Effects of Price and Availability On the Future United States Energy Market

EUGENE F. EISEMANN, JR.

GULF OIL CORP.
PITTSBURGH, PA.

Editor's Note: The following is the third in a series of four articles concerning inter-industry competition in the domestic fuel market. Published in consecutive issues of JOURNAL OF PETROLEUM TECHNOLOGY, *each of the papers approaches the widely (and often heatedly) debated subject from the viewpoint of a different segment of the energy producing-marketing field. Obviously, the ideas and opinions expressed do not necessarily reflect the views of the majority of SPE members but, rather, are presented solely for the purpose of providing the reader with further insight into this controversial problem.*

Abstract

This paper is concerned with the competition between fuels for industrial use in the United States. Energy consumption in the U. S. is allocated between industrial and other uses. The industrial volume is divided into two classifications—(1) where there is competition between fuels, and (2) where there is no competition. The pattern of fuel consumption by electric utilities is studied intensively because there is competition between fuels and because it is the fastest growing industrial market. The growth of each utility fuel in several geographic areas is investigated.

The analysis of these areas includes the study of the relationship between prices where fuels are in competition; i.e., (1) on the East Coast where price competition is between oil and coal, and (2) in the South East states where the competition is between coal and gas.

Introduction

The purpose in developing this energy study was to examine the future demand for petroleum products in the total United States consumption of energy. To predict growth in liquid petroleum fuels, it is first necessary to analyze the competitive position of each fuel in each of the markets it serves. In this approach to the problem, total energy consumption has been segmented into several broad classifications—residential uses, transportation uses, industrial uses, etc. Within these end-use classifications an attempt has been made to separate "captive markets" from "competitive markets".

Captive markets are those in which one fuel has a decided advantage over competitive fuels—where there is virtually no competition. Examples are automotive gasoline, diesel oil for railroad fuel, bituminous coal in coke-making or colliery use. Demand for fuels in captive markets depends upon the economic health of the market and not upon the price of a competitive fuel.

Demand for any fuel in a competitive market not only depends upon the growth in that market, but also in the price and supply position of the fuel relative to any other fuel which could serve equally well. An example of a competitive market is the residential home-heating area. When supply is available, natural gas is less expensive than fuel oil in many areas. Where supply and price allow, natural gas obtains the lion's share of new home heating. Where gas supply is restricted or natural-gas price is high, distillate fuel oils dominate.

Competition also occurs between the fuels consumed for steam generation of electric power. In some areas of the country there is no competition; however, in other areas competition is strong. It is in these competitive areas that some price-volume relationships have been developed.

It is apparent from these analyses that the relationship between the prices of the competitive fuels will determine the relative volumes over the forecast period. The strongest influence upon price levels will result from political or legislative activities. Assumptions in these areas must precede demand forecasting.

Total Energy Consumption

A preliminary to this study was an analysis of total energy consumption in the U. S. Data released by the U. S. Bureau of Mines was analyzed and results were presented by Davis and Schweizer[1] in Feb., 1959. This report indicated that a well-defined trend has existed since 1910, and proposed an extension of the trend through 1970. Fig. 1, from the original paper,[2] includes actual data for the years 1958 and 1959, with an estimate for 1960 added. It can be seen that these additions do not suggest any necessity for revising the original projection.

Original manuscript received in Society of Petroleum Engineers office Jan. 16, 1961. Revised manuscript received Aug. 7, 1961. Paper presented at 91st Annual AIME Meeting, Feb. 26-March 2, 1961, in St. Louis.

[1]References given at end of paper.

The forecast is presented as a broad range. The trend developed is actually the center-line of this range and represents an average growth rate of about 2½ per cent/year between 1957 and 1970. By 1970 this would put the total U. S. consumption at 57.1 quadrillion Btu. However, in the past there has been considerable fluctuation in the use of energy because of variations in business conditions. The vertical shaded areas shown on Fig. 1 represent periods of business contraction. It can be seen that decreases in the use of energy coincide with these periods. The broad range is intended to encompass the highs and lows of these fluctuations.

Many current forecasts predict higher rates of growth for total energy consumption during the period through 1970. If the energy consumption in 1970 were to reach the upper limit of the range shown, it would amount to about 61 quadrillion Btu. This would be an average growth rate of about 3.3 per cent/year. If consumption in 1970 were to reach only the lower limit of the range, however, it would amount to around 52 quadrillion Btu. This would be an average growth rate of only 1.7 per cent/year.

Energy Consumption by End-Use

Next, in an effort to learn more about the consumption of energy in the U. S., the fuels which contribute to the energy balance[2]—bituminous and anthracite coal, crude petroleum and product imports, natural gas and natural-gas liquids—were segregated by end-use. The divisions chosen were industrial, residential and commercial, transportation and other. For each fuel, volumes reported[3-7] have been converted to British thermal units, an equivalent energy basis.

For the bituminous and lignite coal, the reports give the consumption by end-use. The report for anthracite coal, however, gave only the total consumption and the quantity used by railroads except for the most recent past. Therefore, it was necessary to apportion this fuel consumption to its various end-uses.

The Bureau of Mines publishes two series for yearly natural-gas consumption. The first of these, of course, is the consumption published in the energy balance. A second source, the annual *Mineral Market Report*, shows the total consumption by year and also the amounts used in each of the consuming categories. Comparision of the two series shows that natural-gas use for the energy balance averages about 98 per cent of the consumption given in the marketed production report. The total dry-gas consumption in the energy balance was allocated to each end-use in the same proportion as that use bore to the total consumption shown in the *Mineral Market Report*.

Accounting for the crude petroleum, product imports and natural-gas liquid categories shown in the energy balance are a little more difficult because they are not used in these forms but, rather, are consumed as petroleum products. Using Bureau of Mines sales reports, it is possible to get the end-use consumption of kerosene, residual and distillate fuel oil, and an estimate of the consumption of LPG by uses. The consumption of gasoline and jet fuel is included in the transportation segment. In this manner it is possible to account for about 87 per cent of the energy attributable to the crude petroleum, product imports and natural-gas liquids sections of the energy balance.

At the time the industrial use by fuels was being compiled, the individual industrial uses were being classified into one of two categories—either into competitive or into noncompetitive uses. A competitive use or market is one in which more than one fuel can and does serve the same purpose. A noncompetitive market is one in which a single fuel is completely dominant. The primary reason for this is to see whether the growth in industrial use is in captive or in competitive markets. The data show that the noncompetitive sector of the market accounted for about one-third of the consumption in 1940, but while growing in absolute volume declined to less than 29 per cent of the market by 1959. There also may be some evidence that this segment has reached a peak in absolute volume; however, the data are not yet conclusive on this point.

The competitive segment is the fastest growing portion of the industrial market; it has more than doubled in actual volume between 1940 and 1959. The quantity of each fuel consumed by electric utilities is obtained from Federal Power Commission reports.[10] Examination of these quantities show that the electric utility segment is the most rapidly growing portion of the competitive fuel market. In fact, since about 1947 the growth in the electric utility use of fuels has accounted for almost 75 per cent of the increase in competitive fuel use.

Also shown in Fig. 2 is an extrapolation of the total energy curve and a projection for each of the major end-uses. The total shown is the center-line of the range shown in Fig. 1. The forecasts shown are the results of independent estimates of the future consumption of each fuel. These are classified by end-use, utilizing the trends revealed in the past data and balanced to the total.

The forecast of the energy consumed for steam genera-

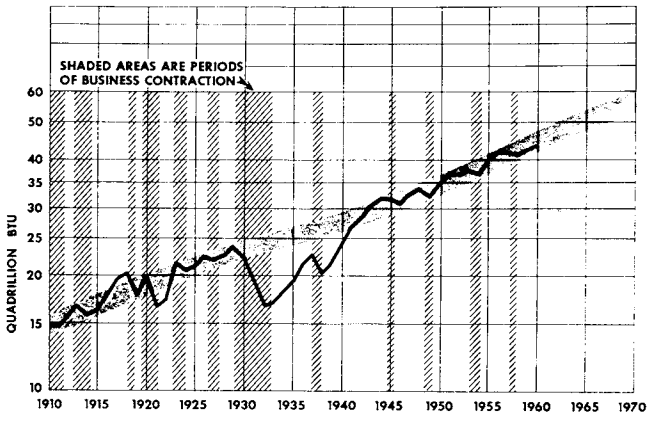

Fig. 1—Energy consumption of the United States, 1910-1970.

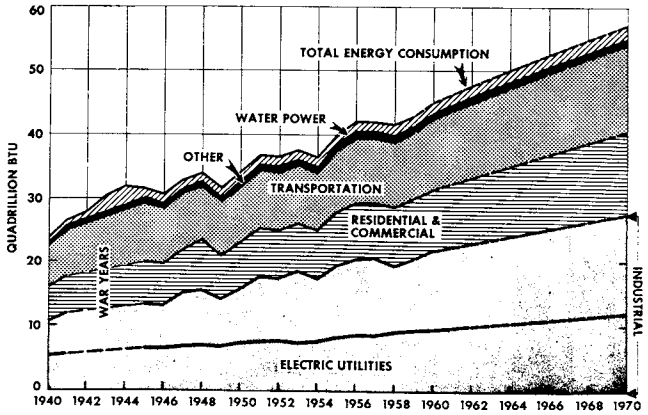

Fig. 2—U. S. consumption of energy fuels by type of use.

tion of electricity was compared to, and agrees with, the forecast given by Sporn[9] before the Subcommittee on Automation and Energy Resources.

Electric Power Generation

It has been determined that the generation of electric power is a very important fuel-consuming activity and is going to become more important in the future. In 1959 there were 6.6 quadrillion Btu consumed for this purpose, and the forecast shown is 12.4 quadrillion Btu by 1970. It is easier to grasp the significance of the fuels consumed by showing in more common units the breakdown of the 6.6 quadrillion Btu. (See Table 1.)

In other words, Table 1 shows that 44 per cent of the coal, 12 per cent of the residual fuel oil and 14 per cent of the natural gas used in the U. S. were consumed in generating electric power.

Fig. 3 is a plot showing the sources of energy for electric power generation since 1940. The first division of energy sources is between water power and steam generation. The water-power data are taken from the Bureau of Mines energy balance. The Bureau calculates the equivalent fuel energy based upon the prevailing consumption of coal per kilowatt-hour generated at central electric plants. It may be seen that the share provided by water power is declining even though the absolute quantity of equivalent energy has grown. The portion of the electric power generated in the U. S. supplied by water power has declined from 35 per cent in 1940 to 20 per cent in 1959. This means, of course, that the share generated by steam has grown from 65 per cent in 1940 to 80 per cent in 1959.

A secondary classification of the energy sources for power generation may also be seen in Fig. 3. The steam-generated portion has been further sub-divided to show the share provided by coal, oil and gas. The relationship among these fuels has changed also. Prior to World War II, coal was supplying more than 50 per cent of the total energy for electric generation. In the late forties and early fifties, its share declined. However, since the middle fifties coal has had around 53 per cent of the market. In the early forties oil provided about 8 per cent of the energy and captured much of the share lost by coal after World War II. Since the middle fifties, however, oil's share has been declining steadily and in 1959 had fallen to 6.6 per cent. The portion supplied by natural gas has been increasing steadily from around 7 per cent in 1940 to its present 20 per cent. This now makes gas as important a source for electric power generation as water power.

Finally Fig. 3 shows a projection of the proportion of electricity that will be generated by water power and by steam through 1970. The forecast of energy supplied by water power is taken from Sporn's testimony. It will be noted that no attempt has been made to project the individual fuels consumed in steam generation. The reason for this will be discussed more fully later, but there are portions of this market which are price-sensitive, and the fuel consumed depends upon the existing price relationships. Therefore, it is felt that volume forecasts must be preceded by corresponding price forecasts.

TABLE 1—1959 FUEL CONSUMPTION IN THE UNITED STATES

	All Uses	Electric Power Generation	Per Cent of Total
Natural gas (trillion cu ft)	11.8	1.6	14
Coal (million tons)	385	168	44
Distillate (million bbl)	659	5	1
Residual (million bbl)	674	82	12

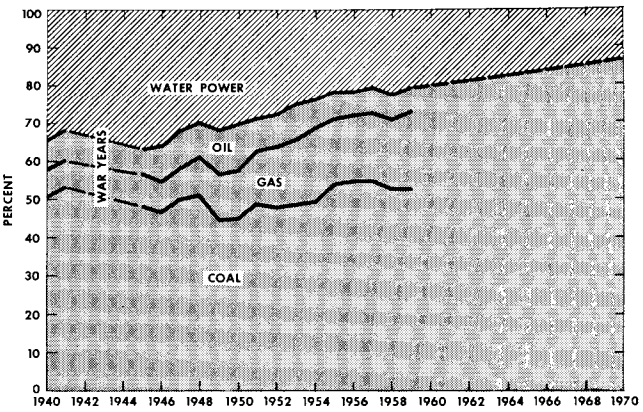

Fig. 3—Energy consumed for electric power generation (per cent of total each source).

Next, the energy used for power generation was examined by geographic area. Fig. 4 shows the source of energy used in each of seven areas of the U. S. for 1959. These areas are those used by the U. S. Census Bureau, but some of them have been combined for simplicity in presentation. It can be seen from the figure that coal is the dominant source in four areas—the New England, Middle Atlantic, South Atlantic and East North Central regions. Coal is not commonly used as a fuel in the Pacific region. Gas is the dominant source of energy in two areas—the West North Central Mountain region and the South Central area. It has a strong position in the Pacific area. Apparent also is the fact that water power is the dominant source in the Pacific area and an important factor in the West North Central Mountain region. Finally, it can be seen that oil provides less than 1 per cent of the energy in two areas—the East North Central and South Central regions. It is a significant factor only in the New England area, the eastern section of the Middle Atlantic states, in Florida and in California. The New England and Middle Atlantic areas specified account for about 20 per cent of the total power generated from steam in the U. S.

To take advantage of the competition among fuels,

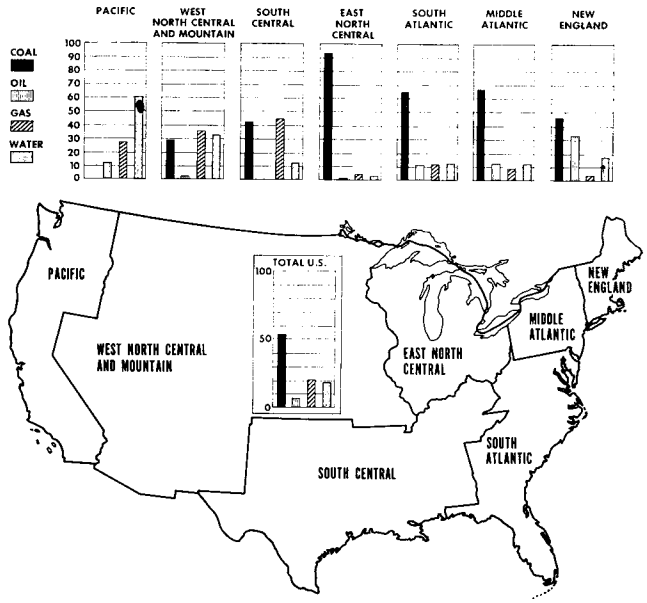

Fig. 4—Energy consumed in electric power generation, 1959.

electric-power generating plants are frequently designed to burn more than one fuel. This permits the selection of the cheapest fuel at any time. In 1959 plants with 37 per cent of the electric-power generating capacity in the U. S. were equipped to burn two fuels, and 7 per cent equipped to select from three— coal, oil or gas.

In New England 64 per cent of the capacity lies in plants equipped for two fuels, and an additional 20.8 per cent in stations which can burn all three. Only 14 per cent of the capacity is restricted to a single fuel. In the Middle Atlantic states, stations having about half the capacity can burn at least two fuels. Looking at the coastal section of the Middle Atlantic states, New York City, New Jersey and Philadelphia, plants with 83 per cent of the capacity are able to choose between fuels. In some areas (particularly in the East North Central and East South Central) where coal is king, most utilities are designed to burn only coal. In 1959 gas served 100 per cent of the West South Central market, but more than half the capacity was designed to use an alternate fuel (mostly oil). Some 80 per cent of the Mountain capacity and 90 per cent of the Pacific capacity are equipped to use at least two fuels.

Price-Volume Relationships

In the remaining charts the cost of oil and/or gas in cents per million Btu is compared to the cost of coal. In each year the share of the total Btu consumed furnished by gas and/or oil has been plotted against the price relationship with coal. The cost per Btu as consumed in electric-power generating plants in each area has been obtained from the statistics published by the National Coal Assn.[11]

As can be seen in Fig. 5, oil furnished 48 per cent of the energy consumed by steam electric plants in New England in 1952. The price of oil per million Btu at this time was 1.2¢ below the cost of coal. In 1953 the price decreased to 2.2¢ below the average cost of coal for the area. In 1954 the cost of oil per million Btu began to increase and, consequently, its share of the market began to decline. In 1957 the price of oil was 5.9¢ higher than the price of coal and its share of the market had fallen to 31 per cent. The price of oil dropped substantially in 1958 and 1959, and it began to regain some of the market, reaching 39 per cent in 1959. Though oil's share of the market increased when the price decreased, it did not again attain the 1952 or 1953 level. Some had been irretrievably lost. With the 1959 price relationship very nearly the same as in 1953, oil had a much smaller share of the market.

Gas, the price of which was below coal in every year from 1952 to 1959 excepting 1955, grew from nothing to 5 per cent of the market despite the fact that supply is restricted and distribution is limited.

Fig. 6 shows the price-volume relationship in the New York City, Philadelphia and New Jersey areas, and again reveals how the increasing relative cost of a fuel results in its share of the market declining. Oil's share of total consumption dropped from 24 per cent in 1954, when the price of oil was below that of coal, to about 16 per cent in 1957, when the price of oil per million Btu was 8.2¢ more than that of coal. In 1958 the price of oil dropped substantially (7.9¢), and its share of the market increased until it reached 26 per cent in 1959 at a price 1.4¢ less than coal. In this particular case, oil has been able to gain back slightly more than its previous share of the market, but a lower price. Gas increased its share of the steam electric plant fuel market from 13 per cent in 1953 to 17 per cent in 1959. The price of gas during this period is always lower than that of coal and oil. Again the supply of gas is restricted, especially in cold weather.

It is apparent that, if gas were made available in large

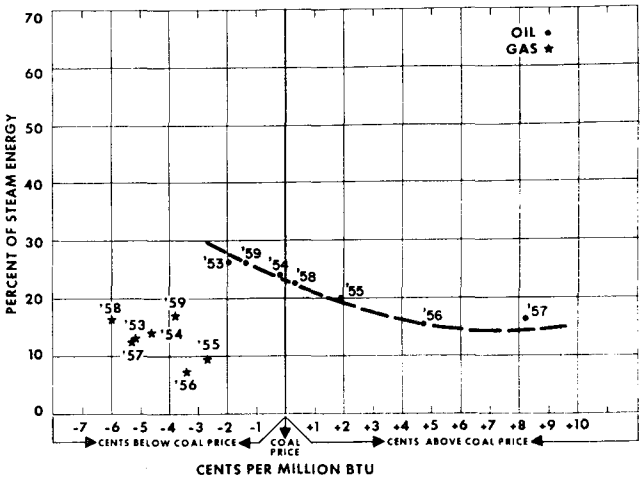

Fig. 6—Price/volume relationship for coal, oil and gas in New York City, Philadelphia and New Jersey.

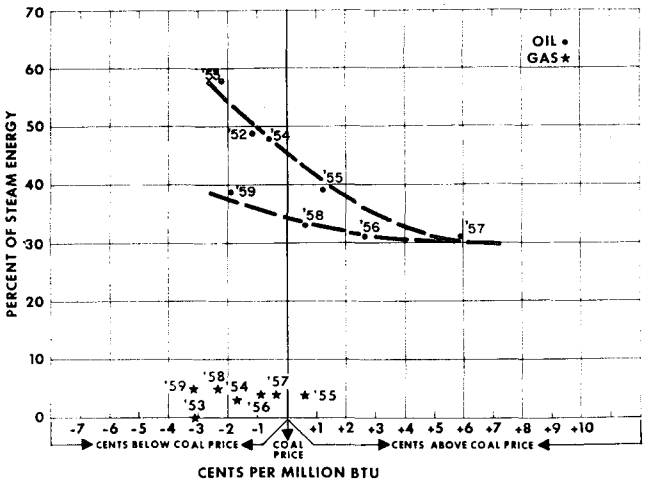

Fig. 5—Price/volume relationship for coal, oil and gas in New England states.

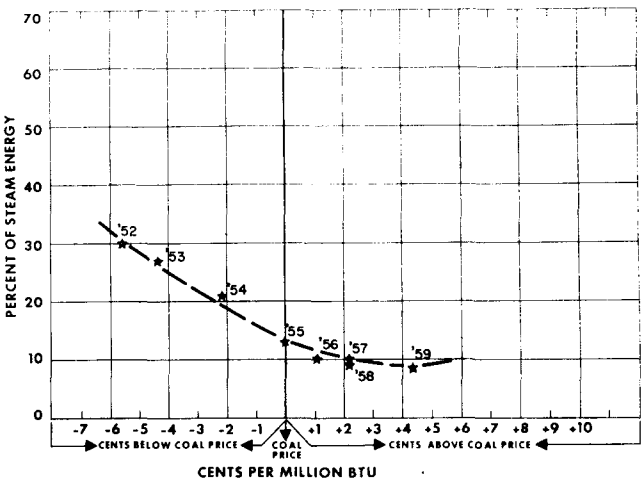

Fig. 7—Price/volume relationship for coal and gas in East South Central states.

amounts, its share of this market would increase sharply, assuming the price relationship with both coal and oil remained the same.

Fig. 7 shows the price-volume relationship between coal and gas in the East South Central states. In 1952 the price of gas was 5.5¢/million Btu less than the price of coal. The price of gas increased until it was 4.3¢ more than coal by 1959. During this period of increasing price, gas's share of the steam electric plant market decreased from 30 per cent in 1952 to 9 per cent in 1959. Oil is not a factor in this area.

Conclusion

The volume forecasts for these fuels are dependent upon the assumptions made concerning these price relationships. Unfortunately, future price levels will be greatly affected by political and administrative activities such as import restrictions, a national fuels policy and FPC regulation of gas sales. Presently, the price of natural gas is artificially low because the field price is not permitted to seek a competitive level in the open market. Prices of residual fuel oil are artificially high because of import restrictions. The new administration is committed to a national fuels study, and the results of this study on prices are almost impossible to predict. The economics of supply and demand are of small assistance when forecasting in this area of competitive industrial energy.

Acknowledgments

The author wishes to acknowledge the aid and assistance of many members of the Planning and Economics Dept. at Gulf Oil Corp., particularly the preliminary work by Davis and Schweizer, and the efforts of Loyal A. Purvis. The permission of Gulf's management to publish this paper is also gratefully acknowledged.

References

1. Davis, W. B. and Schweizer, J. L.: "Natural Gas, Partner and Competitor", *Jour. Pet. Tech.*, (May, 1959) **XI**, No. 5. 13.
2. Monthly Petroleum Statement No. 451, USBM, (Dec., 1959).
3. *Sales of Fuel Oil and Kerosene*, USBM (various years).
4. *Sales of Liquefied Petroleum Gases*, USBM (various years).
5. *Annual Petroleum Statements*, USBM (various years).
6. *Marketed Production of Natural Gas*, USBM (various years).
7. *Minerals Year Book*, USBM (various years).
8. Coumbe, A. T. and Avery, I. F.: "Fuels Consumed for Residential and Commercial Space Heating, 1935-1951", Information Circular No. 7657, USBM (Jan., 1953).
9. Hearings before the Subcommittee on Automation and Energy Resources of the Joint Economic Committee, 86th. U. S. Congress (Oct. 12-16, 1959).
10. *Electric Power Statistics*, FPC (various years).
11. Steam Electric Plant Factors, National Coal Assn., Dept. of Coal Economics (various years). ★★★

EUGENE F. EISEMANN, JR., *economist, heads the marketing section of Gulf Oil Corp.'s Planning and Economics Dept. in Pittsburgh. He holds BS and MS degrees from the Carnegie Institute of Technology in Pittsburgh, and currently teaches marketing and economics at that school. Active in the Pittsburgh Chamber of Commerce, he is a member of the American Statistical Assn., American Marketing Assn., Institute of Management Science and the API.*