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COAL IN THE FUTURE ENERGY MARKET

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ABSTRACT

A five-fold increase in energy consumption has occurred in the United States since 1900. Population has increased to 2 1/3 times its 1900 level, and average per capita energy consumption is equivalent to more than nine tons of coal per year, compared to about four tons 60 years ago.

Because of competition from other fuels, the coal industry has declined even though total energy consumption has increased. From now on the coal industry will move forward.

Competition will still prevent growth of coal in many uses, but projections of continued growth in its use for generating electric power will bring a significant increase in total coal consumption through the mid-1970's. This will help to strengthen the coal industry and enable it to face the opportunities and challenges of the last quarter of the twentieth century when the declining availability of oil and gas will open up new markets and reopen old markets.

INTRODUCTION

A five-fold increase in the consumption of energy has occurred in the United States in the years since 1900. Over the same period population has increased to 2 1/3 times its former level. Annual consumption of energy has risen to an equivalent of more than nine tons of coal for every man, woman, and child in the United States, compared to about four tons 60 years ago.

PATTERN OF FUEL CONSUMPTION

Accompanying the growth in the consumption of energy, there has been a drastic change in the pattern of fuel consumption to provide that energy. Markets that the coal industry once considered exclusively its own have been taken over almost completely by petroleum products. Petroleum, in turn, has been replaced by natural gas in numerous applications. In many installations today the various fuels are readily interchangeable, and the transition from one to the other is made quickly and easily.

As a result of these changes, a new concept with regard to fuel is emerging. Oil, gas, and coal can no longer be considered as separate and individual fuels but must be viewed with regard to their relative position within the total pattern of energy consumption. Instead of being producers of oil, gas, or coal, firms engaged in the production of these fuels have in a broader sense become suppliers of energy and must compete on this basis.

Figure 1 shows what has been occurring in the consumption of fuels and in total consumption of energy since 1920. During this period, total consumption has

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risen from less than 20,000 trillion Btu's to more than 41,000 trillion. At the same time, marked changes have occurred in the relative importance of the various fuels. Coal, which in 1920 provided 78 percent of all energy consumed within the United States, gradually has been displaced from its position of prominence and now accounts for less than 25 percent. Petroleum and petroleum products have risen from about 17 percent of the total in 1920 to 42 percent in 1958. Meanwhile, natural gas and natural gas liquids (including natural gasoline, butane, propane, etc.) have risen from less than 5 percent to almost 30 percent, and water power has shown relatively little change in importance.

PROJECTED TRENDS

Figure 2 also shows the past consumption of energy and fuels, but in addition it shows a projection of past energy trends into the future. In this chart, for ease of comparison, the various fuels have been converted to bituminous coal equivalent. The estimated 1960 level of consumption is about 1650 million tons of coal equivalent. A projected level of 2450 million tons is shown for 1980, 3400 million tons for the year 2000.

Water power, shown at the top, is expected to retain its present percentage of the total, or perhaps even decline as the better sites are occupied. Natural gas, which together with natural gas liquids now provides roughly 30 percent, is shown to increase to about 35 percent by 1980 and then decline to 25 percent by the year 2000. Petroleum, currently furnishing about two-fifths of the energy, is shown at 35 percent by 1980 and some 20 percent by 2000. Based on interpretation of past and current trends, basic coal consumption is expected to remain at its present level of about 20 percent through 1980 and then rise to about 25 percent by 2000. The projected increase in total consumption, however, should cause an actual tonnage rise of about 50 percent by 1980 and of more than 115 percent by the year 2000.

I would like to point out that this is what might be termed the basic consumption of coal. In addition, coal will be in a better position than ever to compete for new markets. The new markets will develop because of what is shown on the chart as "oil and gas deficit," and they will begin to appear in the middle 1970's. To gain the new markets coal will have to compete with a number of other sources of energy including liquid and gaseous fuels from oil shale and tar sands, atomic power in some degree, and, on a much smaller scale, perhaps wind and solar power, and power from fuel cells and other new devices. From present indications, coal will be able to compete strongly with these other energy sources and will be looking forward to a much better period.

In the upper right portion of figure 2 are projections, made by other persons or groups, of future total energy consumption. My interpretation of the trends and

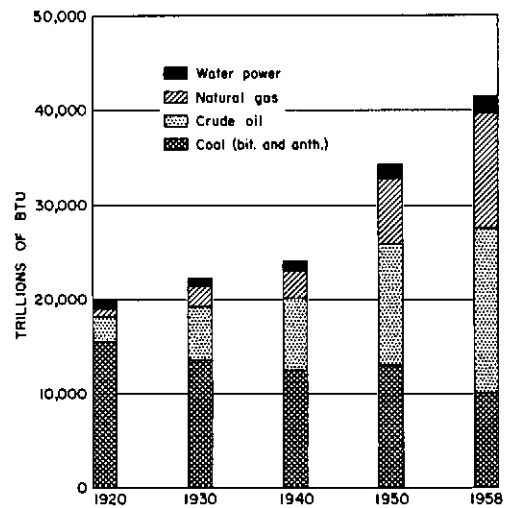


Fig. 1 - Calculated United States energy consumption

factors involved has resulted in a projection of energy demands that is more moderate than the others shown. Perhaps a word of explanation for the difference shown should be given. I am fully confident of a continued strong and long-term growth in the American economy and standard of living. It appears unlikely, however, that the rapid rate of growth experienced since World War II can be maintained indefinitely. Much of this growth stemmed from a pent-up demand that resulted first from the depression of the 1930's and then from the wartime scarcities of goods. There are strong indications that most of this demand has now been filled. I feel that my chart typifies more accurately the long-term trend in energy consumption.

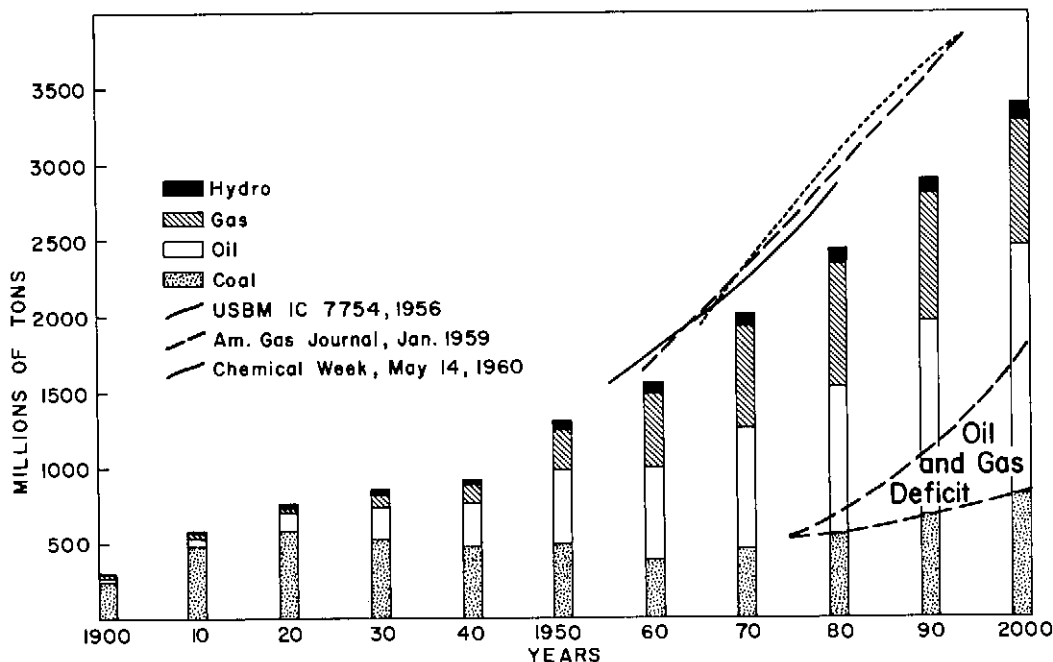


Fig. 2 - United States consumption of energy in tons of coal equivalent

COMPETITIVE FACTORS

The relative quantities of the various fuels used depends primarily on certain competitive factors. In many uses the various fuels are directly competitive, but in others they are competitive in only an indirect manner, or not at all. Where competition between the fuels exists, the following factors are important determinants: 1) Relative cost, 2) relative desirability (cleanliness, convenience, etc.), 3) relative efficiency, and 4) availability.

Relative cost of a fuel, which means not only the initial price of a fuel but also the cost of handling and using it, is a much more important factor in some uses than in others. For example, in the production of electric power and in other industrial applications, fuel cost generally is a prime factor. In residential heating, cost often is less significant than other factors.

Relative cleanliness and convenience are desirable factors which are major competitive determinants for some uses. This is illustrated by the willing-

ness of many householders to pay a premium for gas in preference to coal or oil, even when the latter fuels may be considerably less expensive.

Efficiency is a factor, principally because of its influence on the relative costs of using fuels. Thus, although diesel oil at 9.5 cents per gallon in 1960 may cost three times as much per million Btu's as coal at \$5.60 a ton, it is much less expensive to use because of its greater efficiency.

A fuel may have all the competitive advantages of cost, desirability, and efficiency, and still not enter into competition because not enough of it is available within a given area. The manner in which such a fuel can disrupt traditional markets when it does become available has been well illustrated by the increased use of natural gas made possible through the construction of cross-country pipelines in recent years.

Several illustrations are devoted to the changes that have been occurring in the consumption of fuel and show the effects of the competitive factors discussed.

Coal

Most coal men are painfully aware of what has been happening in the coal markets. However, before discussing other fuels I would like to review briefly the changes in the major markets for coal, shown in figure 3. United States coal consumption, after reaching an all time peak of 594 million tons in 1943, declined to a level of 367 million tons in 1958 and 1959. Railroads, which in 1944 consumed 132 million tons, used only 2½ million tons in 1959. Retail deliveries, which in 1944 accounted for 122 million tons, had dropped to less than 30 million tons in 1959. Only partially offsetting these declines were the electric power utilities who increased their consumption from 77 to 166 million tons during the same period. These three markets — railroads, retail, and utilities — are discussed in more detail below.

The other two major consumer categories — coke and general industrial use (known as "other industrials") — have shown less radical changes than the other categories. They have fluctuated with the general level of industrial activity, but otherwise have remained quite stable. It should be noted, however, that owing to competition from other fuels, the industrial consumption did not gain with industrial expansion but only held its own. Nor did coke consumption keep pace with the growth in steel production. As long as competition in industrial use continues strong and improvements continue to be made in blast furnace operation, coal consumption in these categories is not likely to show any significant gain in spite of industrial expansion.

Petroleum

Petroleum and petroleum products provide the major portion of the fuel energy today. I have no data indicating exactly how much of these products goes into each of the various uses, but a study of the type of products produced by the refineries of the United States gives some clue. Figure 4, which shows changes in these outputs, reveals that the total output of refined products has more than trebled since 1933. Almost half of the 1958 output consisted of gasoline and kerosine — products that are not normally directly competitive with coal. Distillate fuel oil includes both heating oils and diesel fuel. The heating oil is directly competitive with coal in many applications. Diesel fuel used for highway vehicles and farm tractors is not competitive with coal, but that used by railroad locomotives has almost completely crowded coal out of the railroad fuel market. Residual fuel oil, consumed principally in heavy industrial uses, also is competitive with coal.

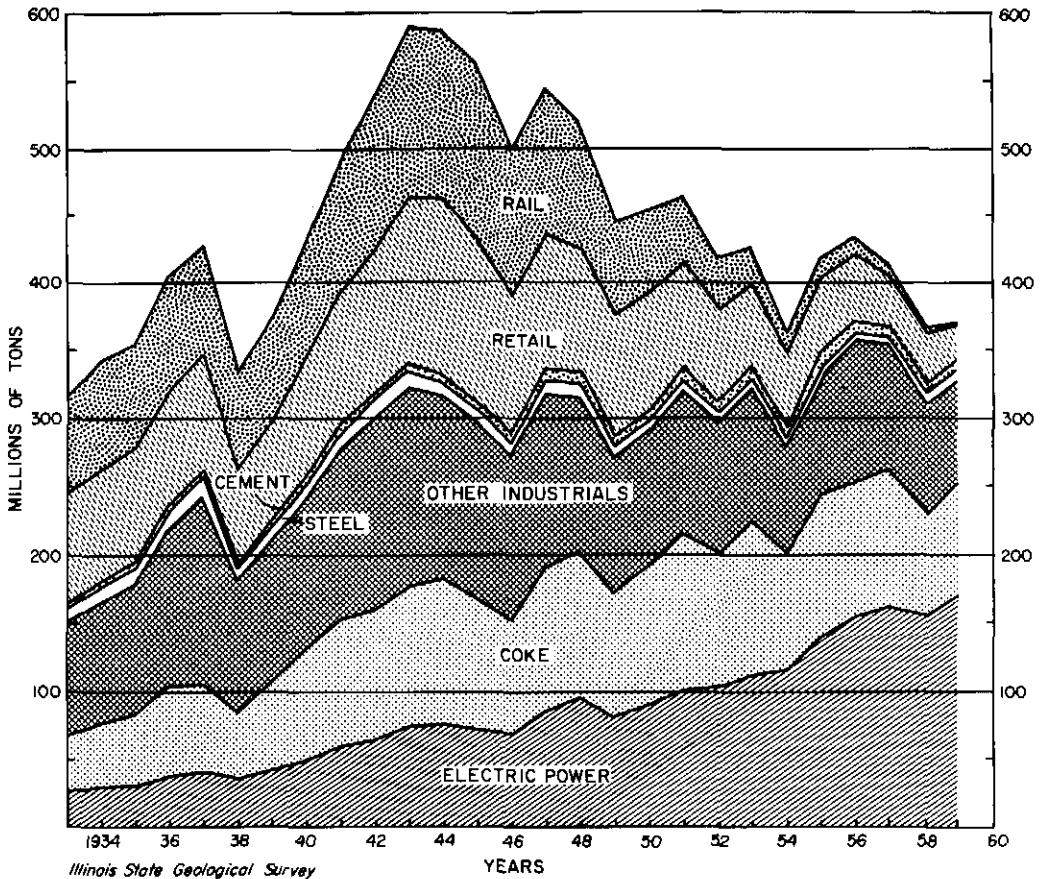


Fig. 3 - United States consumption of coal, by consumer groups

Natural Gas

Natural gas, the fastest growing of the major fuels today, is directly competitive with coal in a large majority of its fuel uses. Gas has shown about a seven-fold increase in the 25 years charted in figure 5. In percentage, commercial and residential uses provide the fastest growing market, and they now consume about one-third of the total natural gas used. The gas that goes into space heating competes directly with coal. Gas consumed industrially amounts to about 50 percent of the total consumption. Industrial gas is divided into that sold on a firm or non-interruptible basis and that sold at low prices on an interruptible contract whereby service may be interrupted under specified conditions. Interruptible gas is directly competitive with other fuels. In some large cities more than half of the industrial gas sold is sold on an interruptible basis.

A part of the non-interruptible gas goes into uses where cleanliness or close temperature control is essential. In such cases oil is perhaps the closest competitor to gas. In certain areas these special uses have been estimated to consume as much as 80 percent of the gas sold on the non-interruptible basis.

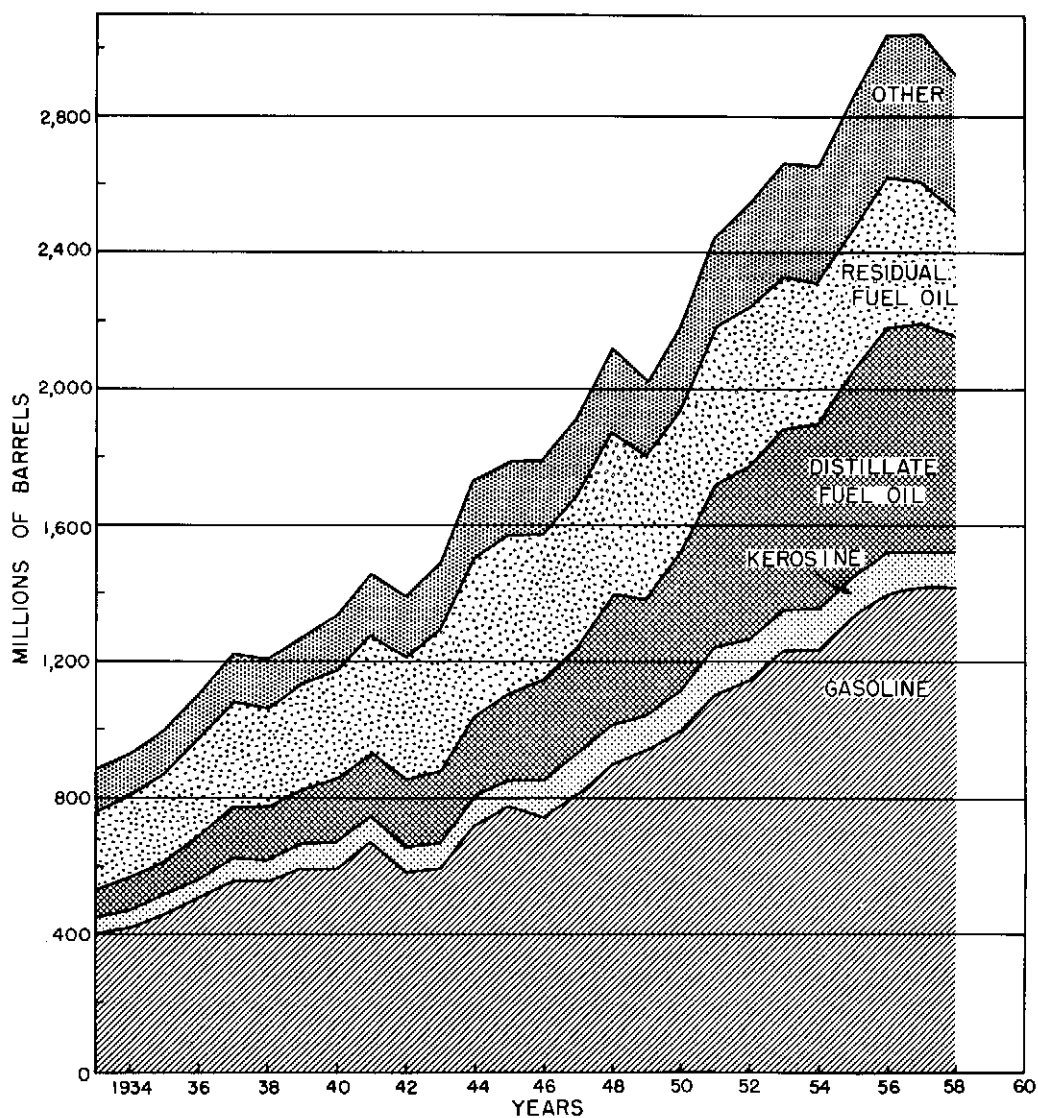


Fig. 4 - Output of petroleum products at refineries in the United States

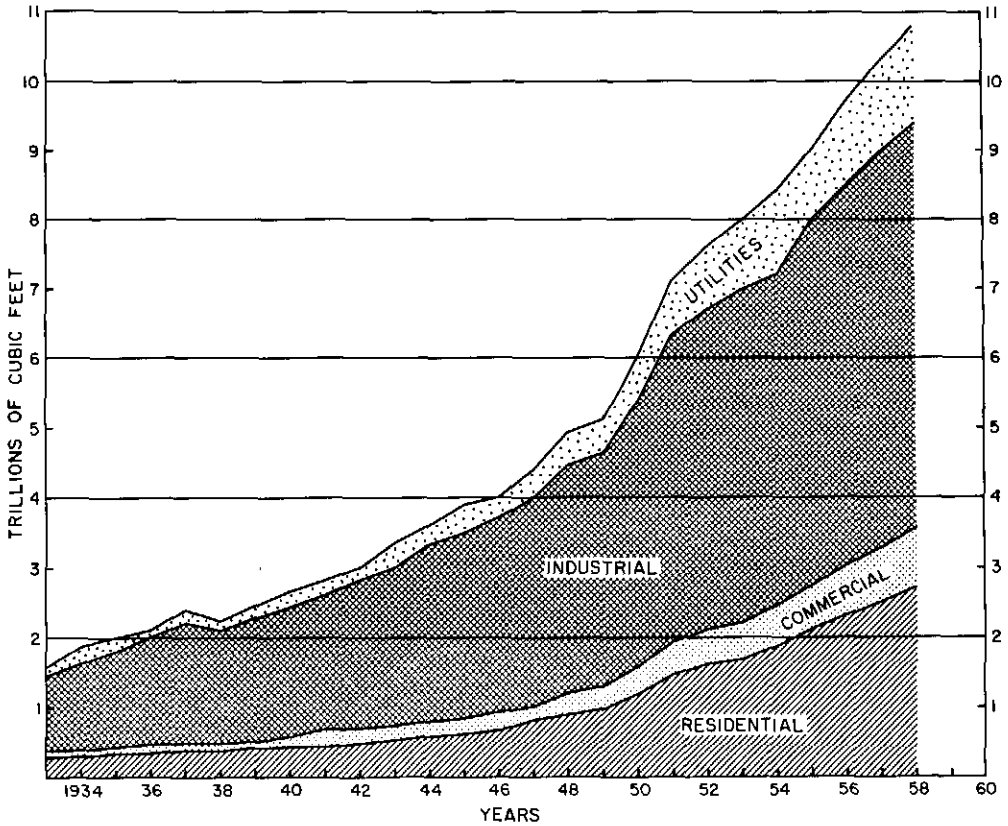


Fig. 5 - United States consumption of natural gas, by consumer groups

Major Markets

Figures 6, 7, and 8 show the direct effects of competition in the three coal consuming categories in which changes have been most drastic. In these charts, all fuels have been converted to tons of bituminous coal equivalent for purposes of comparison.

Residential and Commercial

Figure 6 shows what has been taking place in the consumption of fuel for residential and commercial uses. In spite of the fact that total use has been steadily rising, the consumption of both bituminous and anthracite coal has fallen to a fraction of its former level. The combined consumption of bituminous coal, anthracite, and fuel oil is at about the same level as it was in 1934, but the use of fuel oil has risen from 10 percent to about 66 percent of this amount. The major part of the remaining growth in residential and commercial uses has been in the consumption of natural gas, which has increased about nine-fold. Liquefied petroleum gas is moving into the rural areas and other places not reached by natural gas and is taking an increasing share of the total market. Although cleanli-

ness and convenience are probably the most important factors causing the preference for gas, it also is true that in many areas of the country gas is actually cheaper than the other fuels.

The only way in which coal is likely to regain the domestic market is through electric heating. There is some indication that this may become significant in certain areas of the nation within the next few years.

Railroads

Figure 7 shows the changing consumption of fuel by railroads. Coal consumption has declined from 132 million tons in 1944 to about 2.5 million in 1959. In the years since 1939 diesel fuel has almost completely replaced coal. The relative total has remained at about the same level in recent years, as shown on the chart. However, the chart needs further explanation. The values shown for diesel fuel and fuel oil represent the quantity of coal replaced, or in other words the quantity of bituminous coal that would be required to perform the same work that is now being done by these fuels. Actually, diesel fuel is so much more efficient than coal that only one-seventh as much energy value is required in the form of diesel fuel as in the form of bituminous coal. Therefore, the loss of the railroad market to diesel fuel can be directly attributed to the competitive factors of efficiency and cost.

Electric Utilities

The consumption of electricity in the United States has shown a phenomenal growth and it is still growing rapidly (fig. 8). Coal provides about 65 percent of the total fuel energy required to generate electricity and is holding its own. Much of the increased output of electricity has, of course, gone into the industrial growth of the nation, but a large amount has been consumed directly by the people. With a 70 percent increase in population, residential consumption of electricity has risen from 6 billion KWH in 1920 to more than 190 billion KWH per year at the present time — more than a thirty-fold increase in 40 years.

The reason coal has been able to maintain its strong position as a fuel within the electric power industry is its relatively lower cost. This cost position has been held through marked improvements in the efficiency in the use of coal over the years and by the fact that the coal industry has held the price line through improved mechanization and efficiency while other prices were rising. It is only under special conditions that other fuels can compete with coal in this market.

Much of the gas shown on the chart in figure 8 is that burned in the gas-producing areas of the Southwest and in the areas where it is available at low cost on an industrial interruptible basis. The fuel oil is consumed, for the most part, in areas along the East Coast where oil can be imported at a low cost.

DISCUSSION

Most of the trends discussed have resulted primarily from the four competitive factors mentioned earlier. As long as the competitive factors remain as they are, the trends are likely to persist. That is, as long as other fuels are available in sufficient quantities and can offer advantages in efficiency, cost, or convenience that make them more attractive to the customer, coal will continue to

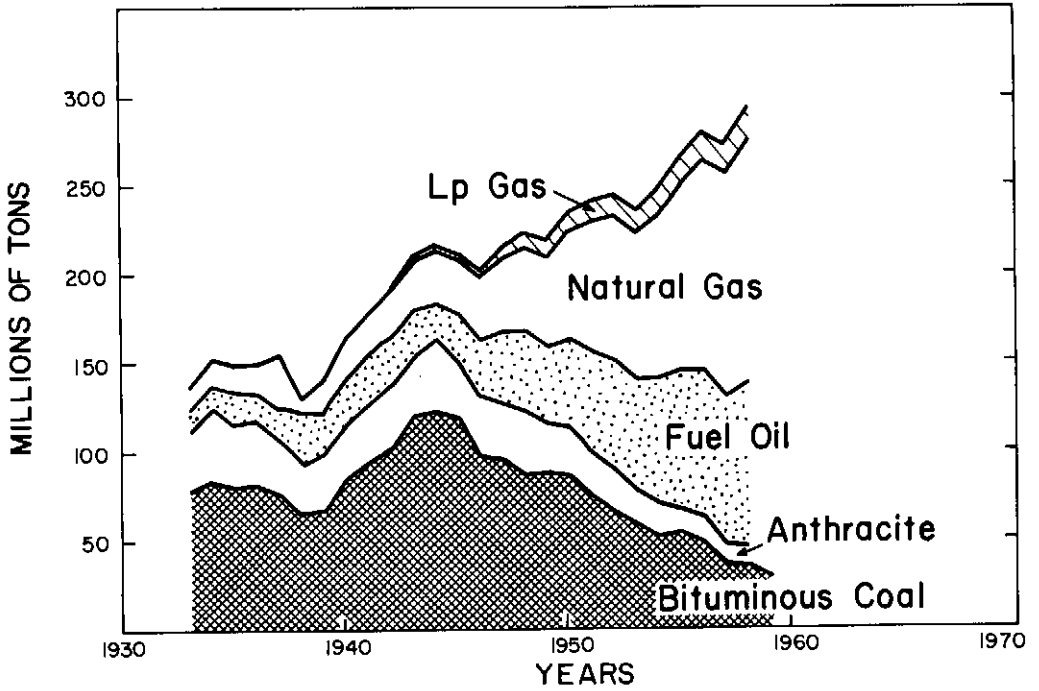


Fig. 6 - Residential and commercial consumption of fuel in bituminous coal equivalent

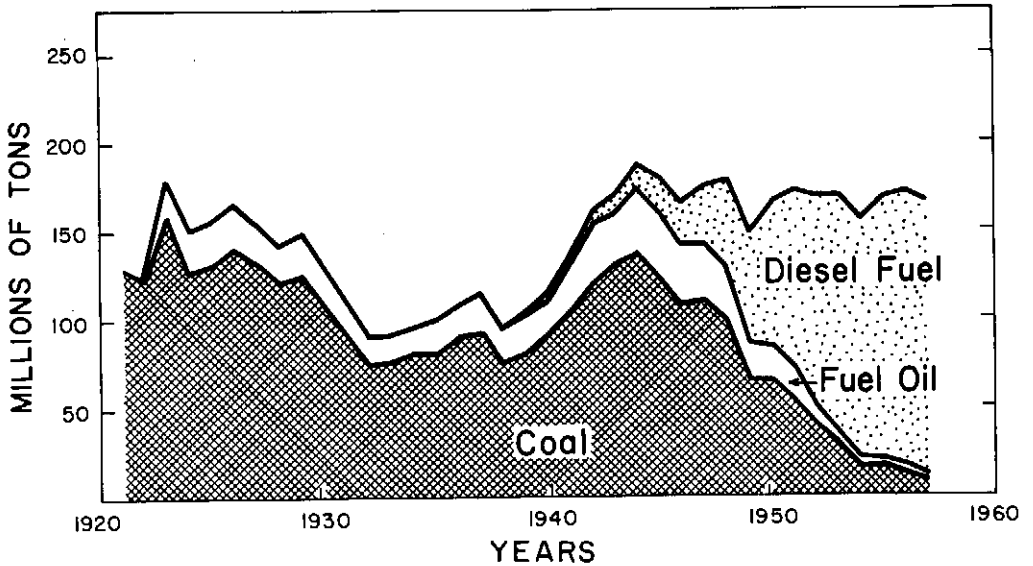


Fig. 7 - Railroad consumption of fuel in tons of coal equivalent

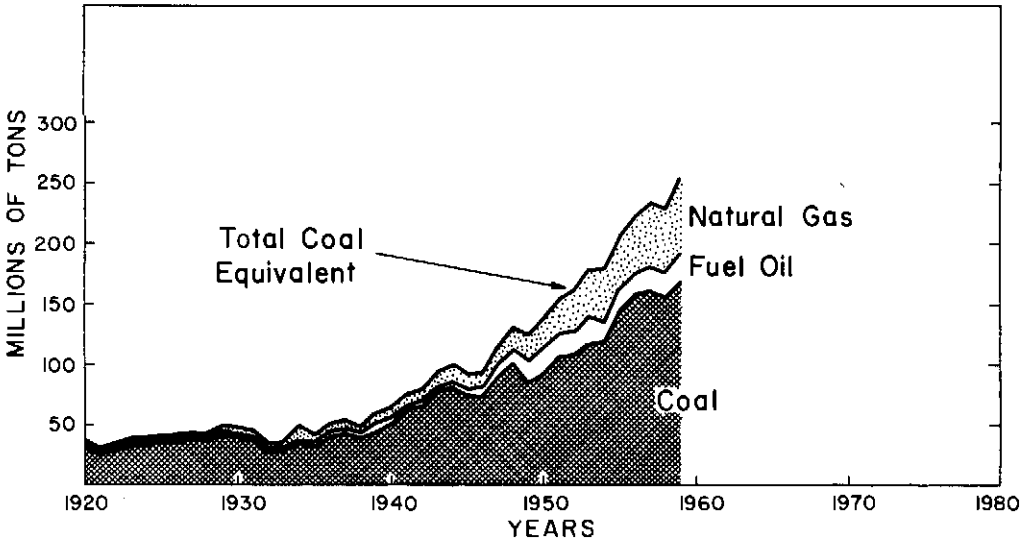


Fig. 8 - Consumption of fuel by electric utilities in tons of coal equivalent

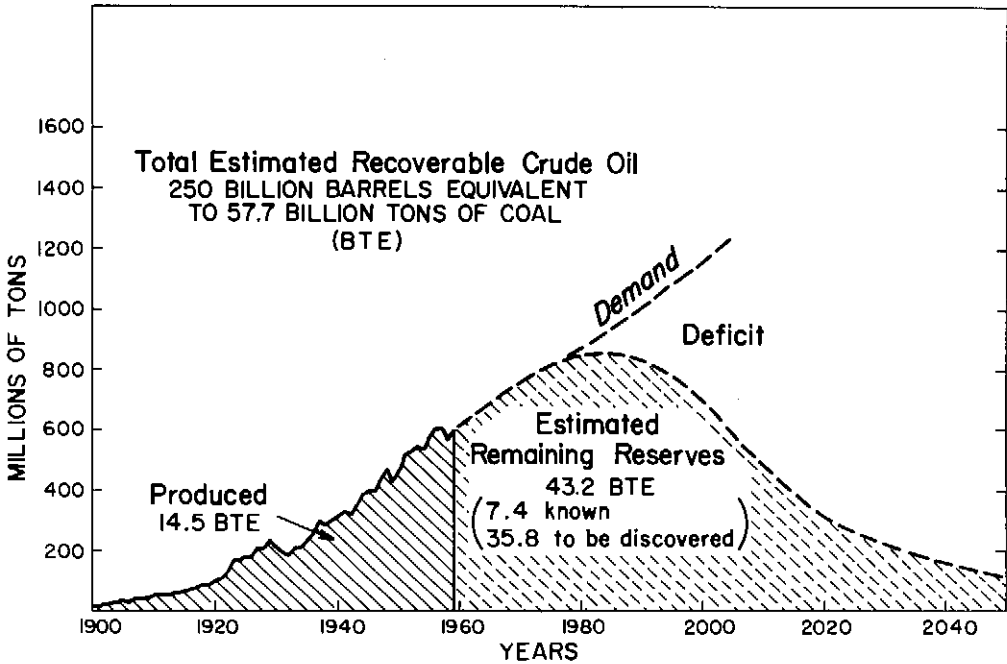


Fig. 9 - Past and projected United States production of crude oil in millions of tons of coal equivalent

be in a difficult competitive position. And there appears to be no reason to anticipate any rapid change or really significant gains in coal use in the immediate future except in electric power. There is, however, considerable evidence that within the next 15 to 20 years the situation will be different (fig. 2), the changes stemming from the continuing growth in energy consumption and the impending deficits of other fuels. The only basis on which an earlier change is at all likely to occur is on a major shift in relative fuel prices. The likelihood of such a shift is greatly lessened by gas price regulation and the availability of low cost foreign oil.

Figure 9 shows a typical mineral production curve applied to estimated petroleum reserves within the United States. The bell-shaped pattern is typical of curves of production for any mineral deposit or group of deposits. Production increases until almost half of the deposit has been recovered, then gradually levels off. When one-half to two-thirds of the deposit is depleted, production gradually declines. As the deposit nears exhaustion, the production tapers out at a low level over a long period of time.

The area under the curve represents the total recoverable oil reserves originally existing in the United States. Geologists have estimated total recoverable United States reserves of oil at 250 billion barrels; this is equivalent to 57.7 billion tons of coal.

By the end of 1959, a total of 14.5 billions tons equivalent had been produced. Of the remaining 43.2 BTE, 7.4 are known and 35.8 are yet to be discovered.

The annual production of oil in past years is shown by the production curve to 1959. Future demand beyond 1959 is projected as shown on the chart. As the production gradually levels off and demand continued upward, the curves begin to diverge. The distance between these curves represents a deficit that must be made up from other sources. This deficit is expected to appear first during the 1970's and will continue to increase thereafter.

Figure 10 shows the same procedure applied to United States natural gas reserves. Past experience indicates the occurrence of natural gas at a ratio of approximately 6 Mcf per barrel of recoverable oil. Because the heat content of an Mcf of gas is approximately one-sixth that of a barrel of oil, the total BTE of gas is estimated to be equal to that of oil. This chart, showing a total gas recovery of 1500 trillion cubic feet, indicates a bituminous coal equivalent of 57.7 billion tons.

Past production of gas has amounted to 6.7 BTE, or less than half that of oil, in terms of energy content. However, demand and production of gas are rising at a more rapid rate than those of oil. As a result, the deficit of gas will occur at about the same time as that for oil, in spite of the greater remaining reserves of gas at the present time.

Most authorities who have studied the subject agree that the deficits shown on figures 9 and 10 will occur at about the time indicated. It is the general consensus, too, that the gap will be filled through the manufacture of gas and liquid fuel from coal, oil shale, and tar sands. I believe that this will undoubtedly occur in order to provide supplies of liquid fuel and gas for those uses in which they are essential. Some energy also will be provided by nuclear energy, and perhaps smaller amounts will be obtained from wind, solar, fuel cell, and other devices. Electricity will provide a substitute for some uses, too. But it appears logical that in many of the uses of gas and oil, where coal can perform the required service in its natural state, a reconversion to coal will take place. Where coal cannot be used directly, it will play an important role through gasification and liquefaction.

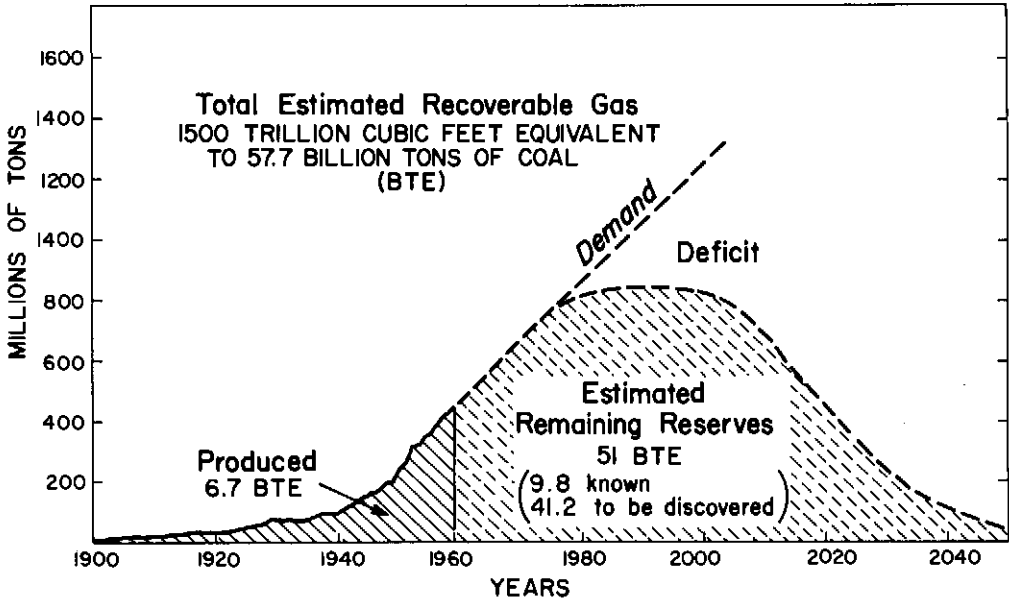


Fig. 10 - Past and projected United States production of natural gas in millions of tons of coal equivalent

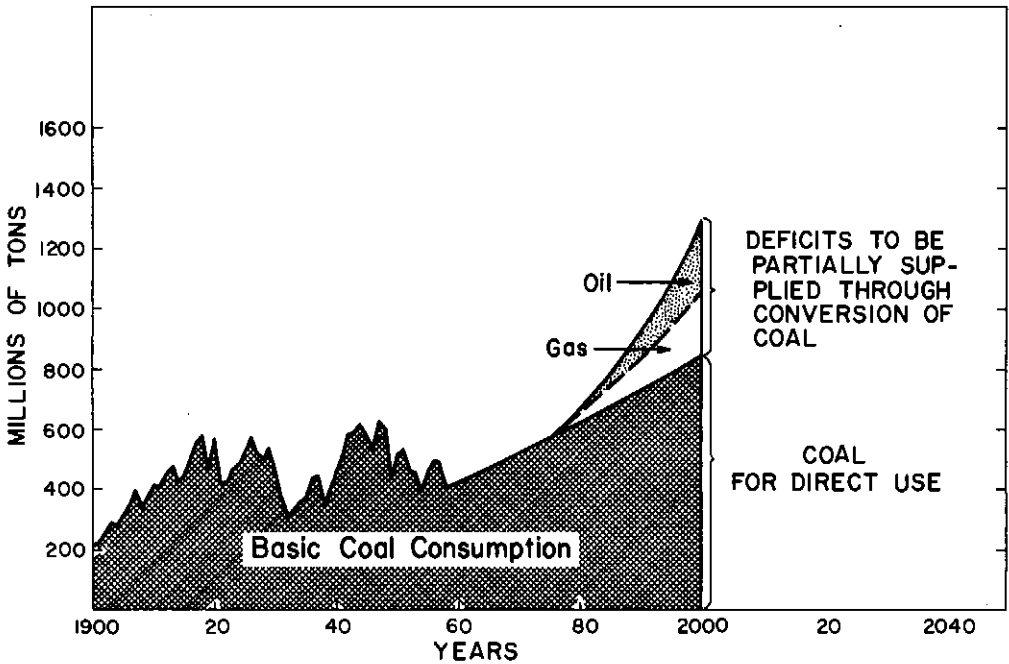


Fig. 11 - Past and projected United States production of bituminous coal

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CONCLUSION

Figure 11 shows the past production and projected consumption of coal in the United States. Up to 1959 the chart represents actual production. To the right, the lower portion of the projection represents anticipated basic consumption. The net increase shown is based on an increasing use of coal for the production of electric power and will carry basic consumption to an estimated 630 million tons by 1980 and to 850 million tons by the year 2000. Although fluctuations in activity may cause production to surge above or drop below the level shown, the basic long-term trend is apt to be fairly close to that shown. Beyond 1975, the declining availability of gas and oil will provide coal an opportunity to enter new markets and regain old markets. How much of the market coal can gain will depend upon its ability to compete with other substitutes for oil and gas. Meanwhile the basic growth will help to strengthen the coal industry so that it will be better able to take advantage of the opportunities and challenges of the last quarter of the twentieth century.



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