13 Oct 1977

The Energy Needs of The Developing Countries

Vaman Rao

THE ENERGY NEEDS OF THE DEVELOPING COUNTRIES

Vaman Rao
University of Missouri-Rolla

Abstract

The energy needs of the developing countries are enormous. They will grow with the passage of time as the pace of economic development accelerates and those countries enter the industrial epoch. The sheer physical non-availability of coal and petroleum to most of them makes it obligatory to choose an unconventional resource as an energy-base. The nuclear fission is the only option now available which is feasible, less-expensive and plentiful. Solar and fusion may be the ultimate sources in the steady state, when appropriate technologies are developed.

I

Even before they could grapple with such chronic problems as capital formation, choice of techniques, man-power planning and balance of payments, the majority of nations constituting the so-called Developing Third World have now to contend with yet another basic problem in economic development. Their choice of an energy base for future economic development, in fact, brooks no delay. Except for a few petroleum-rich countries, the rest of the developing world is being hurt on two counts. Inspite of a very low level of commercial energy consumption, the ever-increasing petroleum bills leave very little resources for essential investment in other areas of development and therefore, their growth process has almost come to a halt. Secondly, the high-cost energy imports have rendered much of the petroleum-based technology obsolete, and therefore, the little progress that had been achieved in the past has come to a nought. The choice of an energy base, therefore, is linked intimately with the whole process of economic development, including the choice of technology, the pattern of investment and the type and magnitude of resources required for this purpose.

The problem of economic development is essentially a problem of reducing the gap that separates the developing countries with the developed countries in the matter of gross national product, both in aggregate and in per-capita terms. The development needs of these countries cannot, therefore, be discussed in isolation from the situation obtaining in the developed countries.

An attempt is made in this paper to present the problem of economic development in its various dimensions, especially as regards to the widening economic gap between the two types of countries. The question of choosing an energy base is

then discussed in all its implications of needs, availability, and international concerns, with the tentative conclusion that nuclear fission seems to be the only feasible alternative available. The nuclear fission may not be the ultimate source, and the solar and fusion energy may be more appropriate candidates for the ultimate steady growth state, but in the immediate future there doesn't seem to be any alternative to nuclear fission.

II

Low per-capita GNP is the major criterion to classify a country as a backward one. The absolute smallness of GNP apart, the huge populations that the developing countries sustain may explain the low per-capita GNP. In terms of growth rates, therefore, a high rate of growth of economy coupled with slowed-down rates of growth of population will help increase the per-capita GNP. But the demographers' opinion that the rates of growth of population will automatically decline with increased per capita GNP, seems to beg the question. Be that as it may. Many of the developing countries have adopted vigorous family planning programmes and yet, it is estimated that in the year 2000, 76 per cent of the world's population will live in those countries, compared to 68 per cent that lived there in the year 1965.

What would be the economic conditions in the year 2000, in which these more than three-fourths of the world population will live? Table 1 shows the GNP and per-capita GNP estimates for different regions of the world. It could be seen that the rates of growth of economy in the developing countries are so low that the resulting rates of growth of per-capita GNP would hardly make any dents in the poverty levels of these regions. In the year 1965, about 68.4% of world's population was heir to about 15.4% of the world's GNP. In the year 2000, about 76% of the world's population would produce and enjoy only 16.7% of the world's GNP. These estimates are based on cheap energy supply position. The estimates now would be much more unfavorable adding to, rather than diminishing, the gap between the rich advanced and the poor backward countries. A close look at the figures and further analysis would reveal that it would require them more than 88 years to reach the 1965 per-capita GNP level of the developed world and another 30 years to reach the 1965 per-capita GNP level of the United States. A rate of growth of per capita GNP of 4-5% or the achievement of the 1965 level by the turn of the century seems much more effective in reducing the economic gap. This may mean sacrifices and hard choices on the part of the developing world, and yet, the alternative seems to be grimmer.

III

It is generally agreed that the GNP and the energy consumption have a linear relationship, although the coefficients of this relationship might get slightly modified with improved technological efficiencies and the adopted life styles. A higher rate of growth of GNP, therefore, necessarily means an increased rate of energy consumption. The developing countries, of late, have been showing an increased rate of energy consumption (Table 2), and yet the Developed World in 1973 consumed almost 7 times more energy in aggregate terms than the developing world. The relevant figure in per capita terms is 17 times which of course is an improvement over the 1950 figure of more than 25 times (Table 3). This inequality would naturally decline as the process of development progresses. What does this mean in terms of absolute amounts, especially when we remember the tenuous conventional sources

of energy supply? Barring a few countries in Central America, the Middle East and the Far East, most of the developing countries are fossil-fuel-poor. More than 80% of world's coal is concentrated in the USSR and the USA. People's Republic of China and Europe account for another 15%. The remaining 5% is distributed among the rest of the countries. A similar story can be told about the petroleum reserves. If the recent experiences are any guide the petroleum-rich developing countries cannot be relied upon for less-costly and regular supplies of energy for the developmental purposes. Coal and petroleum, therefore, are ruled out as dependable energy-base for future economic development, so far as majority of developing countries are concerned. That leaves natural gas and the hydel. The former has identical spread and the latter, has some potentialities of expansion in a few countries. The future source of energy supply should, therefore come from some unconventional source.

Geothermal, wind and tidal energy sources, wherever they exist are highly limited and could, at best, serve only as supplemental sources. Solar energy has the potentialities of becoming an important source, but the present technological feasibilities permit it to be used only for certain limited purposes. Likewise fusion and hydrogen economy have great promise but they are all in the realm of speculation. The immediate programmes of economic development cannot be planned on unknown quantities. By a process of elimination we have arrived at the only alternative available. That is the nuclear fission. Nuclear energy is relatively safe, less costly, and can be made available in the form of electricity, the most convenient form for individual and industrial use. It can also be made available in the form of heat, which many industries do require. The raw material costs are relatively small and with more competitive pricing of nuclear fuel, it can be made available in abundance, without affecting the relative cost advantage.

An idea of how much electricity would be needed (as part of the total energy requirements) for the next 35-40 years can be had if we compute a relationship between the electricity generating capacity and the total energy required. It is estimated that for every million metric ton of coal equivalent of energy consumed the new electricity generating capacity required would be anywhere from 170 MWe to 228 MWe.

Assuming that the goal of developing countries is to achieve the level of aggregate energy consumed by the developing countries in the year 1967, they have to install the electricity generating capacity of the order of 606,560 -- 817,072 MWe. This goal looks formidable, especially when one looks at the present installed capacity which is 76,160 MWe. If the installed capacity grows at 7% per annum, by the turn of the century, the developing countries will be having the 1967 absolute electricity generating capacity of the developed countries and yet in per capita terms they will be still having only 1/8 of the 1967 electricity generating capacity installed in the developed countries. To achieve the same in per capita terms the required capacity would be 4,852,480 -- 6,536,576 MWe. Even to achieve half of this level by the turn of the century the generating capacity shall have to grow at 11% annually. It would be a herculean task involving huge supplies of raw materials, capital and technical manpower.

IV

Several well-meaning critics of nuclear energy have opposed the expansion of nuclear energy producing facilities. But in view of the enormity of the need, there is much in the nuclear energy to commend itself as the energy base of the economic development.

The breakthrough effect that the industrialized countries experienced through the industrial revolution needs to be repeated in the developing countries. Due to a variety of historical reasons, the industrial revolution didn't touch their economies. A planned and rapid industrialization through external stimuli is urgently needed. This can come about only by bold and innovative approach, rather than by waiting for the emergence of the right type of climate.

As the coal and petroleum technologies were industrial breakthroughs in the past, so is nuclear energy a breakthrough in the present. The developing countries could miss it only at their peril. The greater the sophistication of a technique, greater would be the propensity to adapt oneself to the new industrial culture. The backward and forward linkage effects would likewise be stronger to accelerate the process of economic development. The social adjustment process will be painful, but that has always been the experience of every culture whenever such a breakthrough has occurred.

The enormous power programme envisaged requires consideration of the capital and operational costs of generation. The dimension of the programme is immaterial. It is the comparative advantage that has to be looked into. A study conducted for India estimated that the unit capital costs for coal fired, oil-fired and nuclear power generation are in the ratio of 10.50:8.00:17.00. Since the oil fired power programme is out of the question, the real competition is between coal-fired and nuclear. The coal-fired power costs didn't include the capital costs necessary for mining and hauling stages of production. The efficiency of nuclear power generation used in these estimates was 28%, which was true for a first generation nuclear reactor. Most of the present nuclear reactors operate at an efficiency level of 32-33% or more. The present generation nuclear reactors have many more cost-efficient ingredients, all of which make nuclear energy relatively less expensive than coal-fired power.

A recent study by Arthur D. Little, Inc., estimates the ratio to be 5.88 (coal-fired):3.89 (oil-fired):7.02 (nuclear) for the plants operable in 1981 in the U.S. If the fuel costs are also included in the estimates of unit cost of generating electricity by alternate means, the nuclear energy comes out with an advantage of .975¢ per kwh, over coal-fired and of .5¢ over oil-fired options. This is not inconsiderable when we are thinking in terms of a huge power programme.

Fuel supply may not pose a big problem as the supply of uranium is highly price-elastic. The total physical availability of uranium and other radio-active materials is not yet fully determined and there are indications that they are available to last for a long time to come. With the proper safeguards and internationally agreed arrangements for neutral inspection, the supply of enriched uranium should not be a problem.

The safety aspects of nuclear energy have been raised quite often to oppose nuclear expansion. There is an element of panic in this kind of talk. The disposal of waste materials could be handled if the separation of highly toxic, and high

half-lived elements is done with greater purity. Besides, these elements could be used, in times to come, as fuels in the breeder reactors.

The second aspect of safety relates to the human or technological error in handling the reactors and the associated system. This is purely an engineering problem that can be solved by increased tiers of back up systems.

The third aspect of the safety concerns the use of radio-active material for uncontrolled chain reactions. With the proliferation of nuclear reactors, there is a greater possibility of individuals and nations to manufacture devices to threaten the security of other nations. This potential danger, however real cannot be wished away. It is necessary to find out the motivation for such threats. With the increased economic development and the closure of the gap between the rich and the poor, the cause for such an eventuality will diminish rather than increase. Our best bet against this is to help accelerate the process of economic development.

V

The needs of economic development in the area of energy are enormous. Coal and petroleum are either physically non-available or are extremely costly to act as energy-base for future economic development. Natural Gas and Hydel have a similar story to tell. Geothermal, wind and tidal sources can at best, be supplemental rather than primary energy-base. The nuclear energy has the cost advantage and the nuclear fuels can be made available under international safeguards. The safety problems of nuclear energy are real but can be handled satisfactorily. But the ultimate source of energy for any country could be either solar or fusion energy both of which are still technologically infeasible to act as the energy base of an industrialized society.

BIBLIOGRAPHY

(1) Arthur D. Little, Inc., "A Study of base-load alternatives for the Northeast Utilities System," a report to the Board of Trustees of Northeast Utilities by A.D. Little, Inc., Cambridge, Mass. 1973.

(2) Bhabha, H. J. and Prasad, N. B., "A Study of the Contribution of Atomic Energy to a Power Programme in India," in (12).

(3) Bhagwati, Jagdish N., Economics and World Order, from the 1970's to the 1990's, Macmillan, London, 1972.

(4) Energy Policy, "India's Energy Futures," as reported in September, 1975, Science.

(5) Goldsmith, K. "Some Aspects of Power System Expansion in Developing Countries," in (9).

(6) Hafele, W. and Manne, Alan S., "Strategies for a transition from fossil to nuclear fuels," Energy Policy, March, 1975.

(7) Halacy, D.S., The Coming Age of Solar Energy, Avon, New York, 1973.

(8) International Atomic Energy Agency: International Comparison of Nuclear Power Costs, IAEA, Vienna,

(9) International Atomic Energy Agency: Nuclear Energy Costs and Economic Development, IAEA, Vienna, 1970.

(10) Khan, M. and Lane, J., "Extrapolation of nuclear power costs in the case of Developing countries," in (8).

(11) Lovins, Amory B., "Energy Strategy: The Road Not Taken?" Foreign Affairs, 55(1), October, 1976.

(12) Maxwell, I.R. et al (eds.): The Economics of Nuclear Power, vol. 2, Pergamon Press, New York, 1959.

(13) Patterson, Walter C., Nuclear Power, Pelican, Baltimore, Maryland, 1976.

(14) Robinson, Joan, The Accumulation of Capital, MacMillan, London, 1956.

(15) Rose, David J., "Nuclear Eclectic Power," Science, 184, No. 4134, April 19, 1974.

(16) Starr, Chauncey, "Energy and Power," Scientific American, 225(3), September, 1971.

(17) Summers, Claude M., "The Conversion of Energy," Scientific American 225(3), September, 1971.

(18) Surrey, A. J., "The Future Growth of Nuclear Power," Energy Policy, September, December, 1973.

(19) Walsh, P. Environmental Engineer's Thesis, MIT, 1974 quoted in (15).

Table 1. GNP and Per-Capita GNP Estimates by Categories of Countries

	GNP Estimates in 1965 U.S. Dollars					Per Capita GNP in 1965 U.S. Dollars		
	yr 1965		yr 2000		yrs 1965-2000	yr 1965	yr 2000	yrs 1965-2000
	billion $	%	billion $	%	annual % rate of growth	dollars		annual % rate of growth
Less Developed World								
Africa	43.9	2.1	216.0	2.0	4.54	144.0	281.0	1.91
Asia less Japan	203.4	9.6	1,081.0	10.0	4.77	118.0	324.0	2.88
S. America	78.8	3.7	510.0	4.7	5.34	379.0	928.0	2.55
Total	326.1	15.4	1,807.0	16.7	4.91	145.0	388.0	2.82
Developed World								
Japan	84.0	4.0	1,056.0	9.7	7.23	866.0	8,656.0	6.58
N. America	754.8	35.7	3,402.0	31.4	4.33	3,023.0	7,921.0	2.76
Oceania	28.0	1.3	107.0	1.0	3.83	1,641.0	3,344.0	2.02
Europe	923.9	43.6	4,476.0	41.2	4.51	1,377.0	5,087.0	3.73
Total	1,790.7	84.6	9,041.0	83.3	4.60	1,729.0	6,126.0	3.61
World Total	2,116.8	100.0	10,848.0	100.0	4.67	646.0	1,769.0	2.88

Source: Jagdish N. Bhagwati, Economics and World Order, from the 1970's to the 1990's, MacMillan, London, 1972, for GNP estimates.

Notes: Per Capita GNP estimates were computed from the above data and North America excludes Mexico.

Table 2: Annual Percentage Rates of Growth in Energy Consumption

	World		Developed Countries		Developing Countries	
	Aggregate	Per Capita	Aggregate	Per Capita	Aggregate	Per Capita
1965 - 73	5.15	3.32	4.99	4.90	8.75	5.16
1960 - 73	4.75	2.88	4.81	3.76	7.08	4.65
1950 - 73	5.02	3.17	4.21	3.02	7.26	4.92

Source: Based on Energy Consumption data in World Energy Supplies, 1970-1973, United Nations, N.Y., 1975.

Table 3: Ratio of Energy Consumption between the Developed and the Developing Countries

	Aggregate	Per Capita
1950	13.6	25.7
1955	11.1	21.7
1960	9.1	18.9
1965	8.4	18.5
1970	7.4	17.7
1973	6.8	16.8

Source: Based on data in World Energy Supplies, 1970-1973, United Nations, N.Y., 1975.

This paper has been admitted by title only as it was omitted from last year's proceedings.