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ENERGY

by

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In this essay, the term energy has its popular and not its scientific meaning. It refers to the property of matter that is consumed in performing useful tasks such as lighting, heating, transportation, and manufacturing.

Over the past few decades, world energy consumption, expecially oil and gas, has been increasing faster and faster (Figure 1).

With about 5% of the world population and 30% of the world goods and services, the United States consumes about 30% of the world energy. The demand by the various sectors of the economy is shown in Figure 2. In 1979, it was equivalent to about 40 million barrels of oil* per day, including the share for nonenergy applications. Nonenergy applications refer to the use of fuel as feedstock in the manufacturing of such products as petrochemicals, lubricants, and steel. The energy demand beyond 1979 is an estimate and not a forecast.

The energy was supplied by the sources shown in Figure 3. In 1979, about 45% of the oil (22% of the total) was imported and about 30% of all supply was used for the generation of electricity. Supplies beyond 1979 are estimates and not forecasts.

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* 1 barrel of oil $\simeq 6 \times 10^6$ Btu

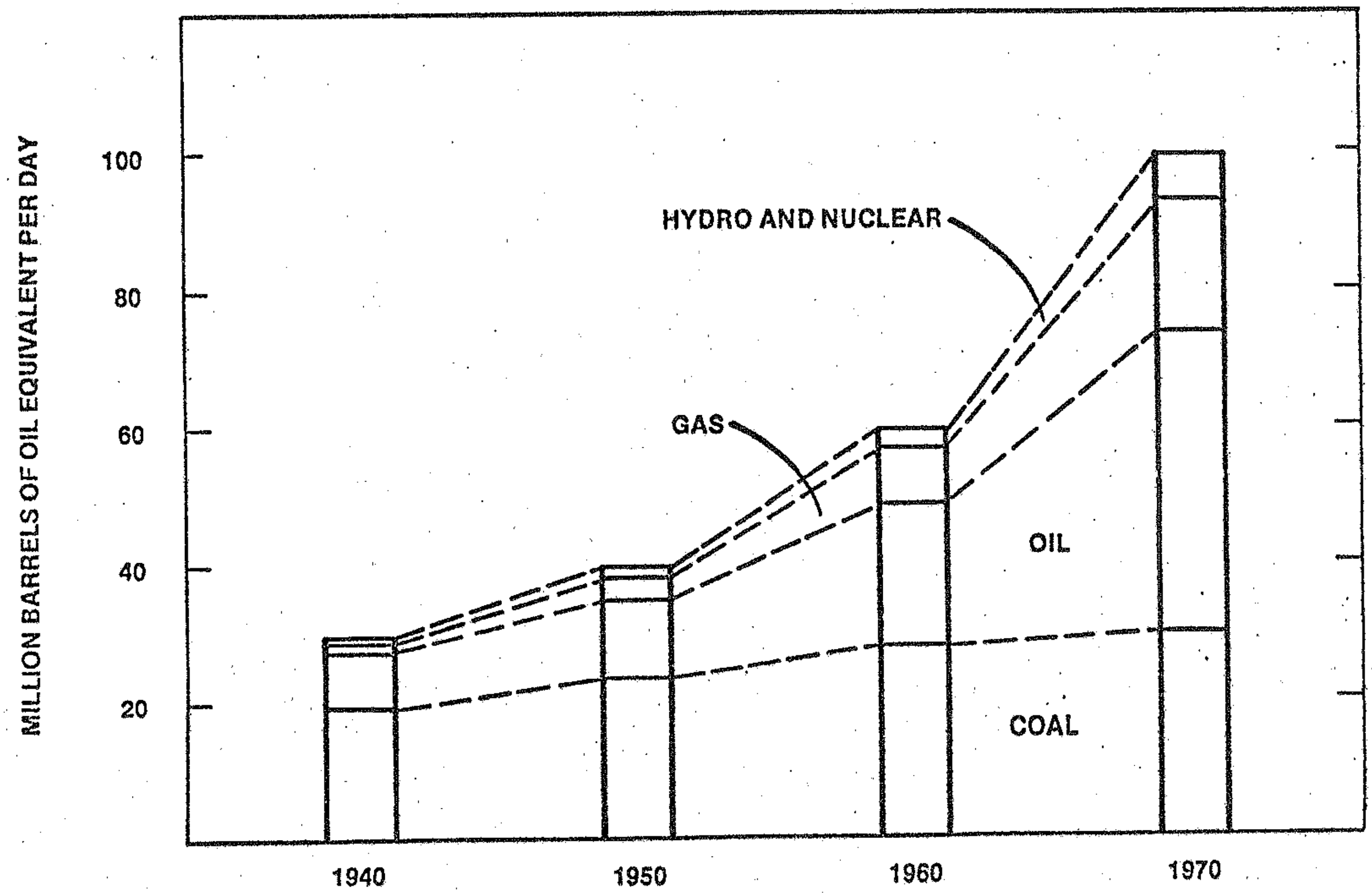


Figure 1

World energy consumption in the post World War II years

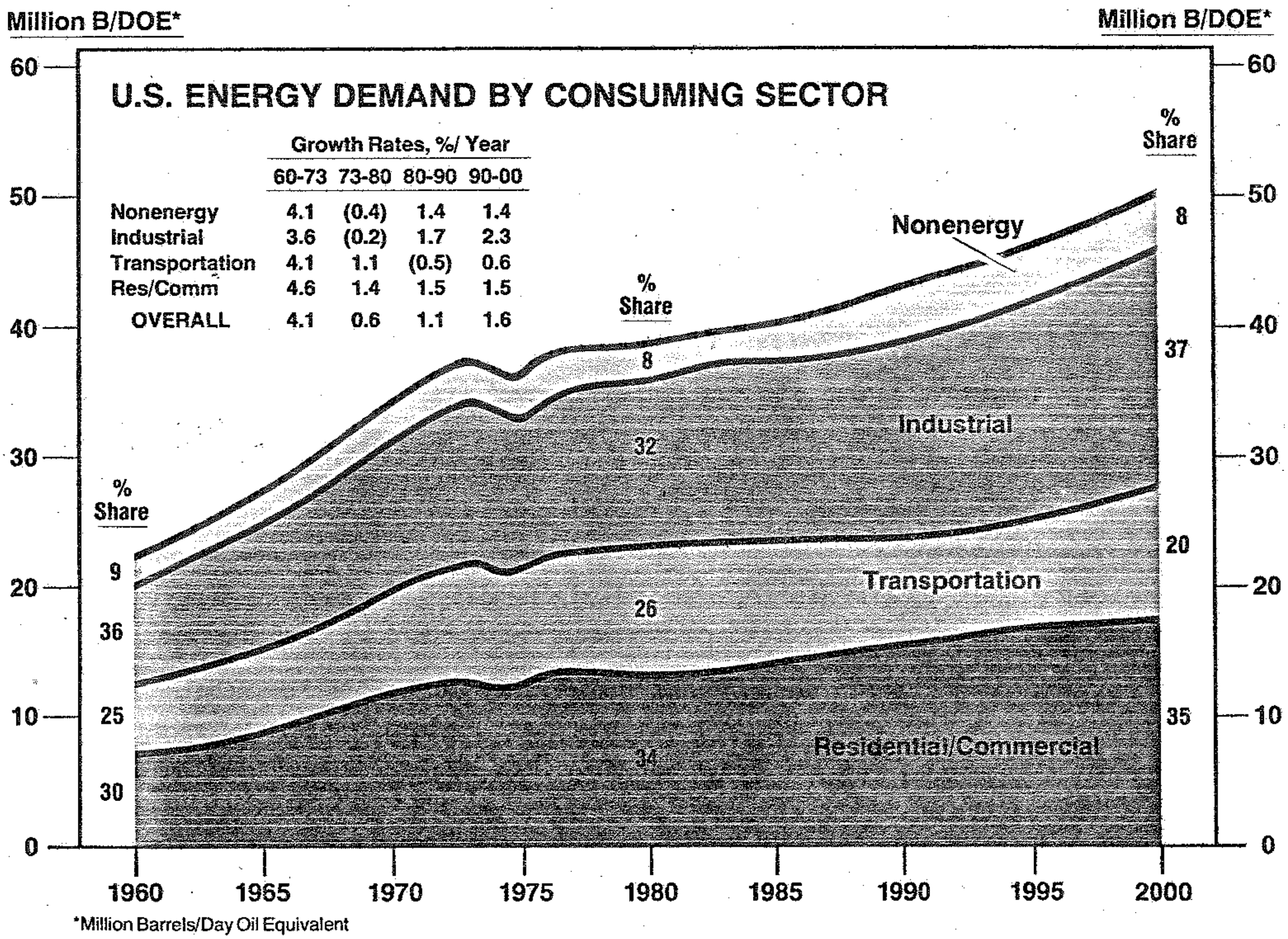


Figure 2

U.S. energy demand by consuming sector. Estimates beyond 1979 were made on the basis of the growth rates of the various sectors listed on the figure. Source: Energy Outlook 1980-2000, Exxon Company, December 1979.

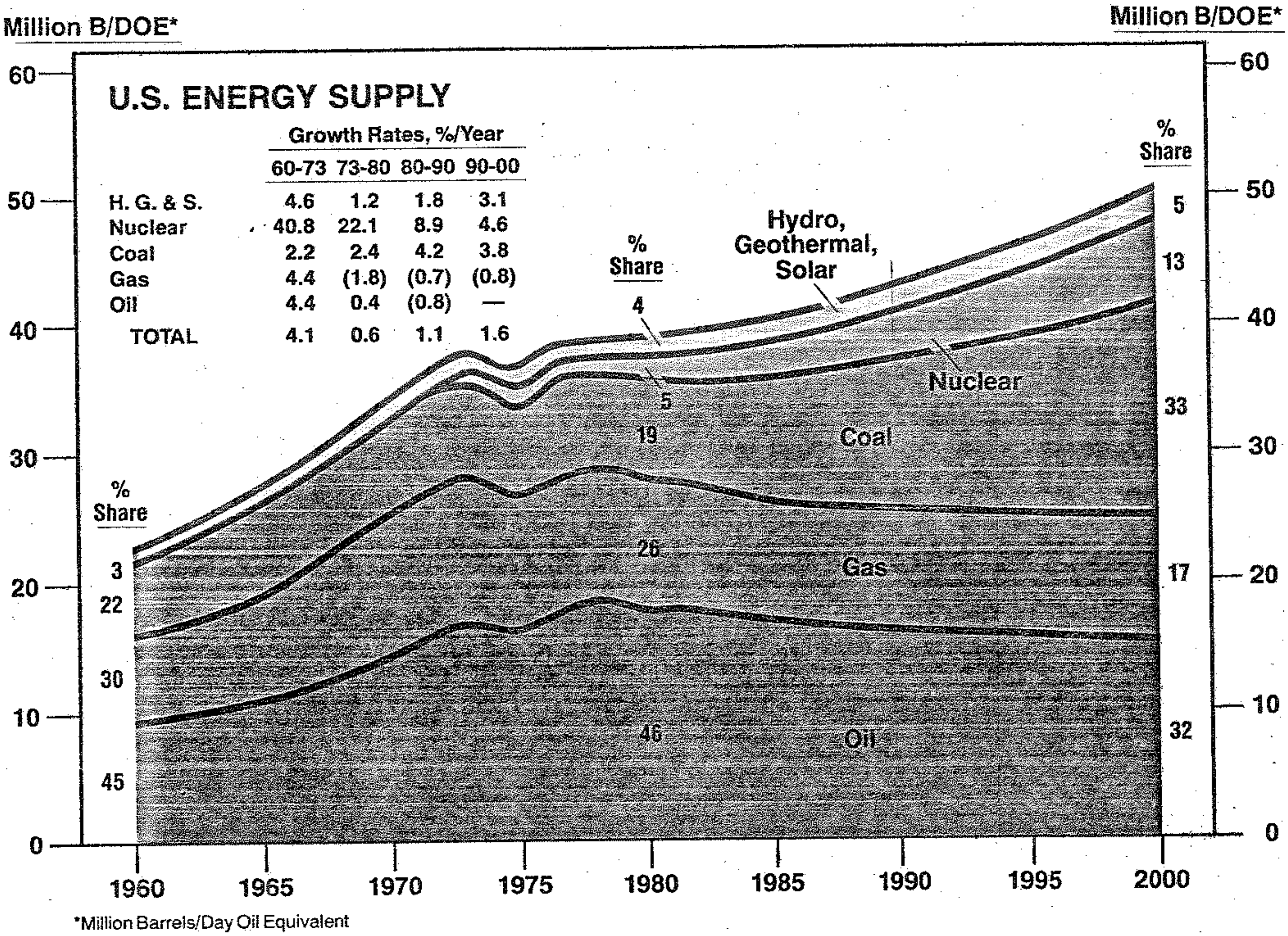


Figure 3

U.S. energy supply. Estimates beyond 1979 were made on the basis of the growth rates listed on the figure. Source: Energy Outlook 1980-2000, Exxon Company, December 1979.

The rapid growth in liquid and gaseous fuels up to about 1970 is understandable. Such fuels were being discovered at rates higher than production, and at relatively low cost. Reserves were doubling every 5 years whereas extraction was doubling every 10 years. The cost of extraction of a barrel of oil was only a fraction of a dollar. The economies of many nations were booming.

Around 1970, however, the euphoria about plentiful and cheap oil and gas took a dramatic turn. In the United States, discoveries of new reserves were not coming on stream as fast as the production required. In the mid-50's, 1-1/4 barrels of oil was being discovered for each barrel extracted, but by the early seventies this had dropped to about 1/2 barrel. Capital investments in new supplies were orders of magnitude higher than those expended in the past. The investment in the North Sea was of the order of $10,000 per daily barrel of capacity whereas the investment for the same capacity in the Middle East used to be only a few hundred dollars. Synthetic fuels are estimated to cost even more.

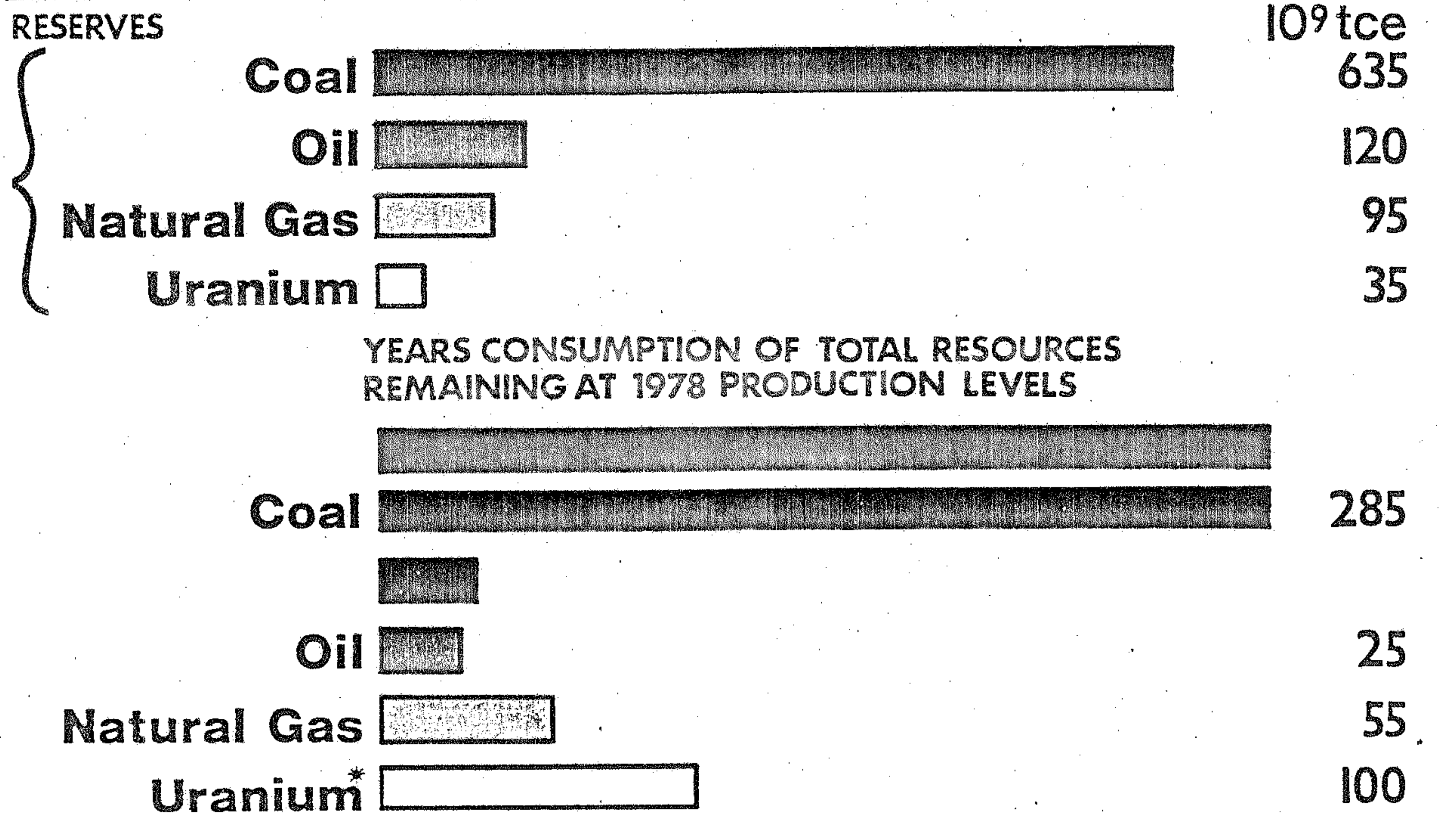
Awareness that oil is a finite resource and the attendant concern over its future availability have become topics of general concern. No one can be sure about the amount of oil and other fuels that are still in the ground. Nevertheless, all agree that oil, gas and coal are exhaustible resources and cannot last for a long time. An estimate of what remains to be recovered is shown in Figure 4.

Even with modest rates of economic growth, world demand for energy will continue to rise. For the United States, an estimate of future demand is

Figure 4

WORLD ECONOMICALLY RECOVERABLE ENERGY RESERVES AND RESOURCES

(tce = tons coal equivalent)



*ESTIMATED, ASSUMING 1978 NUCLEAR ELECTRICITY GENERATING CAPACITY & TECHNOLOGY

Source: Shell Coal estimates based on industry & official sources shown in Figure 2. Because the principal energy supplies we currently use are finite and their replacement expensive, energy prices will continue their spiraling rise. Save a miracle, it does not seem likely that we will ever return to an era of low-cost energy. Can we arrest this rise to a new plateau without turning the clock back to the "good old days" that were terrible for most people? No one can give a sure and simple answer because no such answer has been found. I believe in a positive answer provided we make long term commitments to increase both energy production and energy productivity. The path is long and painful but less so than other solutions.

For the long term, say well into the next century, at least one entirely new major energy source must be developed. By then all sources of energy currently in use will be inadequate. Only three possibilities exist: the sun, nuclear fusion, and nuclear fission with breeding. Each of these possibilities has its own set of scientific, technical, economic, safety, and political problems and uncertainties. As a result, none is a sure bet at the present time. All three must be researched and developed concurrently with the anticipation that 40 to 50 years from now at least one will become the winner.

During the transition to a new major energy source, principal supplies that can substitute for oil are coal (directly or in the form of synthetic fuels), gas, nuclear energy from present generation reactors (light water reactors with enriched uranium, and heavy water reactors with natural uranium), oil from shale and tar sands, solar energy for low temperature (low thermodynamic availability) applications and a number of other resources (i.e., geothermal energy). Each of these supplies has its own combination of technical, economic, environmental and institutional problems that can and must be resolved. The list of issues and controversies is too long to analyze here. Three points, however, need stressing:

- The price of energy should be allowed to find its competitive level in the market. It is counterproductive to regulate the price of a valuable commodity. Regulations preclude the deployment of expensive alternatives such as solar energy, and discourage energy-saving investments such as better insulated buildings.

- None of the transition supplies can by itself make a sufficiently large contribution at a cost we can afford so as to overshadow all the others. All are needed and essential.

- The resolution of the issues and controversies surrounding energy should be balanced. It does not make sense to require no risk from one source, such as nuclear reactors, and yet tolerate the risks of another, such as coal burning.

The deployment of additional energy supplies is only one half of the response to the need to limit the spiraling price of energy to a new plateau. The other half lies in increasing energy productivity.

For each task in the economy resources should be allocated so as to maximize the benefits. Energy and other inputs should be used in such proportions as to achieve the same products and services at the lowest cost. In the 1970's, because of rampant inflation all prices have been rising. But energy prices have been rising much faster than the costs of labor and capital investments. Hence, an economic opportunity exists for replacing expensive energy by other lower cost factors of production.

Correct use of the laws of physics and thermodynamics indicates that the average thermodynamic efficienty of energy end-use in the U.S. economy is about 10%. Hence, a large margin exists for improvement in practically every sector of the economy. Of course, the average efficiency will never approach 100%. Nevertheless, the present low value emphasizes the enormous opportunity for substantial improvements both by means of known technology and through radical modifications of processes.

How much energy could be saved through cost-effective known technology? No one knows the answer for sure. Comparisons with other nations that experienced expensive energy before we did in the U.S. and results of many studies suggest an average of about 25% over a period of a decade.

To achieve large and practical increases in energy end-use efficiency, we must make a long-term commitment in research and development of entirely new, cost-effective processes for every sector of the economy. Such a commitment holds the promise of yielding (saving) energy comparable to that of a major new energy supply indefinitely. It should therefore be given high priority.