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GLOBAL ENERGY NEEDS*

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The quest for fuel has often been a cause of human conflict. In today's world, the competition for energy resources continues to disrupt the international tranquillity. Unfortunately there are many reasons to expect that these stresses will increase in the decade ahead.

Energy is a vital commodity to modern civilization. It runs the machinery in factories and on farms, moves the ships, aircraft and vehicles, and satisfies many necessities of daily living. The more advanced the society the more critically dependent it becomes on a steady, uninterrupted supply of energy.

In addition, there is a strong correlation between energy consumption and national affluence. This can be seen in Fig. 1 which compares per capita annual income with per capita energy usage.¹⁾ In an energy-intensive society the workman can produce more goods or services and thus command a higher wage. He uses more energy in his work and his family can afford to consume more energy for personal comfort and pleasures.

Military strength is also strongly energy dependent. Enormous quantities are consumed to fabricate and operate the machines of modern warfare. Because of military dependence on energy, the military powers tend to be most sensitive about insuring the reliability of their sources of supply.²⁾

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At the present time, the bulk of the world's energy is consumed by only a handful of nations, comprising a small part of the world population. Eight of the largest consumers, USA, USSR, Japan, West Germany, UK, Canada, France, and Italy, consume almost 3/4 of the supply, yet have only 1/5 of the population. (Mainland China is the third largest consumer although her per capita consumption is not large.) The United States heads the list. Last year, the U.S. which has only 5.6% of the world population, consumed one-third of the energy!

It is interesting to note that only three out of the ten largest consumers are self-sufficient (see Table I). Japan is the largest importer followed closely by the US. The US imported more energy during 1970 than was consumed by the entire African and South American continents combined (see Tables I and II).

If we examine broad regions of the world several important facts are obvious (Table II). Western Europe is strongly dependent on imports--almost 60% of its supply must be imported. Asia must import more than half (most of which is for Japan). Despite the fact that the North American continent is the largest producer it nevertheless must import almost 1/10 of its supply.

Petroleum is the principal fuel in international trade. Approximately 60% of the oil produced finds its way into the international markets. It is critical that this flow of oil continue uninterrupted on a day-by-day basis. Since stock-piles are limited, disruptions of the normal flow even for a few days creates hardships. A prolonged interruption would plunge dependent countries into chaos.

The dependence of Western Europe and Japan on producers in the Middle East is particularly a matter of concern. The potential for crisis is very great. Perhaps you can recall the serious events and rash actions by the UK and France during the autumn of 1956 when the Suez canal was closed suddenly. Of course, the Suez is no longer a strategic factor, but the oil fields, pipelines and tanker routes are vulnerable to mischief.

The ten nations which are the largest exporters are Venezuela, Iran, Saudi Arabia, Libya, Kuwait, USSR, Iraq, Nigeria, Algeria, and Trucial Oman. With the exception of the USSR, these nations are relatively weak militarily and politically unstable. Their weakness might become an invitation to adventure by their powerful customers if crises arise.

For the most part, the exporting nations have a history of poverty and possess limited resources other than petroleum. It is quite natural that they should desire to profit as much as possible from their one valuable commodity. Obviously, after a time the oil fields will be depleted. Thus, this is their one and only chance to improve their economic situation. In earlier years, the international oil companies held almost exclusive control over the production and prices. In a few cases exporting countries dictated more favorable terms to the companies, but at considerable risk of economic and political retaliation.

Since the early 1960's the exporting countries have increased their bargaining strength through the Organization of Petroleum Exporting Countries (OPEC). In recent years OPEC has obtained several price increases, and presently is bargaining for an increased share in ownership of capital facilities. This question is a delicate one, since the technology and capital investment of advanced nations are needed to discover and develop new fields.

The great imbalance in energy supply and demand--on the one hand, the militarily-weak underdeveloped nations that possess vast treasure of oil, and on the other hand, the powerful advanced nations that need a steady flow of oil to survive--

has great potential for international crisis. There is little about the situation to inspire hope for avoiding serious confrontations in the years immediately ahead.

I have not yet commented on the many underdeveloped countries of the world who have no appreciable energy resources and who consume very little energy. If these nations are ever to rise above their present dismal economic circumstances they will require access to large amounts of energy.

Let us arbitrarily select a goal of a standard of living equal to that of Western Europe for all peoples of the world, and calculate how much additional energy production would be required to achieve such a goal. With the present population this would require almost exactly double the present production. Since the world population will almost double by the end of the century, this implies that by the year 2000 AD, energy production would have to be about four times the present rate. World resources of conventional fuels are inadequate to satisfy this demand. In fact, the analyses of M. King Hubbert³⁾ indicate that by the year 2000 more than half of the world's oil will be consumed and production will be decreasing.

It would be most desirable to find alternatives to the present sources of energy, alternatives that would reduce the

dependence of Western Europe and Japan on Middle Eastern oil, alternatives that would reduce the US dependence on imports, alternatives that would give some hope for a better future to the poverty-stricken countries of the world.

Unfortunately the potential choices are few. Except in some parts of Africa and South America new hydro power sites are limited. Solar energy holds great promise, but several decades will be needed to devise the practical means for harvesting large amounts of energy and for deploying the systems. Fusion could be a long-term answer to the energy needs of the human race, but the scientific feasibility has not yet been proved and practical application is far in the future. Better use can be made of coal resources which are more abundant than petroleum and natural gas; however, a large increase in coal production would exact severe environmental tolls. Also, the geographical distribution of coal deposits poses extremely difficult logistic problems. Oil shales and tar sands will probably be of some future help, but--like coal--the environmental cost will be high and the geographical distribution presents difficulties.

At the present time, nuclear fission is the only new energy source that is ready for large-scale deployment. More than a hundred nuclear plants are already in operation

and many more are under construction. It is quite obvious, however, that nuclear power cannot completely solve the difficulties in the present world pattern of energy production and consumption. New plants require as much as ten years to construct and rate of expansion is limited by the present capacity of the nuclear industries.

It is not reasonable to expect the underdeveloped countries to derive much benefit from nuclear energy in the near future. Capital costs of nuclear plants are very large, e.g., a nominal 1000 MWe plant costs \$300 to 350 million. It is unlikely that the United States or any other nation will launch new foreign aid programs which could finance such plants. However, there are some interesting exceptions and more can be expected. For example, both India and Pakistan have nuclear plants.

Probably most important, nuclear energy can relieve some of the pressures in critical areas. For example, more nuclear plants in Western Europe and Japan will reduce their dependence on Middle Eastern oil. Also, the situation on the eastern seaboard of the United States will be eased as new nuclear plants are built. At present a large fraction of the electricity generated in the eastern US is from oil, 90% of which must be imported. Already in the New England

area about 40% of the electricity is generated by nuclear plants. As more nuclear plants come into operation, the crucial dependence of the advanced nations on oil imports will be reduced, and thus the likelihood of rash, precipitous reaction to interruption of oil supply will be reduced.

The world-wide deployment of commercial nuclear power has an important disadvantage. It makes plutonium more readily available to any country that might want to fabricate a nuclear weapon. Even now the lack of plutonium is no longer a deterrent to the proliferation of nuclear weapons. Other means must be used to limit a nuclear arms race among the lesser powers of the world.

For the long haul, if it should be necessary, adequate uranium and thorium deposits exist on earth so that fission energy could meet all the energy needs of humanity for several centuries.⁴⁾ Probably at least 50 years would be needed to overtake the demand--to build the many plants and develop improved systems (breeders and synthetic fuel plants) for proper use of these resources.

If we are optimistic and assume that world stability will allow the human race to exploit potential resources that are not yet developed, then it is possible that better methods than fission can eventually be devised. The most likely candidates appear to be solar and fusion energy.

TABLE I

Leading Consumers of Energy, 1970. The data are expressed in units of metric tons (tonnes) of coal equivalent (1 metric ton = 8000 kWh). Data are from Ref. 1.

<u>Rank</u>	<u>Nation</u>	<u>Consumption</u>	<u>Production</u>	<u>Deficit for 1970</u>
	WORLD TOTAL	6843.25	7000.07	
1	United States	2282.32	2053.77	228.55
2	USSR	1079.17	1212.75	--
3.	China ^a	426.41	420.53	5.89
4	Japan	331.90	54.88	277.02
5	West Germany	314.70	176.63	140.07
6	United Kingdom	299.36	163.55	135.81
7	Canada	194.20	206.06	--
8	France	192.79	59.30	133.49
9	Italy	143.87	26.39	117.48
10	Poland	138.10	157.65	--

^aPrincipally China, except Taiwan.

TABLE II

1970 Energy Consumption and Production for Major Regions of the World (data from Ref. 1). Data are in units of millions of metric tons (tonnes) of coal equivalent.

<u>Region^a</u>	<u>Consumption</u>	<u>Production</u>	<u>Deficit</u>	<u>Surplus</u>
WORLD	6843.25	7000.07	--	156.82
Africa	108.81	450.34	--	341.53
North America	2476.86	2259.85	217.01	--
Central America ^b	137.22	357.12	--	219.90
South America	111.68	69.89	41.79	--
Asian Middle East	81.43	941.53	--	860.10
Asia (except Middle East)	540.22	242.21	298.01	--
Western Europe	1348.32	556.62	791.68	--
Oceania ^d	77.44	71.26	6.18	--
Communist Bloc ^c	1961.29	2051.23	--	89.94

^aFor details of regional breakdown see Ref. 1, pp. 336-39.

^bIncludes Venezuela.

^cIncludes mainland China.

^dPrimarily Australia.

TABLE III

1970, Net Energy Exporting Nations. Data are expressed in units of millions of metric tons (tonnes) of coal equivalent, (Ref. 1).

<u>Rank</u>	<u>Country</u>	<u>Production</u>	<u>Consumption</u>	<u>Surplus</u>
1	Venezuela	265.19	25.97	239.22
2	Iran	264.72	26.91	237.81
3	Saudi Arabia	234.57	7.47	227.10
4	Libyan Arab Rep.	210.22	1.25	208.97
5	Kuwait	184.08	7.42	176.66
6	USSR	1212.75	1079.17	133.58
7	Iraq	100.43	5.64	94.79
8	Nigeria	70.80	2.49	68.31
9	Algeria	66.64	6.62	60.02
10	Trucial Oman	49.32	0.15	49.17

REFERENCES

1. Statistical Yearbook, 1971. United Nations Statistical Office, Publishing Service of the United Nations, New York, New York 1972.
2. Vansant, C., Strategic Energy Supply and National Security, (Praeger Publishers, New York) 1971.
3. Hubbert, M. K., The energy resources of the earth, Scientific American, 224, No. 3, 60-70 (1971).
4. Weinberg, A. W. and Hammond, R. P., Limits to the use of energy, American Scientist 58, No. 4, 412-18, (1970).