The Fossil Fuel Era—A Blip on the Scale of Time
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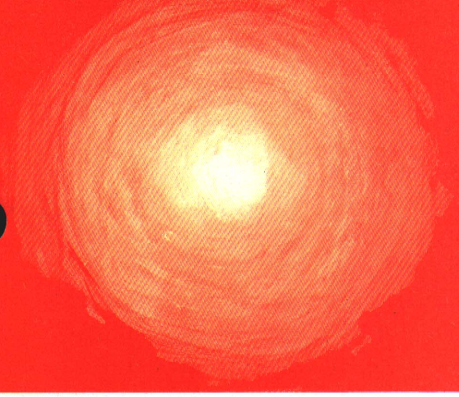

ENERGY FACTS

Cooperative Extension Service
Michigan State University

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The Fossil Fuel Era–A Blip on the Scale of Time[1]

Never before has the security of critical resources for so many people been so threatened. We enter the last quarter of this century with a growing awareness of the inevitable decline in fluid fossil fuels. There is no assurance that substitutes can be made available in the quantities needed for the industrialized world. And, we might not be able to develop and implement known alternative technologies fast enough to compensate for this decline.

The transition from a fossil-fuel-based economy to an alternative energy economy is essential, but it will take time. It will involve modifications in land-use patterns and changes in life style, but it does not necessarily imply a reduction in the quality of life (7).[2] Uncertainties of the future center not so much around the technical aspects of our energy resources but around the socioeconomic and cultural problems of adjustment. Particularly crucial is the time span over which the adjustments will occur and the degree to which they can be planned and managed with social justice and economic order.

FOSSIL FUEL RESERVES — IN SHORT SUPPLY

All land, water and material resources are limited in quality and quantity. The accompanying graphs show the rate at which our fossil fuels and other resources are being depleted. Figure 1 shows U.S. crude-oil production from 1850 to 1956 and the projection through 2050. Two estimates of future production are included indicating the United States has reached its maximum production rate. Peak usage of world crude-oil production is expected to occur before the turn of the century, as is evident from Figure 2.

Growth in domestic oil and natural gas production is presented in Figures 3 and 4. Production cycles for domestic and world supplies of coal are shown in Figures 5 and 6. Most high-grade uranium ore has already been discovered (see Figure 7) and, if nuclear electrical power proceeds as planned, serious uranium shortages will likely develop in the late 1980s (6).

The increase in human population and its growing dependence on fossil energy reserves (largely petro-

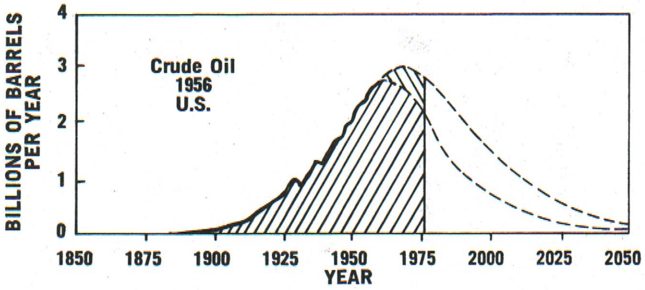

Fig. 1 — 1956 prediction of the date of peak in the rate of U.S. crude-oil production (2).

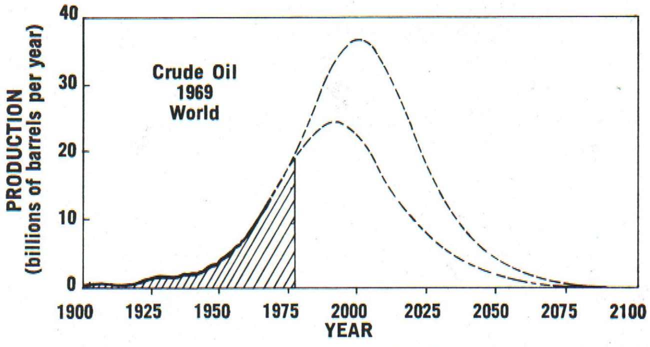

Fig. 2 — Complete cycle of world crude-oil production for two estimates of total supply (3).

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[1] *Adapted from Koenig, H. et al. "Resource Management in a Changing Environment," DMRE-7615, by Bill A. Stout, professor, and Claudia Myers, research assistant, Department of Agricultural Engineering, Michigan State University, East Lansing.*

[2] *Numbers in parentheses refer to Bibliography on p. 4.*

leum and natural gas) — which have slowly accumulated over millions of years — is illustrated in Figure 8. Prior to 1800, population levels were held by natural forces, primarily by famine and pestilence, and technology for releasing energy from fossil reserves had not yet been developed. Between 1800 and 1975, both world energy use and world population increased dramatically. It is doubtful that such population growth could have been sustained without the use of fossil fuels for food production and transportation. The growth rates in energy consumption and population shown in Figure 8 are probably historical aberrations, rather than norms for predicting the future. Obviously the fossil fuel era will be only a brief period in the history of mankind, as illustrated in Figure 9 — a "blip" on the scale of time.

Many people believe there are scientific and technological solutions for all of our problems. But, inevitably, the laws of thermodynamics and limitations of the natural environment must become the foundation on which we base our resource management, economic expectations and cultural values.

LIMITATIONS TO ALTERNATIVES

The natural environment has a limited ability to accept the waste or residual materials and energy from our synthetic processes of production and consumption. There are two basic pollutants: organic com-

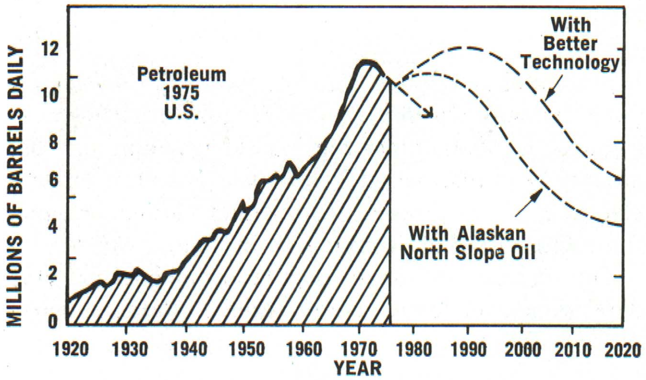

Fig. 3 — United States production of petroleum liquids (8).

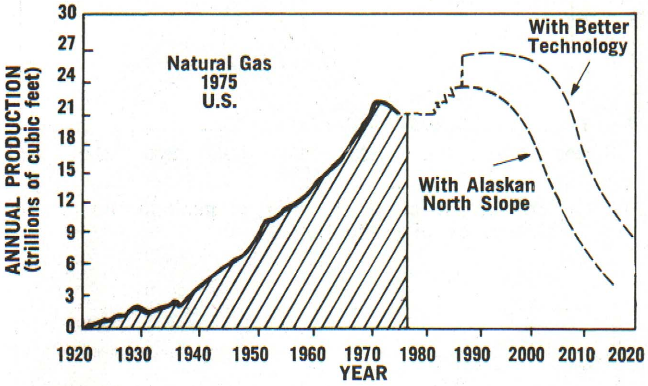

Fig. 4 — United States natural gas supply (8)

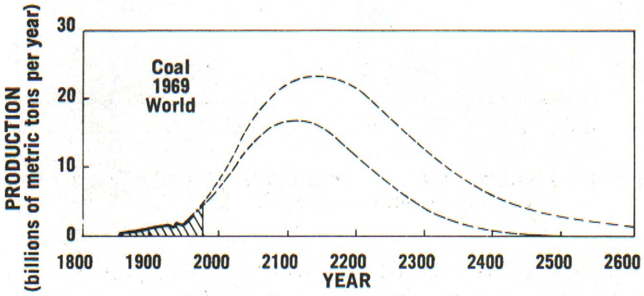

Fig. 5 — Complete cycle of world coal production for two estimates of total supply (3).

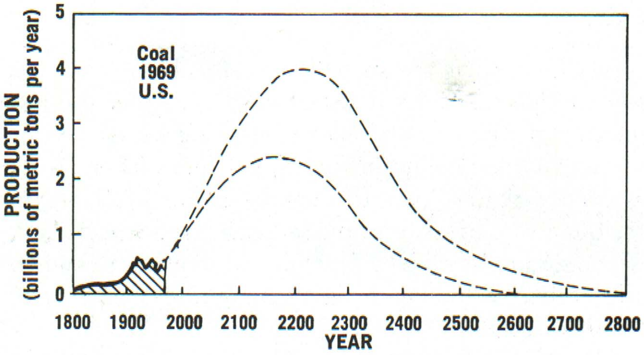

Fig. 6 — Complete cycle of U.S. coal production for two estimates of total supply (3).

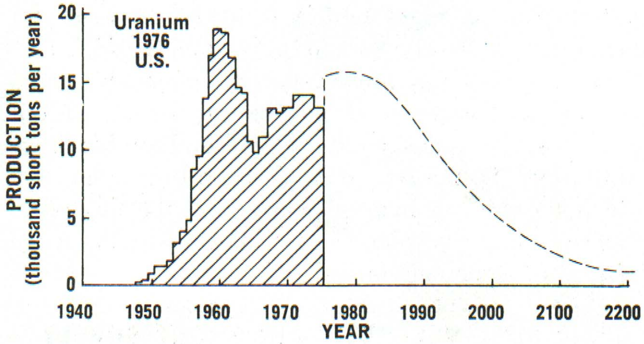

Fig. 7 — Cumulative production of uranium and cumulative discoveries of uranium as a function of time (6).

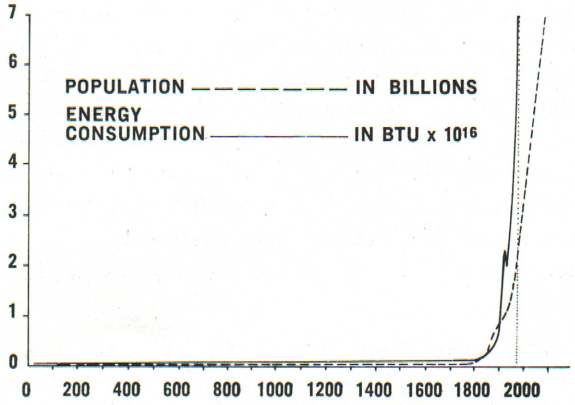

Fig. 8 — Energy consumption and population trends (5).

pounds and synthetic compounds. Organic compounds can be released into the natural environment for indefinite periods of time if properly managed, but the rate cannot exceed that which the environment can readily accept. However, synthetic compounds, such as DDT and PCB, are foreign to natural ecosystems and actually accumulate in the environment.

The capacity of the environment to tolerate waste materials is determined by the buildup and concentration to levels at which biological life becomes threatened. Once the tolerance levels are reached, the environment can no longer contain these residuals — the environmental resource has been depleted. Logically, these environmental constraints should be used to impose restrictions on the production and consumption processes, including chemicals and technology used, scale of operation and land use. Pollution abatement processes are costly, and attempts to rid the environment of waste materials by technical processing ultimately lead to frustration. This means that the capability of a regional environment to accept industrial wastes is a valuable resources of the region.

The laws of thermodynamics form a limiting framework within which technology must work. Basically, the first two laws state that while energy cannot be destroyed, it does change in form to a lower quality energy.

Central to industrialized societies is the transformation of heat energy into mechanical work. This transformation requires relatively high temperatures, and under ideal conditions less than 50 percent of the heat in fuels is converted into work through various engine types. The wasted heat is "unavailable" because it cannot be converted to mechanical form. But with proper management it could be used for its heat value.

In a modern electrical power plant, for example, little more than one-third of the heat produced from fuel combustion can be converted to electrical energy (a form of mechanical work). The remaining two-thirds, in principle, could be used for water heating, space heating and cooling, process steam and other relatively low temperature applications, but it cannot be used to produce additional work.

USING RESOURCES WISELY

Energy resources will probably never again be as abundant as they have been during recent decades. Solar energy in the form of wind and direct radiation, for example, is unreliable and relatively unconcentrated. Under the best conditions, major capital investments in energy, material resources and labor are required to concentrate and store energy derived from these sources. And, the future of nuclear energy is uncertain, both in terms of cost and availability.

Fortunately, there are many ways we can use existing resources more effectively without reducing our standard of living. In fact, such measures are essential to maintain our quality of life even though the technical cost of recovering and harnessing these resources will inevitably increase. Opportunities for more effective resource utilization fall into three categories: technical efficiencies, land-use patterns and product durability.

Technical Efficiencies

"Technical fixes" refer to improved thermodynamic efficiencies in production and consumption (1). These fixes could result in an annual savings of 30 to 40 percent of the present U.S. energy budget. Technical fixes relate to:

1. improved thermodynamic efficiencies at the final point of energy use (improved insulation, improved efficiencies in automobiles, household appliances, heating systems, etc.); and
2. improved thermo-efficiencies in the energy processing sector (power plants, petroleum refineries,

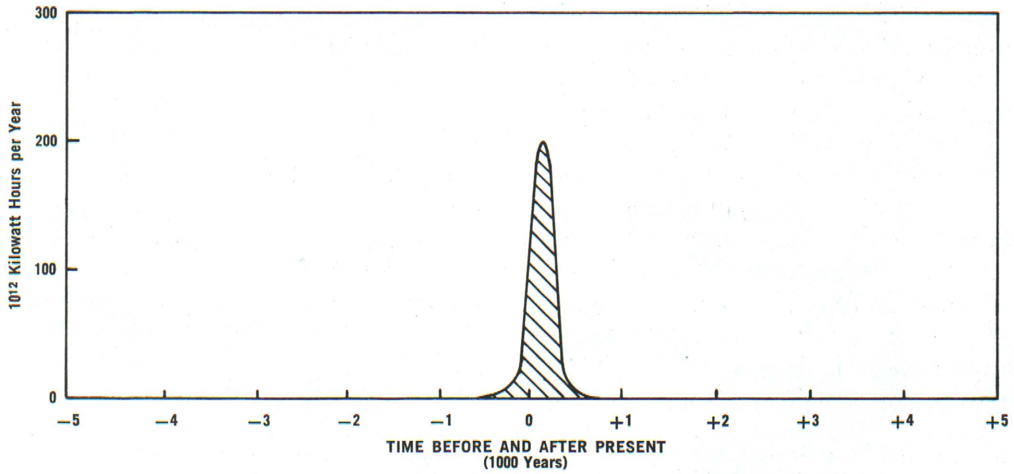

Fig. 9 — Epoch of fossil-fuel exploitation in perspective of human history from 5000 years in the past to 5000 years in the future — a blip on the scale of time (4).

uranium enrichment processes, coal mining and processing techniques, etc.).

All technical fixes involve the integrated use of low- and high-quality energy. These adjustments can take place within the basic framework of our present system of production and consumption without causing major changes in the structure of our economy.

Land-Use Patterns

The spatial organization of production and consumption systems has a major influence on thermodynamic efficiency. The degree to which industrial activity is decentralized and integrated with agriculture and other activities is a major factor in determining the type of transportation facilities that can be effectively deployed and the energy required to sustain those facilities. Since roughly 60 percent of the U.S. gasoline consumption goes for transport, the potential reduction is significant.

The extent to which material residuals of human production and consumption can be recycled through agricultural and natural ecosystems without energy-intensive technologies depends on the organization of the landscape. Thermo-dynamically efficient and environmentally sound land-use patterns will require basic structural changes in the economy, e.g., the decentralization of many industries, the transition to integrated energy systems, the limitation of the size and location of urban communities and an increase in regional economic self-sufficiency.

Adjustments in land-use patterns will have major impacts on labor requirements and many other socio-economic factors. The pace at which these structural alterations take place will depend on the adaptability of institutions and the availability of energy resources.

Product Durability

The political and economic systems of much of the industrialized world unduly emphasize labor productivity and leisure without considering energy efficiencies. For example, if labor force A produces 50 refrigerators per week with an average life of 25 years, it will provide more leisure time than labor force B (of the same size) producing 125 refrigerators per week with an average life of 10 years. Both yield 1,250 years of refrigeration for each week of work, but conventional economic accounting procedures and economic concepts would regard labor force B as "better," since it contributes more to the Gross National Product (GNP) and creates additional jobs, even though labor force A has a lower thermodynamic efficiency.

Increased durability can be accomplished by *(1)* increasing the physical or technical useful lifetime of a product, and *(2)* by reducing or eliminating cosmetic changes (e.g., style changes in automobiles).

EFFECT OF POLITICAL DECISIONS

Each individual and institution within the political economy operates within a limited sphere of responsibility. Unfortunately, the individual in a decision role, tends to look on such issues as unemployment, fuel shortages and nuclear energy, for example, as isolated crisis situations. But these issues are inextricably related.

For technical reasons, such piecemeal, crisis-oriented response does not provide important elements needed for adequate resource management. Improved structural changes require years or decades, and many resource decisions have irreversible repercussions — depleted resources cannot be replaced, urbanized agricultural land is prohibitively costly to reclaim, and species driven to extinction are lost forever.

Formation of goals and management strategies in a democratic society emerges for the most part from political bargaining, debates, hearings, testimonies, scientific investigations and other exchange among the components of the political economy. However, this interaction must be tempered by short-term and long-term thermodynamic, ecological and economic characteristics of the system. Without such knowledge, political processes may call for solutions that are ecologically unfeasible. Social frustration and human tragedy are the likely results.

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