using 19.5 percent less energy to refine a barrel of crude oil than they used in 1972. However, many refiners we interviewed indicated that the existence of the reporting program had little to do with their efficiency gains, and that these gains would have been accomplished without the program.

Development of the efficiency improvement targets

DOE identified the petroleum and coal products industry (Standard Industry Classification 29) as the third most energy-intensive industry in the United States, and contracted with Gordian Associates, Inc., to develop the efficiency improvement target for the industry.

The petroleum and coal products industry contains several industries other than petroleum refining. However, the refining industry accounts for 98 percent of the energy used within the overall industry classification, and thus is the primary focus for potential energy savings.

The target was to be achieved by January 1, 1980, using 1972 as the base year. Each corporation identified as a major energy user is required to report to DOE on its progress in improving its energy efficiency. However, if an industry has a voluntary reporting system acceptable to DOE, individual corporations are exempt from reporting directly to DOE provided they participate in the industry's reporting system. Such is the case in the refining industry--the American Petroleum Institute collects data from the major refiners, summarizes the data, and forwards it to DOE. While reporting to DOE is mandatory, there is no penalty if the industry fails to reach its goal.

The study prepared by Gordian Associates, Inc. concluded that a 20-percent gross efficiency improvement goal should be adopted. 9/ In June 1977, this target was put into effect.

In establishing the energy conservation target for the industry, the Gordian study identified a number of general conservation categories ranging from "housekeeping" measures and insulation to equipment efficiency improvement actions. Measures were considered technologically feasible if they were already in use by the industry, produced a savings without affecting the product produced or the processes used, and could be implemented by January 1, 1980.

The economic practicability of a measure was determined by the extent the industry could be expected to have funds available to install or implement the procedures and technologies. Industry priorities for allocating capital were also evaluated to determine if the industry could implement the potential measures.

The measures that met the technical and economic criteria determined the refining industry's energy conservation target. The Gordian study contained a list of 24 measures most of which by themselves were not significant but when added together totaled the 20 percent goal.

Given that (1) 1972 was used as a base year, when energy prices were significantly lower, and (2) proposed conservation measures had to be already accepted as technically and economically feasible by the industry, the achievement of a 20 percent increase in energy efficiency by 1980 could be expected with a high degree of confidence.

If a conservation measure is considered to be both technically and economically feasible, and the refiner has funds available, it makes sense that the refiner would adopt the measure as a normal business practice.

Industry views on the program

Industry officials we talked to generally felt that the industry-wide goal of 20-percent improvement in energy efficiency would be reached. When this goal was applied to their individual companies, the responses were varied. However, most companies were optimistic about reaching the 20-percent goal. Only one company was extremely pessimistic about the goal. This company was concerned that its capital, if available, will be required for projects needed to meet regulatory requirements in the near future.

The extent of refinery energy efficiency improvement by 1980 greatly depends on how energy efficient the refinery was in 1972. Those refineries which had a relatively inefficient operation in 1972 may reach the 20-percent improvement goal by 1980 by implementing only housekeeping measures and other low-cost projects. Those companies which had more efficient refinery operations in 1972 will have to spend more capital on major improvements in order to meet the goal.

The refiners we talked to could not arrive at a consensus of how to grade the reporting program. According to many refiners, the Federal program had little or no effect on their conservation of energy. They generally believed that the commitment would be the same with or without the program, with improvements made because of their economic benefit. Yet, several refiners believed that the Federal program did indeed have positive effects on their operations and would like to see it continued. The main benefit of the program has been that it helped conservation achieve greater visibility than otherwise might have been the case, and resulted in some companies adopting conservation measures sooner.

Future of the industrial energy conservation reporting program

Two changes to the program occurred with the passage of the National Energy Conservation Policy Act of 1978 (P.L. 95-619). The first expanded the program's scope. No longer will only 50 companies within an industry be identified as high energy users. The criteria now stipulate that a company will have to report its energy use if it consumes more than 1 trillion Btu's of energy per year. According to a DOE official, this change will require 13 additional refiners to report their energy use.

The second change requires DOE in its annual report to the Congress to recommend ways for improving the industrial energy conservation program. According to a DOE official, this reporting requirement will allow DOE to recommend, if desired, that energy efficiency improvement targets be re-established.

In addition, the act did not extend the requirement for DOE to set energy efficiency improvement targets beyond the existing January 1, 1980, expiration date. DOE currently has no plans to extend the improvement targets into the 1980s.

While we have indicated that the efficiency improvement targets cannot be credited with significant energy savings in the refining industry, they have served a useful function and deserve to be continued. New targets will help maintain visibility of effort industry-wide in the energy conservation area, and provide a yardstick by which to measure industry's progress. While the existence of improvement targets may not lead to greater levels of conservation effort than would occur otherwise, they might help prevent any slippage or de-emphasis of conservation in the future. The new targets should be developed with industry's assistance and involvement so as to commit each industry to meeting its target.

If new targets are developed, a change is needed in the program to extend the period covered by the improvement targets. The 1980 targets started with 1972 as a base year but were not put into effect until 1977, making most of the reporting retroactive and giving industry little time to implement new conservation efforts. Consequently most of the improvements made by the refining industry have been easy-to-implement housekeeping measures. The new improvement targets should extend at least through 1990 if major equipment replacements and additions are to be factored into the new

targets. Periodic adjustments could be made in the targets, if warranted, to allow for unforeseen economic and technological changes, such as the recent massive increases in oil prices.

A second change needed in the reporting program is to recognize oil and natural gas savings, as well as savings in overall Btu's per unit of input. While greater efficiency of use of all energy sources is imperative, the Nation's overriding priority should be on conserving scarce oil and natural gas resources. A company changing from oil- to coal-fired boilers may not save any Btu's, but such a switch is clearly in the national interest and should be recognized.

Industrial process efficiency program

The major objectives of DOE's industrial process efficiency program are to

--increase the energy efficiency of energy-intensive processes and

--substitute abundant fuels for scarce fuels in the energy-intensive industries.

These objectives are pursued through cost-shared research, development, and demonstration projects selected from analyses of energy losses and process change potential within industry.

At the time of our review, three studies relating to petroleum refineries had been performed under contract with DOE.

The first study, "Five Year Program Plan for Petroleum Refining," was completed in August 1978, and contained ideas obtained from the refining industry for future DOE projects in the refinery efficiency research and development area. 10/ DOE furnished copies of the report to the American Petroleum Institute to get industry's reaction and expressions of interest on the proposed projects, but did not receive any comments. As one of its projects for fiscal year 1980, DOE plans to obtain, with the American Petroleum Institute's assistance, industry views on the proposals. However, DOE had hoped to hear from the refining industry earlier so that

some projects in the report could possibly be planned for fiscal year 1980.

In the study, "Energy Conservation in Distillation," the distillation process was analyzed in refineries, natural gas processing plants, and the chemical industry to suggest areas where energy conservation efforts should be directed. 11/ In connection with the study, the contractor developed a new, more energy-efficient distillation process. DOE has asked the contractor to do further work by comparing the new distillation process with conventional processes. The contractor is to contact refiners to determine their interest in using this new process. If refiners are not interested, DOE will discontinue this project.

The study, "Refinery Energy Profile," demonstrates a technique for conducting a refinery energy audit by identifying the large energy-using elements in the refining processes. 12/ Refiners can use this study to help analyze their own particular energy use patterns and help identify potential conservation areas. Results of the study indicated that the crude unit was the largest energy consumer, and as one of its future projects, DOE plans to do further work in this area by determining how to reduce the crude unit's energy consumption.

During fiscal year 1979, DOE allocated only $14.4 million for the entire industrial process efficiency program. DOE is allocating $20.7 million in its fiscal year 1980 budget, a portion of which will be spent for followup work on the "Refinery Energy Profile" and "Energy Conservation in Distillation" studies, and for the reformulation of a program plan in the petroleum refining area based upon the comments received from the industry on the "Five Year Program Plan for Petroleum Refining" report.

One view on the program from the industry is that most refiners have sufficient expertise in areas relating to energy conservation, and the DOE program has not added significantly to the state-of-the-art in the refining industry. Therefore, the program has not been received with anything approaching enthusiasm.

According to a DOE program official, the industrial process efficiency program has had no effect as yet on improving energy efficiency in the petroleum refining industry. In this official's opinion, industries such as petroleum refining and chemical are hesitant to become involved with

the Federal Government for fear their activities will become regulated. The official stated that DOE has had better success with some other industries under this program.

Given the relatively low level of funding for the program and the industry's apparent reluctance to involve itself with it, it appears that this program is not likely to have much of an impact on future refinery efficiency improvements.

Ten-percent investment tax credit

The Energy Tax Act of 1978 (P.L. 95-618) allows a 10-percent investment tax credit for specified industrial energy investments made during the period beginning on October 1, 1978, and ending on December 31, 1982. This credit is in addition to business investment tax credits already allowed under existing tax laws.

Basically, the 10-percent investment tax credit is intended to encourage industry to conserve energy and convert from oil and gas to alternative forms of energy.

Those investments eligible for the tax credit include

--alternative energy property and

--specifically defined energy property.

Alternative energy property includes boilers and other combustors which use coal or an alternative fuel, equipment to produce alternative fuels, pollution control equipment, equipment for handling and storage of alternative fuels, and geothermal equipment. Specifically defined energy property includes equipment to improve the heat efficiency of industrial processes, heat exchangers, and recuperators.

The tax credit may have some positive impact in encouraging the adoption of otherwise marginal conservation projects that could be completed quickly. However, most refiners we talked to believe that the credit will not have much impact on their investment decisions. First of all, the tax credit will only improve the rate of return by 1 or 2 percent. Secondly, the time frame during which the tax credit is allowed--slightly over 4 years--is not long enough to induce refiners to invest in new conservation projects unless the project can be completed within the 4-year span. Unfortunately, major projects in larger companies may require more than 4 years to complete. For example, 2 years may be required for approval by the board of directors, another 2

years for implementation and construction, and a final 18 months to 2 years for project completion and testing. Thus, projects being conceived now would not be completed in time to take advantage of the tax credit.

However, the new Windfall Profits Tax Act (P.L. 96-223) enacted on April 2, 1980, has extended the deadline to December 31, 1990, for certain projects normally requiring more than 2 years to construct. To be eligible for the extension, engineering studies must be completed and construction contracts entered into by January 1, 1983 and January 1, 1986, respectively. This extension should stimulate some additional conservation investments throughout industry.

REFINING INDUSTRY CONSERVATION EFFORTS

Many of the companies we visited have institutionalized their conservation activities within the company operations, either formally or informally, depending on company size. A small refiner generally has only one refinery, and the refinery manager or chief engineer tries, without large staff resources, to improve the refinery's efficiency. In contrast, the large company has well-organized programs staffed and coordinated at the corporate level.

The refining industry has substantially improved its efficiency of energy use and expects to continue to do so in the future. Estimates from the industry are that about $2 billion will be spent on conservation measures between 1972 and 1980. 13/

Through December 1978, DOE reported that the industry has improved its energy efficiency by 19.5 percent compared with 1972, and all the refiners we interviewed indicated that they had made efficiency improvements since 1972. Higher energy prices are the primary reason, and the rate of return refiners are realizing on conservation projects has been good. Future rates of return may be lower and require more capital-intensive investments since many of the low-cost, high-rate-of-return conservation opportunities have already been pursued. Further, financial and institutional constraints may act to offset future gains. However, the refiners we talked to were generally optimistic about their ability to continue making steady improvements. The huge oil price increases of 1979 should provide higher incentives.

Conservation project investment criteria

There are a number of factors refiners must take into account when deciding on conservation projects to fund. After environmental, safety and other regulatory requirements are met, cost effectiveness is the primary consideration. All projects are judged generally on their economic rate of return. Conservation projects are currently getting more attention because the cost of fuel has increased significantly, thereby making them better investments. Expenditures that were once considered only marginal are now profitable.

Proposed conservation projects must compete for available corporation dollars with other spending priorities. For some proposed expenditures, however, such as for pollution control and maintenance, the rate of return is almost irrelevant. These expenditures must be made if the refinery is to remain in business. Other investment decisions that might take priority over conservation measures include ordering additional equipment to meet changing supply and demand patterns, such as increased use of higher-sulfur crude oil and producing unleaded gasoline.

However, some refinery officials informed us that a factor which might help get conservation projects funded is their low risk, based on their surer payoff potential than other projects a refinery might undertake.

The refiners we visited were not willing to provide many details concerning their individual investment criteria. Some did, however, discuss the criteria with us. The smaller companies expected paybacks on energy projects in around 6 years or less, with most in the 2- to 3-year range. The larger companies could accept somewhat longer payback periods. The Gordian study indicates the minimum rate of return in the refining industry to be at least 15 percent, but states that most minimum rates were in the 20- to 30-percent range. 14/

The study also identifies several other factors refiners use to decide whether or not to implement an energy conservation measure. 15/ These factors include:

--Economic plant life. If the remaining economic life of a plant is short, it may not be economical to install energy-conserving equipment.

--Operating rate. The lower the operating rate of the refinery, the lower the rate of return on energy-conserving measures.

--Cost of retrofitting versus new capacity. Often it is more expensive to retrofit an energy-conserving measure into existing facilities than to build it into a new plant.

--Location. Regional variations in fuel, labor, or raw materials costs and availability can create varied economic incentives. Environmental regulations may also vary locally and affect decisions significantly.

Opportunities for improved efficiency

Many of the officials we interviewed believe that conservation opportunities in their companies would receive greater emphasis than at present for 1980 and beyond. None thought this emphasis would be reduced. Several indicated their companies expected refinery energy consumption per unit of input to decrease in the range of 1 to 5 percent annually.

The refiners anticipate that high energy prices will dictate continued attempts to improve the efficiency of energy use. Most of the improvements will have to come through capital investment, since most of the housekeeping and operating efficiency improvements will already have been achieved. When new facilities are built, particular efforts will be directed toward energy efficiency. Replacement facilities will also be more energy efficient than present equipment, much of which was designed when energy costs were much lower.

Refiners do not expect significant efficiency improvements or breakthroughs to come from any one area. However, based on information obtained from the refining companies, the highest level of emphasis on conservation projects will generally be in four categories, (1) process heater efficiency improvements, (2) steam system improvements, (3) heat exchange applications, and (4) waste heat recovery improvements.

Some of the improvements may come from processes and equipment that become available as technology advances are made. However significant opportunities for improvement

already exist using proven technology, as evidenced by estimates that (1) a new refinery could be as high as 30-percent more energy efficient than an existing refinery, and (2) retrofitting an existing refinery might improve its efficiency by as much as 20 percent.

Constraints to future efficiency increases

While the refiners we interviewed indicated they will continue to emphasize conservation opportunities, they also identified various constraints which they claim are causing them to use more energy than they would otherwise. The constraints generally fell into two categories--institutional and financial. The institutional constraints were the most frequently mentioned hindrance. While economics is the primary driving force behind conservation projects, the extent to which refiners implement future energy conservation efforts can be greatly influenced by Government activities and programs.

Institutional constraints of particular concern to most of the refiners involve some Federal programs designed for various purposes, both energy- and non-energy-related, which adversely affect refinery operations. Examples of such programs include some environmental control regulations, the coal-switching program, and small-refinery bias provisions.

For example, refiners in the West Coast area informed us that they have been unable to use preheaters on their process heaters and boilers to conserve energy. They stated that although an air preheater reduces fuel use, thereby reducing particulates and hydrocarbon emissions, it does increase nitrogen oxide emissions slightly. According to the refiners, with proposed Environmental Protection Agency (EPA) rules indicating a need for a 90-percent reduction in these emissions, it is not economically practicable to make the trade-offs required by EPA before increased emissions are permitted. Another problem is excess air control on boilers and heaters. If excess air is kept low for greater energy efficiency, there is a greater possibility of generating smoke. As a result, levels of excess air are kept high enough to preclude smoking.

Some refiners also stated that other environmental regulations, although not preventing energy conservation projects, are resulting in additional energy consumption by the industry. For example, the partial or total elimination of lead and manganese in gasoline reduces the quantity of

of gasoline that can be refined from a barrel of crude oil and directly increases energy usage through higher operating severity. Of course, not all environmental regulations have this negative effect. A carbon monoxide boiler creates additional energy for the refinery by burning the gas and thus preventing its release to the atmosphere.

DOE's coal-switching program drew criticism from some refiners. The program is intended to conserve oil and gas use by industry and electric utilities by forcing them to use coal or other alternate fuels in existing facilities or when new facilities are built. One refiner informed us that his company wished to replace an old natural-gas-fired facility with a new, more energy efficient natural-gas fired unit, but was not going to do so for fear of being forced by DOE to build a coal-fired unit instead. This point is discussed more fully in chapter 3.

DOE's small-refinery bias provisions were also mentioned by some refiners as an institutional constraint. DOE's crude oil entitlements program has a provision which favors small refiners with added entitlements. This provision encourages the operation of small refineries, which are generally less efficient than larger ones, and make little high octane gasoline. 16/ For example, 12 new refineries started operating in 1978, 11 of which had capacities of 12,000 B/D or less, and one had a capacity of 27,000 B/D. For 1979 DOE estimated that 15 new refineries will have started operating, 10 with capacities of 12,000 B/D or less and the other 5 with capacities between 12,000 and 50,000 B/D. 17/ However, in May 1979, DOE amended the small-refinery bias provisions to reduce the benefits possible under the provision. Thus, this provision may be less of a constraint to more efficient energy use in the future.

Financial constraints are often closely tied to the institutional constraints just discussed, as compliance with governmental requirements often costs the company money that might otherwise have been available for other purposes, including increases in efficiency.

Small refiners, in particular, may have difficulty financing capital intensive projects such as revamping crude units, installing carbon monoxide waste heat boilers, and installing flare gas recovery equipment. Some small refiners stated that if they could borrow the necessary capital at reasonable interest rates, they could initiate energy-saving conservation projects that otherwise would not be possible.

Increasing demands are being placed on limited capital funds throughout the industry, which potentially may limit funds available for improving efficiency. These demands come from both Government and market-place sources. Increased investment in pollution control facilities and unleaded gasoline production equipment are examples of Government-inspired capital investments. From a marketplace perspective, however, diminishing supplies of low-sulfur, light crude oil are forcing refiners to make major additions of desulfurization and residual upgrading facilities in order to process higher-sulfur, heavier crude oil.

NOTES

CHAPTER 2

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CHAPTER 3

OPPORTUNITIES FOR FUEL SUBSTITUTION IN REFINERIES

Refineries currently use a variety of fuels for their energy needs. Unfortunately, virtually all of the refining industry's internally generated energy (excluding purchased steam and electricity) comes from scarce fossil fuels--oil and natural gas. Only about one-tenth of 1 percent comes from coal, an abundant fossil fuel. As an example of the magnitude of the industry's reliance on scarce fossil fuels, over 4 percent of all the natural gas consumed in the United States in 1978 was burned by the refining industry.

Instead of using scarce fossil fuels to generate the process heat, steam, and electricity which refineries need, it is theoretically possible to use as substitutes coal, or synthetic fuels derived from coal. The refining industry has not employed these alternatives due mainly to economics, along with environmental constraints. However, a number of studies have shown that coal or synthetic fuels derived from coal could be substituted for some of the energy used by the industry. These studies also predict greater use of coal by the industry as oil and natural gas become more expensive and less available. Although economics may not currently justify the use of coal, a significant percentage of the energy used by refineries could eventually be derived from coal.

Federal programs designed to promote greater use of coal have had little impact on the refining industry. Federal programs and policies can, however, influence the future speed at which coal-burning technologies are adopted.

This chapter discusses the potential for

--direct use of coal by refineries and

--use of synthetic fuels derived from coal by refineries.

The chapter also discusses some of the major existing Federal programs designed to foster the use of alternative fuels in industry.

DIRECT USE OF COAL

Current use of coal in refineries is miniscule. In the early 1900s, many oil refining units were coal-fired. Compared to the refining units of today, however, these units were small, costly, and inefficient. By the end of World War II, coal-fired units for economic reasons had been largely replaced by units using natural gas and petroleum products.

Today coal is used in only three States (Pennsylvania, Ohio, and West Virginia), generally by small refiners located near local sources of coal. We interviewed two small refiners that used coal. Both refiners' use of coal was for steam generation in boilers, and they are able to burn coal economically because of their location.

Direct use of coal by the refining industry in the future may increase, although there are a number of factors that will limit its use. The main limiting factor today is that current coal-burning technology can be applied only to boiler applications--only 25 percent of the industry's energy needs. Process heaters--65 percent of the industry's energy needs--that burn coal are not yet practicable. In recent years there have been some papers and articles prepared discussing the feasibility of using coal in process heaters. 1/ However, the industry believes that further research, engineering, and testing are needed before coal is used for process heat applications. 2/

Federal coal-switching program

DOE's Office of Fuels Conversion is responsible for managing coal-switching activities. Its main objective is to reduce projected use of oil and natural gas in the industrial sector. This program has had little positive impact on the refining industry, and may temporarily be hampering some refiners' conservation efforts. Its future impact on the industry is uncertain.

Several laws affecting this program include

--the Energy Supply and Environmental Coordination Act (ESECA) of 1974 (P.L. 93-319),

--the Energy Policy and Conservation Act of 1975, and

--the Powerplant and Industrial Fuel Use Act of 1978 (P.L. 95-620).

Section 2 of ESECA states that a prohibition order may be issued to prevent any existing major fuel-burning installation--a stationary unit consisting of a boiler, gas turbine unit, combined cycle unit, or internal combustion engine--from burning natural gas or petroleum products as its primary energy source. In doing so, DOE must first determine that the facility has the necessary equipment to burn coal, that coal supplies are available, and that it is economically and environmentally feasible to burn coal.

According to a DOE official, only one prohibition order has been issued to a refiner. However, the order is not yet final, and the refiner is contesting the order because the refiner claims that the boilers in question, which at one time did burn coal, had been extensively modified and could no longer burn coal.

Section 101 of EPCA provides that DOE may issue a construction order requiring any new major fuel-burning installation to be built with the capability of burning coal. DOE has not issued any construction orders to petroleum refineries.

The Fuel Use Act modified and expanded the coal-switching program in several ways, such as:

--Facilities can use not only coal but also alternate fuels when prohibited from burning oil or natural gas, whereas under ESECA only coal or coal derivatives were covered.

--New, large facilities are automatically prohibited from burning oil and gas unless they can demonstrate to DOE that an exemption is justified, whereas previously DOE, in issuing construction orders, had to justify the use of coal on a case-by-case basis.

--The criteria for obtaining exemptions have been tightened. For example, firms can receive an exemption on economic grounds if the cost of burning an alternative fuel "substantially exceeds" (by 30 percent or more as interpreted by DOE) the cost of burning imported oil.

Those firms seeking an exemption must file a Fuels Decision Report explaining why no alternate fuel can be substituted for natural gas or petroleum. Also, they must generally demonstrate that available and potential alternate fuels have been examined before DOE approves an exemption.

Some of the refiners we interviewed felt that the coal-switching program could hamper efforts to improve refinery efficiency. One refiner stated that his company would like to replace some small boilers with one larger, more efficient boiler, but would not now do so for fear DOE would make them burn coal. Another refiner wants to install a waste heat boiler as a conservation measure, with minimal amounts of fuel oil burned for flame stabilization, but would abandon the project if ordered to burn coal because of the higher costs associated with coal firing.

One refiner is adopting a wait-and-see attitude about how strictly DOE would apply the provisions of the Fuel Use Act. The refiner would like to replace some old, inefficient gas turbines but will first allow some other larger refiners to test DOE's exemption process.

To date the coal-switching program has not achieved any oil and gas savings in the refining industry. Whether or not the program, as revised by the Fuel Use Act, will have a greater impact on the industry in the future depends on several factors. The first factor is how strictly DOE will administer the program. DOE has been meeting with several refiners desiring to construct new facilities fueled by refinery waste products. DOE has to decide whether these waste products are in fact unmarketable, which would qualify them as alternative fuels. Secondly, the future success of the coal-switching program depends on whether the industry ultimately commits itself to greater coal use. It is apparent that the industry will not voluntarily switch to coal as long as it considers oil and gas more desirable to use, economically and operationally.

Limitations on the direct use of coal

Some refinery officials we talked to strongly opposed the direct use of coal in refineries, and those refiners currently not using coal had no plans, at least through 1985, for using coal.

The direct use of coal is constrained by a number of factors. The most important such factor is that coal technology is currently used only in boiler applications, and the refining industry only uses boilers for about 25 percent of its energy needs. However, even when only examining refinery boilers, there will be significant constraints, falling into three general categories:

--Environmental limitations.

--Physical limitations.

--Economic limitations.

Environmental limitations

A major environmental impediment to existing refineries' installing coal-burning equipment is the nonattainment provision of the Clean Air Act, as amended (42 U.S.C. 7501, et seq.). The act precludes construction or expansion of any facility that emits a pollutant in a nonattainment area--a region where air quality standards have not been met for one or more pollutants--unless an offset is found for the new source of pollution. Over 80 percent of domestic refining capacity is in nonattainment areas. 3/ Under the current offset provision, if a company is allowed to construct or expand a refinery in a nonattainment area, it has to more than offset the new pollutants by reducing the emissions from either its own facilities in the area or possibly those of other companies.

According to one refiner we interviewed, environmental regulations have also resulted in refineries that once burned coal switching back to using oil. This refiner has three refineries, one of which is located in a coal field and was built to burn coal. The refiner stated that environmental regulations forced the refinery to switch to burning oil, and that the company could save $500,000 a year in fuel costs if it could switch back to coal.

Physical limitations

Physical limitations concerning the direct burning of coal by refineries center on two major areas, coal handling and preparation, and retrofitting equipment to burn coal. Refineries need space for coal handling, storing, and preparation. The needed space should be located either next to or near the refinery boilers. Refineries having limited

space and seeking to replace an oil- or gas-fired boiler with a new coal-fired boiler would find that the additional space required may not be available.

The other physical limitation is the extent to which refinery equipment can be modified to burn coal. All boilers are technically capable of burning coal. However, the equipment in almost all domestic refineries was designed and constructed to use either natural gas or some form of petroleum product. To burn coal, the firebox design may require the derating of the boiler, meaning that boiler capacity is reduced. Modifying the refinery equipment to burn coal could end up being so expensive that replacement would probably be cheaper. One report discussed boiler retrofit costs in general, and concluded that no accurate costs for retrofitting could be presented since each retrofit application should be considered on a case-by-case basis. 4/ Individual characteristics of the boiler type and design, and support equipment accessibility have to be taken into account.

Economic limitations

The economic limitations on greater coal use relate to the costs of coal-fired boilers compared to gas- and oil-fired boilers. Some refiners stated that refinery fuel now accounts for a greater percentage of operating costs than any other component. However, while coal is cheaper than oil on a Btu basis, coal is not necessarily a cheap fuel when transportation, coal handling, and pollution control charges are included.

The higher initial costs for coal-fired boilers also act as a deterrent, especially for smaller refiners having less access to capital, even though subsequent annual fuel savings may make the coal boiler ultimately more economical. The following estimates obtained from DOE compare the costs (1978 dollars) of conventional coal- and oil-fired boilers of the same size.

Comparative Costs of Conventional Coal- and Oil-Fired Boilers

Boiler size	Coal-fired	Oil-fired
100 million Btu's/hr.	$ 4.1 million	$0.67 million
500 million Btu's/hr.	18.7 million	5.9 million

One refiner invested about $1.3 million for two replacement boilers fueled by refinery waste gas, with residual oil (in

that geographical area, an unmarketable waste product) as a standby. This company rejected spending more than $33 million to buy and build auxiliary coal facilities. Another refiner, in 1976, considered switching to coal as boiler fuel and selling its natural gas on the open market, but did not because an economic analysis showed it to be only "marginally profitable." Two years later, the feasibility of this project was updated, and showed that it would have had a negative rate of return because the spread in the cost per Btu of coal versus natural gas had since narrowed. In hindsight, this company concluded it was a good thing it has not switched to coal.

Further limiting the potential for coal-fired boilers is the fact that most refineries do not need to purchase boiler fuel because they are self-sufficient (using internally generated refinery gas and petroleum coke since the market for these products is limited). Also, many refineries are using less and less steam from boilers as their energy conservation projects show results, and as steam drivers are replaced with more efficient electric motors.

Another reason for the limited potential of using coal as a boiler fuel in refineries is that not all boilers use fuel of any sort. "Waste heat" boilers extract heat from the hot refined products, which is then used to generate steam. Some refineries have functioned for years generating steam in this manner having no direct-fired boilers.

Potential for greater direct use of coal

Given the problems inherent in retrofitting existing refinery boilers to burn coal, any increased direct burning of coal is likely to come from boiler replacements and refinery expansions.

To determine how many refinery boilers need replacement, we examined data collected several years ago by DOE in a one-time survey of all industrial boilers or burners with capacities of over 99 million Btu's per hour. We determined that in 1974 there were 441 boilers in the refining industry burning oil or natural gas. Of these, 153 boilers, or more than one-third, were installed prior to 1949--currently over 30 years old and thus candidates for replacement. If all of these boilers were to be replaced with coal-fired boilers, the equivalent of almost 86,000 B/D of fuel oil would be saved (based on 1974 consumption data). Of course, not all

of these boilers, when replaced, will be replaced with coal-fired units for the reasons previously discussed.

Increased use of coal is most likely to occur in new boiler expansions or new refinery construction where initial design efforts can incorporate advanced technological improvements, and problems encountered through retrofitting and replacement can be abated. DOE is currently working on alternative boiler processes showing potential for improvement over conventional coal-fired boilers with stack gas scrubbers. According to DOE, coal-fired fluidized-bed boilers 5/ may be more attractive for commercial use than conventional coal-fired boilers.

Fluidized-bed boilers can burn a variety of coals with sulfur dioxide and nitrogen oxide emissions well within EPA standards. Since emission control is centered in the combustion zone, expensive and energy-consuming stack gas scrubbers are not required. Above all, capital costs of such units are estimated to be 10 to 20 percent lower than those of conventional coal-fired boilers. 6/ Industrial applications are being investigated using atmospheric fluidized-bed boilers.

USE OF SYNTHETIC FUELS DERIVED FROM COAL

Synthetic gas produced from coal offers an alternative potentially more attractive than direct burning of coal as a means of conserving the use of oil and natural gas as refinery fuels. One study estimated that this gas could supply as much as 25 percent of refinery energy needs in certain parts of the country, by the year 2000. 7/ The attractiveness of synthetic coal gas results from the following factors:

---Coal gas can be used to fuel refinery process heaters (65 percent of the industry's fuel requirements), whereas direct burning of coal is currently limited to boiler applications (25 percent of the industry's energy needs).

--Nearly 70 percent of the industry's energy needs are met by gases (both refinery and natural gas). Thus, a substitute fuel source that also is a gas would be desirable.

--Existing refinery equipment can be retrofitted, with minimal problems, to burn coal gas.

The main factor currently working against adoption of coal gas is its cost. It is still cheaper for refiners to burn oil and gas. However, the attractiveness of coal gasification technologies should increase in the future if oil and natural gas prices continue to rise.

Synthetic fuels derived from coal on a commercial basis were first used in the United States in the early 1920s and 1930s when approximately 11,000 coal gasification units were in operation in the United States, converting about 15 million tons of coal per year into low-Btu gas. 8/

With the advent of inexpensive natural gas in the late 1940s and early 1950s, the coal gasification industry was largely replaced because it was no longer economically competitive. Currently, there are only a few small commercial coal gasifier plants operating in the United States. There are, however, numerous operating gasifiers in other countries.

Current efforts to convert coal to synthetic fuel focus on three major areas: (1) synthetic natural gas, (2) synthetic low- and medium-Btu gas, and (3) synthetic liquid fuel. As a substitute source of energy in the petroleum refining industry, the three areas have possible applications. However, low- and medium-Btu gas is considered to be a more viable alternative energy source for refinery use. While both synthetic natural gas and synthetic liquid fuels from coal are interchangeable with natural gas and petroleum, and could be used as refinery fuels, low- and medium-Btu gas is a lower cost alternative that has limited applications, but would be acceptable for refinery use. On an equivalent-Btu basis, the capital and operating costs are significantly lower for conversion of coal to a low- or medium-Btu fuel gas than for conversion to pipeline quality, high-Btu gas.

Synthetic low-Btu gas, which has a heating value of 120 to 200 Btu's per cubic foot (compared with a value of about 1,000 Btu's for natural gas), is usually produced by reacting air and steam with coal. The reaction consists of the partial combustion of the coal and produces a gas composed of carbon dioxide, carbon monoxide, hydrogen, and approximately 50 percent nitrogen. Synthetic medium-Btu gas, which has a heating value of from 250 to 350 Btu's per cubic foot, is produced by substituting oxygen for the air in the gasification process. The substitution has the effect of reducing the nitrogen to about 1 or 2 percent and doubling the heating value of the gas.

Federal low- and medium-Btu coal gasification programs

DOE has several programs aimed at examining industrial and utility use of low- and medium-Btu gas. DOE divides the programs into three separate areas:

--Research and development.

--Demonstration.

--Commercial application.

To date, these programs have had limited involvement with the refining industry.

Research and development

The objectives of DOE's low- and medium-Btu coal gasification research and development activities are to

--develop new gasification processes,

--insure that technological advances are made available to industry,

--generate confidence necessary for industry acceptance of a new technology, and

--develop environmentally acceptable emission clean-up systems.

According to a DOE official, the refining industry has shown more interest in coal liquefaction technologies since coal liquids could be used as refinery feedstocks to replace crude oil. However, DOE has sponsored two major studies that analyzed the potential for using low- and medium-Btu coal gas by industry, including petroleum refining. One study, entitled "Market Opportunities for Low- and Intermediate-Btu Gas from Coal in Selected Areas of Industrial Concentration," concluded that coal gas could supply as much as 25 percent of a refinery's energy needs by the year 2000 in selected areas of the United States, assuming competitive cost. 9/ The other study, entitled "Low Btu Gas-Industrial Application Analysis," concluded that 89 percent of the refining industry's energy consumption for direct heat and steam can technically be replaced by low-Btu gas. 10/ Also, this study indicated that the refining industry constituted about 21 percent of the identified industrial potential for low-Btu gas.

Demonstration

The major objective of DOE's low- and medium-Btu coal gasification demonstration activity is to demonstrate the technical and economic feasibility of replacing natural gas and oil with coal gas in large-scale industrial and utility applications. So far, DOE has not directly involved the refining industry in any demonstration projects. According to a DOE official, all industrial and utility groups were afforded the opportunity to bid for a contract when DOE advertised a request for proposal in 1976 for generation of low- and medium-Btu gas, but nobody from the refining industry responded.

Currently, DOE is funding two medium-Btu coal gas demonstration projects, one of which has a potential refinery application. The project, sponsored by Memphis Power, Light, Gas, and Water Company, is to have Delta Refining Company, (one of the subcontractors) operating the plant which will furnish coal gas for a planned industrial park. However, Delta has not indicated whether it will be a definite user of this gas.

For fiscal years 1980 and 1981, DOE requested no money from the Congress for its low- and medium-Btu coal gasification demonstration activities. According to DOE officials, prior year appropriations are sufficient to carry its activities through fiscal year 1980, but no definite decisions have been made to continue funding beyond 1980.

Commercial applications

DOE's Resource Applications Division is responsible for low- and medium-Btu coal gasification commercialization activities. The objective of this program is to stimulate industry's interest in using gasification technologies. The main activity by DOE to achieve the objective has been to sponsor studies concerning coal gasification applications.

One 1979 study funded by DOE discussed refinery usage of low- and medium-Btu gas as part of an overall analysis of industrial markets for low- and medium-Btu coal gasification. 11/ The study concluded that medium-Btu gas is feasible for use in the industry because (1) refineries are designed for varying fuel qualities, and (2) the industry has the ability to achieve economic utilization of the gasifier. Further, the study indicated that those States likely to be the sites of future gasifiers, because of their proximity to

coal sources, are also the sites of a number of existing refineries. However, the study predicted that the refining industry is not likely to be an early adopter of gasification technologies mainly because of their reliance on by-product fuels from the refining processes.

For fiscal year 1980, DOE is funding eight separate studies which will explore site-specific low- and medium-Btu gas industrial applications. DOE will make the results of the studies available to industries considering using coal gas.

Two of the eight studies will deal with potential refinery applications of low- and medium-Btu gas. In one study the feasibility of a gasification plant supplying medium-Btu gas made from coal and petroleum coke to a nearby refinery and electric utility will be explored. The second study will examine the feasibility of blending medium-Btu gas with excess refinery gas from a refinery and supplying it to a second refinery.

Up until now Federal commercialization activities have been limited to the funding of studies. Proposed and recently enacted legislation may change this role, however. The administration's proposed Synthetic Fuel Corporation (S.932) is designed to provide financial assistance for developing alternative fuels. Although the Corporation has not yet been created, the fiscal year 1980 interior appropriation bill (P.L. 96-126) already provides $2.2 billion for purchase commitments, price guarantees, feasibility studies, and cost-sharing arrangements with industry, all to spur the commercialization of alternate fuels, including gases made from coal. DOE already solicited proposals for feasibility studies and cooperative agreements from industry in February and intends to issue other proposals such as loan guarantees and price purchase supports in May or June. If an industry wants to build a low- or medium-Btu coal gas commercial plant, it may soon be able to receive direct financial incentives from the Federal Government.

Coal gasification commercialization prospects

More widespread adoption of coal gasification technologies by industry is expected during the 1980s. One study predicted that, with no additional Federal initiatives, industry's interest in gasification technologies should increase moderately, and that by 1985 there might be 10 to 20 low-Btu plants and 2 to 3 medium-Btu gasification plants in or near operation. 12/

While there are a number of existing proven gasification technologies available, as evidenced by plants operating both in the United States and in other countries, the overall technology is not yet considered to be commercially viable on a wide scale in this country. There are several gasifiers currently in commercial operation in the United States. However, in most cases the companies using the technology had histories of natural gas interruptions and thus were motivated by a desire for fuel security rather than the economics of the gasification processes. 13/

The major constraint to increased commercial coal gasification activity is economic, although there are also some technical and environmental problems to be overcome.

Major economic factors influencing commercialization are

--total investment capital required,

--price competitiveness of the product produced, and

--investment risk associated with a new industry.

Coal gasification technologies are very capital intensive. Estimates of the capital costs required to build and operate a coal gasification plant vary greatly depending on size of plant, type of coal, product required, and pollution control equipment needed. A 1979 coal gasification study disclosed a wide range of projected total capital costs ranging from a low of $1.7 million for a plant producing 1.3 billion Btu's a day of low-Btu gas to a high of $573 million for a plant producing 140 billion Btu's a day of medium-Btu gas. 14/ The study produced fuel cost estimates that also varied widely. Fuel costs per million Btu's ranged from $2.70 to $9.33, with most likely "base case" estimates ranging from $3.53 to $6.28. These wide ranges of estimated costs tend to increase the risk that is always associated with the introduction of a new unproven product that must compete with proven products--in this case, oil and natural gas.

The technical constraints associated with the commercialization of coal gasification technologies are more mechanical than theoretical in nature, and include the following.

--Upgrading and improving known gasification processes.

---Matching and integrating existing coal preparation techniques and equipment with coal gasification equipment in a commercial plant.

---Locating sufficient coal and water resources.

---Developing facilities for manufacturing and fabricating coal gasification vessels, equipment, and materials.

None of these are insurmountable problems, by themselves, but the rate at which they are solved can affect the rate of commercialization.

The environmental impact of gasification plants varies from process to process but there appear to be measurable advantages over direct coal firing. First, gasification plants emit essentially no particulates from the stack. Second, plants can be tailored or modified to meet almost any level of sulfur emission contemplated. Lastly, nitrogen oxide emissions are eliminated or drastically reduced with many processes. For direct coal firing, plant modifications are not easy and changes in environmental levels, such as the degree of sulfur removal, could force plant operations to shut down temporarily.

Privately financed coal gasification effort

While much of the coal gasification development activity in the country is being conducted with Federal assistance, there is one totally private venture currently being explored which is worth discussing because of possible application to the refining industry.

Exxon Company USA, a division of Exxon Corporation is considering building a coal gasification plant atop a coal field near Troup, Texas. The plant would convert East Texas lignite into a medium-Btu gas (400 Btu's per cubic foot). The gas would then be pipelined about 200 miles to the Texas Gulf Coast, sold to industrial users, and would be used as a petrochemical feedstock and premium industrial fuel to displace natural gas. Currently, Exxon is starting design work and anticipates to begin permitting activities soon. If built, operations would begin in the late 1980s. This coal gas could displace natural gas used by the refining industry in the Texas Gulf Coast area, which contains close to 20 percent of the country's total refining capacity.

The size of this venture is enormous. The capital investment would exceed $2 billion, and would be entirely privately financed. Company officials did not know what the coal gas would sell for but believed that as natural gas prices rise, coal gas looks more and more attractive.

This venture would use proven technology. Thus, technological feasibility of the gasification process is not a potential impediment.

Company officials stated that several environmental issues remained to be resolved: gas treating, sulfur recovery, waste water disposal, utilization of coal particles too fine to be used in the gasification process, and compliance with the Clean Air Act.

Thus, it is possible that coal gas could replace some natural gas by the late 1980s in Texas Gulf Coast refineries, if the price of the coal gas is competitive.

Coal gasification applications in refineries

From a technical standpoint, coal gasification technologies, especially those producing medium-Btu gas, could be adopted by the refining industry with few problems. The major factor that will limit the contribution coal gas can make, however, is the industry's expected continued reliance on refinery by-products as fuel sources.

Although most industries are a potential market for synthetic gas from coal, three key industries constitute the most potential: petroleum refining, basic steel production, and chemical manufacturing. These industries are large users of energy and need a continuous supply of energy as would be produced by a coal gasification process. 15/

The SRI International report on market opportunities for coal gas estimated the potential contribution of coal gas in five metropolitan areas for these three industries. The report concluded that medium-Btu gas could account for as much as 25 percent of a refinery's energy needs by the year 2000 in several localities, including the Texas Gulf Coast, Philadelphia, St. Louis, and Chicago. Nationwide, the study projected that about 9 percent of the refining industry's total energy needs in the year 2000 could be met by coal gas, amounting to savings equivalent to about 200,000 B/D of crude oil. 16/

The information presented is based on a few important assumptions. First, the study assumes that the refinery gas contribution will continue to be significant. Second, petroleum coke should continue its contribution unchanged, and third, natural gas utilization will decline to a minimum of 5 percent. These assumptions suggest that the most potential for coal gas exists in refineries presently operating on large amounts of natural gas or refinery liquids. The most important assumption made by the study, however, is that the price of coal gas will be competitive with other refinery fuels.

The study did not discuss in detail the economics of coal gasification, but did make several observations. The study indicated that the most likely fuel to be displaced by coal gas in the 1980s would be residual fuel oil. By that time, the study indicated that natural gas supply problems and use restrictions will probably have forced most refineries along the Gulf Coast to curtail natural gas use. The study also estimated that the price of coal gas could be 10-15 percent above the price of the marginal fuel--residual oil--and still be competitive. A gaseous fuel is worthy of a pricing premium because of superior flame patterns, enhanced process control, and reduced maintenance expense and "down" time compared to a liquid fuel.

There are a number of technical advantages that favor the selection of medium-Btu gas over low-Btu gas in refinery applications. The fuel characteristics of medium-Btu gas provide a closer approximation to refinery gas quality than low-Btu gas. Also, the combustion air requirements and the flue gas volumes generated by medium-Btu gas are the same magnitude as those for natural gas, meaning that no heater or boiler derating would be necessary and retrofit problems would be minimal. With low-Btu gas, derating might be necessary and retrofit would be more extensive.

In addition to the comparative ease of facility retrofit, distribution economics and scale considerations also tend to favor medium-Btu gas. Pipeline transportation of low-Btu gas is not economical for distances beyond 1 mile, while medium-Btu gas may be economically piped distances up to 150 miles. Economies of scale can be realized through constructing larger size medium-Btu gas plants, thus lowering the cost per Btu produced. Low-Btu gas may be preferred, however, in site-specific conditions or areas where a small-scale application will meet the user's needs.

For optimal economies of scale, it will probably be necessary for a medium-Btu gasification plant to serve more than one refinery or other industrial user, as the proposed Exxon facility would do. Such arrangements would generally serve the refining industry well, since logistically the industry generally consists of several refineries located near other energy-intensive industries.

Constraints to use of synthetic fuels from coal

Continued reliance by the refining industry on by-products, such as refinery gas, for fuel will limit the contribution coal gas can make. Refinery gas commonly accounts for one-third to one-half of a refinery's fuel requirements.

Most of the refiners we interviewed expect their reliance on refinery gas to increase through 1985 since production of unleaded gasoline will be increasing, and refinery gas is a by-product of the current processes used to make unleaded gasoline. While it certainly makes sense for refiners to use, as energy sources, by-products that otherwise might have little value, refinery gas is not an entirely free source of energy. One refiner informed us that he is using less natural gas now because of increased production of refinery gas during the making of unleaded gasoline. However, his yield of gasoline has dropped since more crude oil is needed to make unleaded gasoline than an equivalent amount of leaded gasoline. Continued crude oil price increases may make it profitable to process refinery gas into saleable products or devise processes that produce less refinery gas. In the short run, however, refinery gas will continue to be burned as a refinery fuel and thus will limit the marketability of coal gas.

Refining industry's comments

Petroleum refiners we talked to have no plans to adopt coal gasification technologies for fueling their refineries, but appear to favor coal gasification over the direct burning of coal. Many of the refiners interviewed agreed that a gasification facility producing low- or medium-Btu gas could be used to displace natural gas and/or fuel oil in refineries. When asked how they would use coal, assuming economic competitiveness and capital availability, most of the refiners generally felt coal gasification would be preferred to direct combustion largely because of its favorable environmental characteristics. Small and large refiners alike favored the

idea of a vendor furnishing medium-Btu gas to the refinery similar to natural gas service. This generally favorable attitude contrasted sharply to the generally unfavorable response toward the direct burning of coal, even in boilers.

The most frequently cited barrier to using coal gas is its uncertain competitive status with other fuels. There is no incentive to switch to coal if natural gas and oil prices remain cheaper. One report found that industrial fuel consumers seldom acknowledged a willingness to pay more for coal-based energy than for oil and natural gas. 17/ Further, even if no cost disparity existed, conventional energy sources, especially natural gas because of its ideal burning characteristics, would still be preferred.

Several companies indicated that they could operate on little or no natural gas if forced to do so, and that residual fuel oil would be used if natural gas were not available. These statements support the conclusion reached by one study about residual fuel becoming the marginal fuel, and have an important bearing on the interfuel economics between oil and natural gas, and coal gas. It appears that the price of coal gas may be insensitive to natural gas prices since this will not be the standard of economic comparison against which coal gas will be measured. Rather, the marketability of coal gas may be sensitive to the price of residual fuel oil because this energy source may provide the standard of economic comparison in the future.

NOTES

CHAPTER 3

1/Foster Wheeler Energy Corporation, "Coal as a Process Fuel," presentation before National Petroleum Refiners Association annual meeting, San Antonio, Texas, Mar. 19-21, 1978.

Exxon Research and Engineering Co., "Coal Fired Fluidized Bed Process Heater Studies," presentation before American Petroleum Institute Refining Dept., midyear meeting, Toronto, Canada, May 8-11, 1978.

2/American Petroleum Institute, testimony before Senate Committee on Energy and Natural Resources on S.977, coal switching legislation, Apr. 5, 1977.

3/U.S. General Accounting Office, "U.S. Refining Capacity: How Much is Enough?" EMD-78-77 (Washington: U.S. General Accounting Office), 1979, p. 22.

4/SRI International for U.S. Department of Energy, Market Opportunities for Low-and-Intermediate Btu Gas from Coal in Selected Areas of Industrial Concentration (Washington: U.S. Department of Energy, 1978), p. 194.

5/GAO recently issued a report critical of DOE's atmospheric fluidized-bed combustion demonstration program, recommending that DOE demonstrate the technology for industry and utilities faster than planned: U.S. General Accounting Office, "How to Burn Coal Efficiently and Economically and Meet Air Pollution Regulations--The Fluidized-Bed Combustion Process," EMD-80-12 (Washington: U.S. General Accounting Office, 1979).

6/SRI International, for U.S. Department of Energy, op. cit., p. 193.

7/Ibid., p. 87.

8/Dravo Corp., Economic Advantages and Areas of Application of Small Gasifiers (Pittsburgh: Dravo Corp., 1978), p. 1.

9/SRI International for U.S. Department of Energy, op. cit., p. 87.

10/Systems Consultants, Inc., for U.S. Department of Energy, Low Btu Gas Industrial Application Analysis (Washington: U.S. Department of Energy, 1979). pp. 15 and 26.

11/Booz, Allen and Hamilton, Inc., for U.S. Department of Energy, Analysis of Industrial Markets for Low and Medium Btu Coal Gasification (Washington: U.S. Department of Energy, 1979).

12/Ibid., p. 1.

13/Ibid., p. IV-6.

14/Ibid., pp. III-11 to 14.

15/SRI International, for U.S. Department of Energy, op. cit., pp. 10-12.

16/Ibid., pp. 12, 79, 86.

17/Ibid., p. 13.

CHAPTER 4

THE FEDERAL ROLE IN HELPING ACHIEVE GREATER ENERGY SAVINGS IN REFINERIES

What should be the Federal role in assisting the refining industry in becoming both more energy efficient and more committed to the use of coal? This question receives a wide range of responses depending on the attitudes and background of those answering the question. This chapter contains some views of the refiners we interviewed on what the Federal role should be, along with a discussion of various other options available. Unfortunately, we could not identify options available that will (1) result in immediate significant energy savings and (2) not have economic and political consequences. All of the options available to the Government will be opposed by one group or another.

INCREASING ENERGY EFFICIENCY

We received a variety of responses from refiners with no one answer predominating on the question of what the Government could do to enable them to become more energy efficient. Predictably, however, the general consensus was for the Government to reduce its interference with refining industry operations.

Specific actions would include

--decontrol of domestic petroleum prices,

--relaxation of some overly strict environmental standards,

--speeding up the permit processes for construction of new projects, and

--better coordination between agencies and departments currently organized around a single objective (e.g., DOE and EPA) to eliminate conflicting regulations and policies.

Current Federal energy policies of moving toward eventual decontrol of oil and natural gas prices, while resulting in higher energy costs for the Nation, should result in the industry undertaking additional projects to improve efficiency.

Many of the refiners felt that if, after decontrol is accomplished, it is deemed desirable to provide further incentives, consideration then could be given to providing special investment tax credits and accelerated depreciation for energy conservation projects to encourage and expedite their implementation.

Some larger refining companies also felt that the entitlements program with its small-refinery bias provision should be ended, since it encourages construction and operation of small and less energy-efficient refineries.

The refiners believed that the additional 10-percent investment tax credit will not have a large impact on energy conservation efforts. Some refiners indicated that it could have some influence on marginal projects.

Views of some small refiners differed somewhat from those of the larger companies. Some small refiners showed interest in the opportunity to receive low-interest loans for energy conservation projects. They also felt that information on potential energy projects which have been identified or implemented by other refiners should be made available. The idea of DOE publishing facts on various energy-saving projects implemented by petroleum companies was well received. It was suggested that this publication could be in the form of a newsletter or a quarterly report. One small refiner felt DOE could provide some help in aiding small refiners, who could benefit substantially from having an independent consultant evaluate their refinery operations. There may be potential conservation projects overlooked by the small refiners because of inadequate in-house technical capability.

In the past, there have been proposals to use higher energy prices to encourage conservation, but targeting the price increases only at industry. The President's 1977 National Energy Plan proposed a tax on industrial and electric utility use of oil and natural gas. Such a proposal not only would encourage industry and utilities to use oil and natural gas more efficiently, but might also result in some companies switching to lower cost, nontaxed energy sources--coal and renewable resources. The Congress failed to enact the tax into law.

An option for increasing refinery efficiency without directly raising energy prices would be to set industrial performance efficiency improvement goals by making the existing voluntary industrial conservation reporting program mandatory. A criticism of the voluntary program is that

there are no penalties if the industry efficiency improvement targets are not reached, and that the companies are not undertaking any more conservation projects than they would have without the program. A mandatory program could free conservation projects from having to compete against other corporate investment priorities for funding.

In a previous comprehensive report 1/ that examined Federal energy conservation programs affecting all sectors of the economy, we also concluded that DOE's voluntary industrial conservation reporting program had resulted in little additional energy savings. We recommended that DOE, after considering the views of industry, implement a revised program to extend beyond 1980 which includes

--development of a set of energy conservation goals that reflect levels of energy conservation achievement for each industry within a specified time frame,

--establishment of an energy conservation goal for each industry along with incentives, if necessary, to allow each industry to achieve its goal,

--development of an adequate measure of each industry's progress in achieving established goals,

--establishment of specific milestones to assess each industry's progress toward the goals, and

--development of standby authorities to implement if milestones are not being met.

Our examination of the refining industry has revealed that such a program, containing incentives and standby authority to set mandatory standards, could be made to work but might be difficult to administer. Whereas the voluntary reporting program established one efficiency improvement target for the entire industry, a mandatory program would probably need to establish an individual standard for each refiner. The setting of individual company efficiency improvement standards, even if only for the top 10 or 20 companies, would be difficult since no two refineries are alike, and energy usage varies greatly among refineries. One possible way around this problem might be to (1) set improvement standards for groups of refineries of similar complexity, age, or size, or (2) establish efficiency standards for major energy-consuming equipment used by refineries.

INCREASING USE OF COAL

The role of the Federal Government to date in promoting increased use of coal in industry has been to both allow domestic oil and natural gas price increases and to subsidize coal use, thus making coal more attractive; to prohibit by regulation the use of oil and natural gas through DOE's coal-switching program; and to promote improved coal utilization technologies through coal research, development, demonstration, and commercialization activities. The refining industry's position on use of coal has generally been that refiners should decide when and if they should convert to coal rather than have the Government make the decision for them.

Government policy can influence the interfuel economics of competing energy sources. Removing oil and natural gas price controls, in addition to encouraging more efficient refinery fuel use, will make direct burning of coal and use of coal gas more attractive. Imposition of oil and gas user taxes, or more rapid removal of oil and gas price controls, would further increase the cost of these fuels and make coal look even better. Such actions could expedite acceptance of coal use into this industry, but to what degree is still conjecture at this time.

The provisions in the Energy Tax Act that allow an additional 10-percent investment tax credit on alternate energy property and permit a depreciation allowance for early retirement of oil- and gas-fired boilers provide some financial stimulus for converting to coal. However, most refiners felt these were insufficient to compensate for the increased capital outlay requirements and technological risks associated with coal use. In addition, these incentives would not alter significantly the interfuel economics, which must change if direct coal firing and/or coal gas are to become competitive energy sources.

DOE's coal-switching program is a regulatory program designed to stimulate use of coal, coal-derived products and other new energy technologies in industry by prohibiting the use of petroleum or natural gas. To date, this regulatory approach toward fuel switching has not been very successful in the refining industry. While the Fuel Use Act strengthened the program, it is questionable how much impact the program will have. The exemption provisions still allow companies to continue burning oil and natural gas. All the refiners we interviewed not currently using coal had no plans to voluntarily switch to coal.

DOE's coal gasification research, development, demonstration, and commercialization activities have examined the use of coal gas in various industrial applications. While the refining industry possesses favorable technical attributes for using coal gas, DOE has not emphasized refinery applications because the industry itself has not shown much interest in using coal gas.

The proposed Synthetic Fuel Corporation could significantly change the Federal Government's role in commercializing alternative energy technologies, including coal gasification. Instead of just funding commercialization studies, the Energy Security Corporation will be in a position to provide direct financial incentives. The Corporation could play a major role in helping gain industry's acceptance of coal gasification technologies.

NOTES

CHAPTER 4

1/U.S. General Accounting Office, "The Federal Government Should Establish and Meet Energy Conservation Goals," EMD-78-38 (Washington: U.S. General Accounting Office, 1978).

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

The refining industry has been steadily taking measures over the years to improve its efficiency of energy use. The refiners we interviewed expect efficiency improvements to continue throughout the foreseeable future due to high energy prices, but Federal energy conservation policies and programs can speed up or hinder the pace at which these improvements are made.

Opportunities exist for a significant portion of the refining industry's energy needs to be met by coal, with the most potential coming from using medium-Btu coal gasification technologies. The major Federal energy programs designed to promote greater use of coal in industry have had little impact to date on the refining industry, but may have greater impact in the future.

While we have looked at how Federal conservation programs and policies have impacted on only one industry--the refining industry--we believe sufficient parallels exist between the industry and industry as a whole for us to draw some conclusions and make recommendations having general industrial application.

IMPROVING ENERGY EFFICIENCY

DOE's voluntary industrial energy conservation reporting program--the Government's most visible program designed to improve energy efficiency in industry--has not played a major role, but has had some impact on petroleum refiners' energy conservation efforts. The 20-percent efficiency improvement target set by the program will likely be achieved by the refining industry, but the industry would probably have achieved a 20-percent improvement anyway. Economic factors--the cost of fuel--have been and are expected to continue to be the prime incentive driving energy conservation.

While a more challenging industrial efficiency improvement program, containing incentives and standby authority to set mandatory standards, such as we have previously recommended (see p. 48) might result in higher levels of energy savings than the voluntary program, we do not believe such a program is needed at this time, on top of the recent massive oil price increases. Given the dramatic jump in energy prices during the past year, additional energy conservation opportun-

ities beyond those previously envisioned should now be cost effective, and further increases in energy efficiency in the refining industry, and other industries as well, should be realized in future years. The adoption of stronger programs by DOE, however, should not be ruled out in the future if circumstances change.

We believe the voluntary efficiency improvement targets have served a useful function in the refining industry and deserve to be continued for the 10 most energy-consuming industries. The existence of new improvement targets beyond 1980 will afford a degree of visibility and a measuring stick for industry's conservation efforts that would not be there otherwise. While the targets may not lead to greater levels of conservation effort than would occur otherwise, they might help prevent any slippage or deemphasis of conservation in the future. The new targets should be developed with industry's assistance and involvement so as to commit each industry to meeting its target.

The additional 10-percent investment tax credit is not expected to have a major impact on refiners' energy conservation efforts, but could possibly have some influence on marginal projects. The recent extension of the tax credit for certain conservation investments beyond 1982 makes the credit more attractive, but the refiners felt the credit is not large enough to significantly influence their investment decisions.

Such proposals as low-interest loans and accelerated depreciation were more attractive to the smaller refiners than the tax credit.

INCREASING COAL USE

Direct use of coal

The direct burning of coal in refineries has limited potential because

--it is not practicable today to burn coal in refinery process heat applications (65 percent of a refinery's energy requirements) and

--most existing refinery boilers (supplying 25 percent of energy needs) were not designed to burn coal.

The most potential for coal use lies with future refinery boiler expansions and replacements, but refiners expressed great reluctance to adopt coal-fired boilers for economic, technical, and environmental reasons.

DOE's coal-switching program has had little impact on the refining industry. The Fuel Use Act amended and strengthened the program, but it is still questionable how successful the program will be.

Indirectly, the coal-switching program may be hindering efforts to improve energy efficiency. One refiner intends to delay replacing old inefficient boilers to await the outcome of those refiners seeking exemptions. Two other refiners informed us they would continue to operate older equipment unless they can replace the equipment with oil- and gas-fired boilers rather than coal-fired boilers.

Coal gasification

The refining industry possesses favorable technical characteristics for adoption of coal gasification technology, but near-term conversion will be hindered by the cost of the coal gas. Refiners we interviewed have no plans to adopt coal gasification technology, but seemed to favor coal gasification to the direct burning of coal.

Selected Government actions such as removal of petroleum and gas price controls, or imposing oil and gas user taxes could significantly alter the interfuel economics of alternative energy sources and improve the attractiveness of coal gas. The recent world-wide oil price increases should help improve the economics of coal gasification processes.

Medium-Btu gas is strongly preferred to low-Btu gas in this industry because of the comparative ease of facility retrofit, gas distribution economics, its closer approximation to refinery gas quality, and scale considerations. Low-Btu gas, however, may be preferred in site-specific situations or remote areas.

Federal coal gasification activities have not been directed toward demonstrating the use of coal gas in a refinery application since the refining industry has not shown much interest in coal gasification. However, since coal gas could potentially displace a significant amount of oil and natural gas used in refineries, the industry should not be ignored as a possible coal gas user. It is apparent from our interviews that (1) the refining industry is not likely to use

coal gas until it can be more certain about the costs and reliability of the gasification processes, and (2) no refiner appears willing to take the risk in building a gasification plant to obtain actual operating data. Thus, DOE may have to take the lead in seeing that reliable technical and economic data are available.

RECOMMENDATIONS TO THE SECRETARY OF ENERGY

Pursuant to provisions of the National Energy Conservation Policy Act that provide for DOE to recommend to the Congress changes in the industrial energy conservation reporting program, we recommend that the Secretary of Energy request legislative authority to develop new industrial energy efficiency improvement targets for the 10 most energy-consuming industries. New legislation may technically not be needed since Section 372 of EPCA already gives DOE broad authority to implement programs "to promote increased energy efficiency by American industry." However, we believe a specific legislative mandate would be appropriate in this instance to add congressional support behind DOE's efforts and help dampen possible objections by industry.

The Secretary should closely monitor industrial energy usage and progress towards achieving the new improvement targets. If progress is unsatisfactory or if national policy dictates that greater industrial energy conservation savings should be achieved, the Secretary can develop additional programs, including proposals to change the investment tax credit, to assure that conservation goals are met.

Several changes need to be made in the new efficiency improvement targets based on experience of the targets that expired January 1, 1980. First, savings in oil and natural gas should be recognized, as well as savings in overall Btu's per unit of input. Secondly, the new improvement targets should extend at least through 1990 so that major equipment replacement and additions can be factored into the new targets.

We also recommend that the Secretary examine the extent to which companies in all industries are neglecting to replace old energy-inefficient equipment because of DOE's coal-switching program, and take appropriate measures if a significant problem is seen to exist. It does not make sense that a program designed to reduce U.S. dependence on imported oil may actually be having an opposite effect. If there is a problem, one possible solution might be for DOE to allow companies to replace old boilers with new oil- and gas-fired

boilers if the company can demonstrate that the new equipment is significantly more energy efficient than the old equipment.

Lastly, we recommend that the Secretary, working with industry, take further steps to demonstrate coal gasification technologies in a variety of industrial applications, including the refining industry if appropriate, to advance the development of more comprehensive economic and technical data based on actual operating conditions.

RECOMMENDATION TO THE CONGRESS

We recommend that the Congress take the initiative to enact legislation requiring DOE to develop new industrial energy efficiency improvement targets if DOE fails to request the necessary legislative authority.

AGENCY COMMENTS

We furnished a draft of this report to DOE for their comments. DOE agreed with our assessment that gas produced from coal may become more attractive to refiners than direct burning of coal. However, DOE disagreed with the report in several areas.

DOE stated that our report appeared to evaluate and criticize Federal programs from the refining industry's viewpoint rather than from the broader, more objective perspective of national energy considerations. We believe our report objectively portrays the impact Federal energy conservation policies and programs have had on the refining industry. The report does include the comments of the refining industry, as it should. DOE may not agree with these comments, but any appraisal of industrial conservation programs must consider the views and reactions of the affected industries.

DOE said our report appears to accept the refining industry rationale for opposing the use of coal. We were concerned with assessing how DOE's coal-switching program affected the refining industry and what impact the program might have in the future. While it would be nice if the refining industry voluntarily committed itself to greater coal use, we believe there are legitimate economic and technical obstacles why it is not reasonable to expect the industry to do so. Further, we did not state, as DOE contends, that the refining industry be excluded from complying with the Fuel Use Act. We reported that several refiners interviewed planned to continue using old inefficient oil- or gas-fired equipment rather than modernizing and risk being forced to burn

coal. This concerned us since it appears to be contrary to the intent of the Fuel Use Act. Therefore, we are recommending that DOE investigate further to determine whether this is happening with regularity throughout industry, or is an infrequent occurrence and nothing to worry about.

DOE stated that the report inaccurately portrayed its industrial energy conservation reporting program as the Government's primary industrial conservation program when, dollar-wise, it represented only a small portion of DOE's total activities in the industrial conservation area. Our description of the reporting program as the "primary" industrial conservation program was meant more in terms of industry-wide visibility and application than dollars spent. DOE agrees that the program has been the Government's most visible industrial conservation program. We have made appropriate changes in the report to clarify our meaning.

DOE commented that the report failed to mention that it was required by law to set industrial efficiency improvement goals that were both technically and economically achievable. While the report discussed the fact that DOE had set goals that were technically and economically achievable, it did not specifically state that DOE was legally required to do so. We have revised the report to recognize this fact.

Finally, DOE stated that our recommendation to establish new industrial efficiency improvement targets was illogical since we had concluded that the old targets had not resulted in any energy savings. The report recognizes that new targets may not result in greater energy savings than would have occurred without the targets. However, we believe that new targets can serve a useful function in terms of (1) being a reference point against which industry's progress can be measured, (2) providing visibility to industrial conservation activities, and (3) helping prevent possible future deemphasis of conservation by industry.

APPENDIX I

Department of Energy
Washington, D.C. 20585

MAR 19 1980

Mr. J. Dexter Peach
Energy and Minerals Division
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Peach:

We appreciate the opportunity to review and comment on the GAO draft report entitled "The Petroleum Refining Industry--A Case Study Of How One Industry Approaches Energy Conservation." The Department of Energy (DOE) believes that sound Federal programs to improve energy efficiency and to promote conversion from oil and natural gas to alternative fuels by the petroleum refining industry are needed to achieve national energy goals. The draft GAO report appears to evaluate and criticize some of these Federal programs from predominantly the refining industry's viewpoint, rather than from the broader, more objective perspective of national energy considerations. Evaluating Federal programs and formulating recommendations from such a limited viewpoint is misleading and not helpful in achieving national energy objectives.

The draft GAO report appears to accept refining industry rationale for opposing the conversion from oil and natural gas to coal. Technical, environmental, physical and economic limitations are described as obstacles blocking this industry's conversion to coal. DOE recognizes that obstacles do exist. However, none of the limitations presented in the report are unique to the refining industry. Other major industries and utilities are contending with these problems and in many cases are successfully overcoming them.

The draft report discusses the petroleum refining industry's aversion to participating in the expanded Federal coal switching program based on the revised Fuel Use Act. The primary intent of this Act is to force a reduction in oil and natural gas usage by industry. The report reflects the industry's opinion that the fuel switching program is counterproductive, and cites examples where compliance is actually hampering some firms' efforts to use more efficient boilers. We do not agree with the report's contention that the petroleum refining industry should receive special consideration or be excluded from compliance with the Fuel Use Act. The rationale offered to support special consideration for the refiners appears to be that they will be able to conserve oil and gas by purchasing more energy efficient units. Amounts of oil and gas conserved in this manner are miniscule compared to the savings which would accrue through the industry's installation of coal or alternative fuel-fired units in compliance with the Fuel Use Act. Refiners can petition for an exemption from the provisions of the Act for a variety of reasons, such as environmental requirements, site limitations and cost.

APPENDIX I

DOE understands the refining industry's current concerns over converting to coal. The Department recognizes that gas fuel produced from coal may become more attractive to some refiners than the direct burning of coal. The Federal coal gasification program recognizes the petroleum refinery industry as a potential coal gas user.

With respect to references made to the Federal industrial energy conservation reporting program, DOE agrees that program targets afford added visibility and a means of measuring industrial conservation efforts. However, the draft GAO report does not reflect a realistic understanding of the program or its impact on industry. The draft report states that the reporting program is "...the Government's primary program designed to improve energy efficiency in industry..." and further that the program is the "...main Federal program designed to promote energy efficiency by industry in general and by the refining industry in particular..." Neither of these statements accurately characterizes the program. The reporting program may appear to be the primary program to the refining industry because of its visibility. Other major Federal programs, such as the Waste Energy Reduction Program, the Industrial Cogeneration Program and the Industrial Process Efficiency Program are of at least equal importance. The Department's emphasis on these programs is indicated by the following budget allocations for FY 1979 and FY 1980:

PROGRAMS		FY 79		FY 80
Waste Energy Reduction		$ 15,240		$ 16,450
Industrial Cogeneration		5,000		11,250
Industrial Process Efficiency		14,400		20,675
Deployment and Monitoring		3,160		9,800
(Implementation & Analysis)	$2,851		$9,500	
(Monitoring and Reporting)	309		300	
TOTAL		$ 37,800		$ 58,175

The reporting program constitutes only $300,000 out of the $58 million budgeted for industrial related conservation programs in Fiscal Year 1980.

In summarizing the impact and result of DOE's voluntary energy conservation program, the draft GAO report states that achieving the 20% improvement goal by the refining industry was largely a self-fulfilling prophecy. The report reflects industry's view that they "...would probably have achieved a 20% improvement without the program." GAO concludes that rising fuel costs, and not the reporting program, was the prime incentive driving energy conservation in the refining industry. The draft report does not indicate that the Department of Energy was required by Congress to establish improvement targets that were both technically and economically achievable. Admittedly, an important factor in private industry decisions is economics. The targets that were established, by law, recognized this.

APPENDIX I

The basis for the recommendation that either DOE or Congress take the initiative to develop new industry targets to improve energy efficiency is not well founded. The need for new targets is not demonstrated in the draft report. The report repeatedly asserts that energy savings are the same with or without targets. As indicated in the report, rising fuel costs should cause the refining industry to continue to emphasize energy conservation. If the GAO evaluation of the effectiveness and utility of reporting targets is valid, the recommendation for further Federal involvement in target-setting is illogical.

Comments of an editorial nature have been provided directly to members of your staff. We appreciate the opportunity to comment on this draft report and trust you will consider our comments in preparing the final report.

Sincerely,

Jack E. Hobbs

(003230)

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