

The values on this chart indicate a cumulative 1970 requirement of 12,000 million tons of coal plus 172 billion bbl of oil plus 800 trillion cu ft of natural gas. The tremendous increase in nuclear energy indicates the need for an accelerated exploration program to locate economically obtainable reserves of uranium and other fissionable materials. Our presently known U.S. reserves of uranium are estimated to be adequate only through about 1981; however, the need for nuclear fuel will create an extensive exploration program. The reserves of fissionable nuclear fuel required will be significantly affected when the breeder reactor becomes a commercial reality, probably by the mid-1980s.

The history of the past indicates, for all fuels, that the amount of proven reserves is a direct function of the amount of exploration.

Although the problems of future supply are tremendous, these projections of future energy consumption are based on the assumption that the required reserves will be available either by U.S. production or by imports from other countries.

U.S. raw-energy reserves and sources. Fig. 4 shows the breakdown into major energy sources—oil and commercial, industrial, transportation, and electric generation—as a percentage of the total energy consumption each year. Here 100 percent equals 15,000 trillion Btu in 1960, increasing to 17,000 trillion Btu in 1990 as shown in Fig. 3.

Fig. 5 illustrates the percentage of raw energy provided by the various types of fuel resources for each of these major raw categories. Only 1970 and 1990 are shown to avoid making the charts too complicated and to illustrate a reasonably long-term trend of 20 years. Coal, oil, and gas are the principal raw-energy sources for direct use in the household, commercial, and industrial markets. Today coal is a major contributor to household and commercial energy use. This market is served primarily by gas and oil because of source proximity for the convenience of these fuels. We expect this situation will continue into the future.

For industrial use, coal is a significant energy source and provides only about 25 percent of industrial raw-

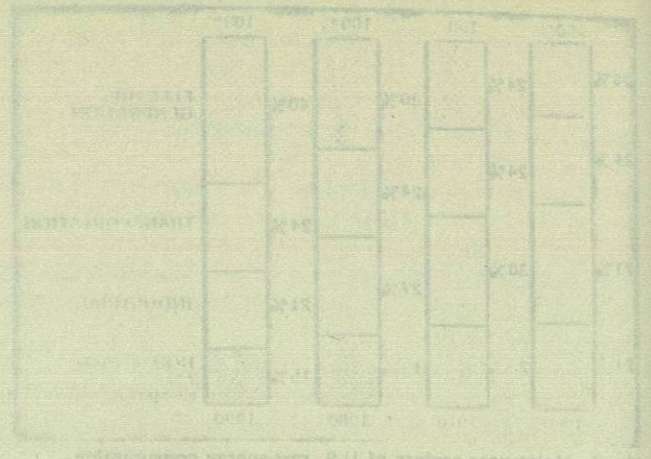
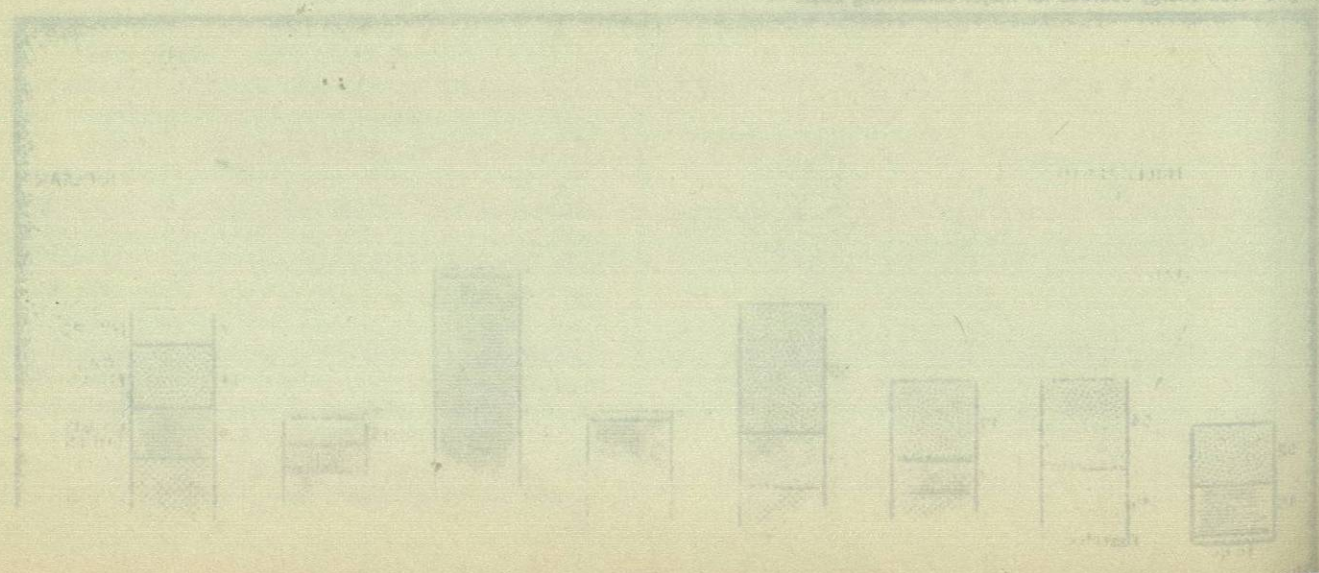


Fig. 4 Major energy sources for U.S. raw-energy consumption.

energy and the reduced rate of increase in coal through requirements in the future.

Our proven U.S. oil reserves of about 30 billion barrels are only equal to about 11.8 years' supply at the 1970 consumption rate (as against 12 years in 1960). There are "probable" additional reserves of about 100 billion barrels (equal to perhaps 100 years' supply at the 1970 consumption rate). About 25 percent of our oil needs are imported. The huge reserves reported available in Alaska are only equal to about three years' supply at the 1970 rate of consumption. The same applies to the rate at which new oil reserves must be discovered and proven through an accelerated exploration program.

Our U.S. proven gas reserves of about 300 trillion cu ft are only equal to about 13.3 years' supply at the 1970 rate of consumption (as against 20 years in 1960) and there are probable additional reserves equal to 21 or more times the 1970 consumption.

In recent years, the annual rate of new discoveries of oil and gas has been less than our annual rate of consumption, resulting in decreasing reserves-to-production ratios.

An increase of 50 percent in annual oil consumption and 75 percent in annual gas consumption during the next 20 years certainly indicates the magnitude of the exploration program required both in the U.S. and abroad to locate new reserves and develop new wells and transportation techniques.

Fig. 5 Raw-energy sources for major consuming areas.

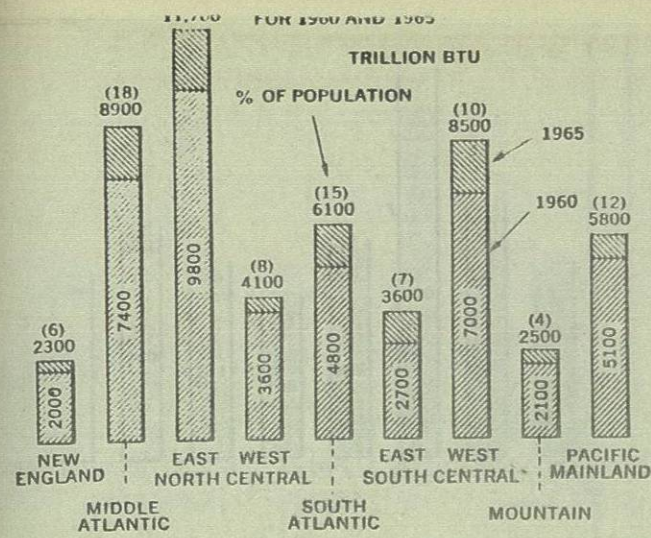


Fig. 6 Total energy consumption by U.S. census divisions.

energy needs today and will decrease to about 22 percent of industrial needs by 1990. About 75 percent of industrial raw-energy needs are furnished by petroleum products, gas and oil, and we expect that this pattern will continue into the future.

These values represent only the gas, oil, and coal consumed directly by the household, commercial, and industrial markets.

Fig. 5 also shows that practically all raw-energy requirements for transportation are provided by oil products, with a very minor percentage furnished by natural gas. We expect this situation to continue into the foreseeable future, because there is no indication today that the internal-combustion engine will not remain the primary source of motive power.

Consumption of fuel energy for the production of electric power is, however, both interesting and dramatic. Today, 46 percent of electric power is produced by coal, 12 percent by oil, 25 percent by natural gas, 15 percent by hydro, and only 2 percent or less by

Census Division	Population (Millions)	Energy Consumed (Trillion BTU)
New England	10	8900
Middle Atlantic	18	9800
East North Central	8	4100
West North Central	15	6100
South Atlantic	7	3600
East South Central	10	8500
West South Central	4	2500
Mountain	12	5800
Pacific Mainland	12	5800

nuclear energy. By 1990, however, nuclear sources will account for 49 percent of electric energy produced, hydro will account for only about 7 percent, and the consumption of gas, oil, and coal for electric power generation by coal will decrease dramatically. The percentage generation by coal will decrease from 46 to 21 percent, oil from 12 to 9 percent, and gas from 25 to 14 percent.

These changing patterns, the increasing reliance on nuclear and the decreasing reliance on fossil fuels and water power, are based simply on economics. The electric power industry has no preference for any type of fuel. It will use whatever raw-energy source is the most economic to produce electric power and energy at the lowest possible cost.

As the availability of fossil fuels decreases and the cost of fossil fuels increases, it will become more and more economic to use nuclear energy for electric power generation.

Water power will become a less important source of electric power, simply because our more advantageous hydro sites have already been utilized.

Even though the percentage participation of these fuels in electric power generation will decrease, it is evident that the absolute quantities of coal, oil, and gas required for electric generation will increase substantially. For example, consider coal: 21 percent of 60,000 trillion Btu in 1990 is 70 percent more coal than is represented by 46 percent of 16,000 trillion Btu in 1970. The same type of comparison for oil and gas indicates that during the next 20 years the annual consumption of oil for electric power generation will increase by 180 percent, and gas by 110 percent.

It is clear that we are on the threshold of the nuclear era. In the next 20 years, nuclear energy will increase from less than 2 percent to about 49 percent of energy needs for electric power production, while at the same time customer preference will increase electric energy from 24 to 40 percent of the total energy consumed in the U.S. annually. The net effect is that during the next 20 years, nuclear energy will increase from less than 1 percent to about 20 percent of total U.S. raw-energy needs.

**Energy-Use Patterns**

Until recently, few data had been published to show how much of our total annual energy was consumed in different parts of the country. The Bureau of Mines, in 1970, published such data (Information Circular IC8434) for the years 1960 and 1965.

Fig. 6, derived from that report but with all values rounded out for simplicity, indicates the energy-use pattern by U.S. census divisions for 1960 and 1965. Table 2 lists the states included in each census division to assist in understanding this and Figs. 7 and 8.

These energy-consumption values include all energy for all purposes. They include the direct use of fuels, as well as the fuels energy consumed in the generation of electric power.

Fig. 6 indicates that, broadly, energy consumption is population-related. See also Table 3. While, in general, energy consumption is population-related, it is evident that there are important differences among the several census divisions, probably related to the



These changing patterns, the increasing reliance on nuclear energy, the 1960s, however, nuclear sources will account for 10 percent of electric energy produced, hydro will account for only about 7 percent, and the consumption of gas, oil, and coal for electric power generation by coal will decrease dramatically. The percentage generation by coal will decrease from 40 to 31 percent, oil from 13 to 9 percent, and gas from 25 to 14 percent.

As the availability of local fuel decreases and the cost of local fuel increases, it will become more and more important to the nuclear energy for electric power generation.

Water power will become a less important source of electric power, simply because our more advanced hydroelectric plants have already been utilized.

Even though the percentage participation of these sources in total electric power generation will decrease, it is estimated that the electric generation of coal, oil, and gas will increase. The electric generation will increase and the percentage of total electric generation will increase from 40 percent in 1960 to 44 percent in 1970. The amount of coal, oil, and gas consumed in the electric power generation will increase by 10 percent, and gas by 110 percent.

It is clear that we are on the threshold of the nuclear era. In the next 20 years nuclear energy will increase from less than 2 percent to about 40 percent of energy. The electric power production, which at the same time electric production will increase electric energy from 41 to 49 percent of the total energy consumed in the U. S. annually. The net effect is that during the next 20 years nuclear energy will increase from less than 2 percent to about 30 percent of total U. S. energy.

Both energy law data had been published to show the amount of our total energy was contained in different parts of the country. The Bureau of Mines in 1958 published such data (Information Circular IC-7454) for the years 1960 and 1965.

Fig. 8 derived from that report but with all values rounded out for simplicity, indicates the energy use pattern by U. S. census divisions for 1960 and 1965. Table 2 lists the states included in each census division to assist in understanding this and Figs. 7 and 8.

These energy consumption values include all energy for all purposes. They include the direct use of fuels as well as the total energy consumed in the generation of electric energy.

Fig. 8 indicates that broadly energy consumption is concentrated. See also Table 3. While in general energy consumption is population-related, it is evident that there are important differences among the several census divisions, probably related to the

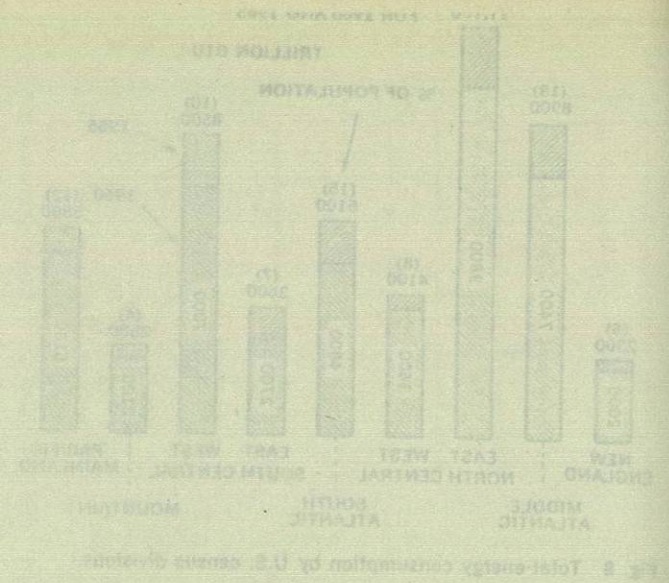


Fig. 7 Per capita energy consumption by U.S. census divisions.

differences in the nature of the economic activity, although a clear pattern is not evident from these statistics.

Fig. 6 also indicates the increase in energy consumption in each census division between 1960 and 1965. The total energy consumption in each division and the rate of increase in energy demand in each division give a clear indication of where energy resources must be delivered for use, and consequently the expansion required in facilities for transportation of fuels from areas of origin to areas of use, in facilities for storage and distribution of fuels, and in the energy companies' marketing efforts.

For example, between 1960 and 1965, energy consumption in the New England division increased from 2000 to 2300 trillion Btu, or only 15 percent. The increase was 15 percent or less in the West North Central and Pacific Mainland divisions. In all other divisions, the increase was about 20 percent or more, ranging up to 27 percent in the South Atlantic and 33 percent in the East South Central divisions.

Per Capita Consumption. Fig. 7 illustrates the per capita consumption of energy in 1960 and 1965. The lowest per capita energy consumption is in the New England division and in the South Atlantic division, comprising the states of Florida, Georgia, North and South Carolina, Virginia and West Virginia, Maryland, and Delaware. These areas have no significant indigenous resources of gas or oil, and except for West Virginia have no significant reserves of coal.

The highest per capita consumption is in the West South Central division, comprising Arkansas, Louisiana,

TABLE 3 1965 Population and Energy-Consumption Percentages for U.S. Census Divisions

Division	Population, Percent	Energy, Percent
New England	6	4
Middle Atlantic	18	16
East North Central	20	22
West North Central	8	8
South Atlantic	11	11
East South Central	7	7
West South Central	10	16
Mountain	4	5

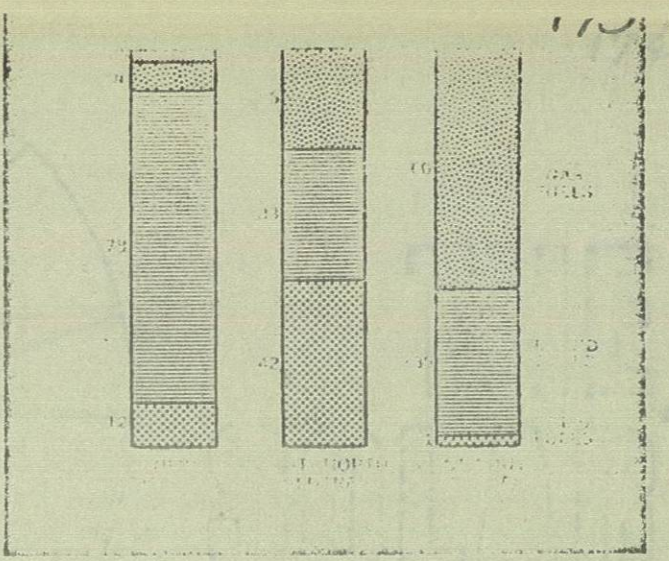


Fig. 8 Total energy consumption for selected census divisions, 1965, percentage by sources.

Oklahoma, and Texas, the area having the bulk of our U. S. reserves of gas and oil, probably about 75 percent or more.

Significantly, the energy consumption per capita in the areas having substantial reserves of gas and oil is more than twice that of areas deficient in fuel reserves.

Table 4 is a summary of the 1965 sources of energy consumed in each census division in terms of percentage of the total consumption for that division.

Summary

From these data and predictions it seems evident that:

- 1 Total energy consumption is related to population growth, and in the U. S. is increasing at a rate of about three times that of population.
- 2 Consumption of energy, in all forms, is a vital ingredient in our economic growth, in the continuing improvement in our standard of living, and in increasing income per capita.
- 3 Consumption of energy presents environmental problems, but means will be found to control the environmental impact without having to reduce our appetite for energy.
- 4 The energy sources that will be used and the form in which energy is used are related to technological developments, the availability of fuel resources, and consumer preferences. It is expected that all of these factors will result in electric power becoming an ever larger source of energy to the ultimate consumer in the decades ahead.

TABLE 4 Percentages of Census-Division Total Consumption of Energy Sources

Division	1965 Percentage			
	Coal	Oil	Gas	Water Power
New England	12	78	8	2
Middle Atlantic	30	51	16	3
East North Central	42	33	25	—
West North Central	16	43	38	3
South Atlantic	32	50	16	2
East South Central	39	31	25	5
West South Central	1	39	60	—
Mountain	14	37	39	10