ABSTRACT

The earth is a virtually closed material system composed of the 92 naturally occurring chemical elements, all but a minute radioactive fraction of which obey the laws of classical chemistry. Into and out of this system there occurs a continuous flux and degradation of energy. As a consequence, the materials of the earth's surface undergo either continuous or intermittent circulation. The principal energy influxes into the earth's surface environment are three: solar energy 174,000 x 10^{12} thermal watts; geothermal energy, 32 x 10^{12}; and tidal energy 3 x 10^{12}. The outfluxes are low-temperature radiation into outer space.

During more than 3 billion years of geologic history a minute fraction of the materials of the earth's surface has been aggregated into the dynamical system of living organisms. By the process of photosynthesis, a small fraction of the incident solar radiation is captured by the green leaves of plants and is stored chemically in the organic molecules of carbohydrates and other more complex chemical compounds. This is the source of the physiological energy requirements for the entire plant and animal kingdoms. The rate of decay and of oxidation of organic materials is almost equal to their rate of formation, but a small fraction becomes buried in peat bogs or other oxygen deficient environments of incomplete decay. Such accumulations during past geologic time have become buried under thick accumulations of sedimentary strata and have become transformed into the earth's present supply of fossil fuels.

By about 2 million years ago the ancestors of the present human species began to walk upright and to use stone tools. From that time to the present, this species has distinguished itself from all others in its cumulative inventiveness in means of capturing ever-larger quantities of the energy of its environment. A large increase in the consumption of energy per capita was not possible, however, until the exploitation of the large stores of energy of the fossil fuels was begun about 9 centuries ago. The rise of the world's present technological society, with its concurrent ecological disturbances, including that of the human species, has been an inexorable consequence.

The length of time during which this has occurred is deceptive unless account is also taken of the exponential growth in the rates of consumption. During the 9 centuries since the beginning of coal mining, approximately 142 billion metric tons had been mined by the end of 1972. Of this, one half has been produced since about 1940. Eighty percent of the world's initial coal supply will be consumed within the next 2-3 centuries, and the middle 80 percent of the world's oil during the 65-year period from about 1967 to 2023.

As to the future, the fossil fuels are short-lived; nuclear power is potentially large but also hazardous; water power is large but inadequate; and geothermal and tidal power are inadequate. On the other hand, the largest source of energy available to the earth is that of solar radiation. Because the earth itself cannot tolerate more that a few tens of doublings of any biological or technological activity - and most of these have already occurred - it is now becoming evident that the present episode of exponential industrial growth can be only a transitory epoch of about 3 centuries duration in the totality of human history. It represents a brief transitional period between two very much longer periods, each characterized by rates of change so slow as to be regarded essentially as a period of nongrowth. Although the forthcoming period poses no insuperable physical or biological difficulties, it can hardly fail to force a major revision in those aspects of our current economic and social thinking which are based upon the premise that the growth rates which have characterized this temporary period can somehow be sustained indefinitely.

SPEAKER FOR EVENING MEETING MONDAY, JANUARY 14, 1974

DR. M. KING HUBBERT

Biographical Review

M. King Hubbert was born in San Saba, Texas. He received his primary education in one and two teacher country schools and attended Weatherford Junior College in Weatherford, Texas. His professional education was attained during the late 1920's at the University of Chicago where he received B.S., M.S. and PhD. degrees in geology, physics and mathematics.

During and immediately following his studies at Chicago Dr. Hubbert worked as an oil geologist for Amerada Petroleum Corp. in Texas, New Mex. and Oklahoma. During the next ten years Dr. Hubbert taught geology and geophysics at Columbia University and spent summers in geophysical exploration for minerals with the Illinois State and U.S. Geological Surveys. During World War II Dr. Hubbert conducted world wide mineral resource supply studies for the Board of Economic Warfare in Washington, D.C. The following twenty years (1943-1963) were spent with Shell Oil and Shell Development Companies in Houston as Research Geophysicist, Associate Director of Exploration and Production Research, and Chief Geological Consultant. Since 1964 Dr. Hubbert has been Research Geophysicist with the U.S. Geological Survey and until 1968 also held a part-time Professorship at Stanford University.

Dr. Hubbert's early scientific work was involved with the physics of underground fluids; migration and entrapment of petroleum under hydrodynamic conditions; and electrical, magnetic and gravitational prospecting. But his career has also embraced four decades of continuing studies of the world's mineral and energy resources, and the significance of their exploitation in human affairs.

Dr. Hubbert has published some 65 papers and several books. He is a member of the National Academy of Sciences, the American Association of Petroleum Geologists, Society of Exploration Geophysicists, Society of Petroleum Engineers of AIME and he was President of the Geological Society of America in 1962.

For his work in Geophysics, Dr. Hubbert was awarded in 1954 the Arthur L. Day Medal of the Geological Society of America. The same Society awarded him the Penrose Medal for General Geology in 1973. For his contributions to Petroleum Engineering he received the Anthony F. Lucas Gold Medal Award from the American Institute of Mining and Metallurgical and Petroleum Engineers during its 1972 Centennial celebration. The citation for the award read; "His efforts in establishing the fundamental concepts of flow through porous media greatly speeded the transition of petroleum engineering from an art into a science."