ENERGY, ENVIRONMENT AND DEVELOPMENT[1]

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ABSTRACT

Conventional projection-driven approaches which measure development in terms of energy consumption are failing due to rising economic costs, erosion of self-reliance, growing environmental degradation and increasing danger to peace. With regard to the global environment, developing countries are even today contributing very significantly to the build-up of carbon in the atmosphere and therefore to the deterioration of global climate. If these countries pursue conventional supply-obsessed energy futures, they are certain to aggravate the threat to global climate. If their development is based on such futures, a development versus global climate dilemma is bound to arise and lead to an irreconcilable conflict between industrialized and developing countries.

Fortunately, a new paradigm for energy is emerging in which the level of energy services is the true indicator of development. Least cost planning suggests that conservation may have to be the first option, decentralized renewable sources, the next option, and conventional centralized supplies, the last resort. The alternative approaches to energy futures permit the tackling of need-oriented, self-reliant and environmentally sound developmental priorities in developing countries whilst simultaneously reducing the emissions of greenhouse gases and contributing positively to the solution of the problem of global climate. Using this paradigm, the future for energy, for the local, national, regional and global environment and for development appears far brighter than it does to the supply- siders.

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DEVELOPMENT. We set out to develop a different way of thinking about energy. It is this new paradigm or pattern of thinking for energy analysis and planning that is the main theme of this address.

INTRODUCTION

My interest in energy issues for the past 14 years has led me to work at the village (Pura and Ungra villages in Tumkur District of Karnataka, South India), city (Bangalore), state (Karnataka), country (India) and global levels. This work convinced me that the multi-faceted problems at these various levels would only be aggravated by the conventional approach to the energy problem.

I was not alone in this conviction because a number of other energy analysts felt the same way. In particular, mention must be made of Jose Goldemberg (Brazil), Thomas Johansson (Sweden) and Robert Williams (USA) with whom I have collaborated over the past six years in writing a number of papers and several books including ENERGY FOR A SUSTAINABLE WORLD and ENERGY FOR THE CONVENTIONAL APPROACH TO ENERGY

Before presenting this theme to you, let me describe the conventional approach briefly. This approach starts with economic growth as the objective. It then links growth to energy by assuming that there is a correlation between total energy use and Gross Domestic Product (a measure of growth). It asserts: if you want to increase GDP, you have no option other than to increase the input of energy. So, energy becomes an end in itself, and the focus shifts to increasing energy consumption. The important thing is to make projections of energy demand into the future (invariably assuming that business will continue as usual). The central question is how to increase energy supplies and meet the demand projections. Efficiency improvements are either lip-service, nominal, after-thoughts, add-ons or retrofits to the analysis. The primary goal of energy planning is to make this energy supply expansion possible and bring about ”a• ”sustainable energy system•.

On the basis of such an approach, energy demand from the developing countries would rise enormously. In 1980, the developing countries had a per capita energy consumption of 0.55 kW of commercial energy where 1 kW is an abbreviation for 24 kWh per day or 8760 kWh per year. If the 1970's growth rate were to continue, then in the year 2020, the energy consumption in the developing countries would be 2.3 kW per capita. Taking into account the growth in population, the developing countries would increase their total consumption of commercial energy from 2 TW to 15 TW. If this increase of 13 TW is compared to the world energy use in 1980, it is equivalent to 1.3 times more total energy, 3 times more oil, 5 times more coal, 7.5 times more natural gas, 9 times more biomass and 60 times more nuclear energy.

To sustain such a dramatic increase in demand, there would have to be staggering increases in investments on new energy supplies. Some estimates of the investments necessary to meet the rising energy demand have been made by the World Bank. Between 1980 and 2000, an investment of about $475 billions would be required and the expenditure on energy would have to rise from 4% of the GDP to 6%.

The energy supply projects that would be necessary to meet the enormous demands for energy would have serious environmental impacts. Even though, in the past, the industrialized countries did the bulk of the damage to the atmosphere, the current contribution of the developing countries to global warming is not insignificant. The latter accounted in 1987 for about 43% of the carbon pumped into the atmosphere, of which about 19% arose from their combustion of fossil fuels and the remaining 24%, from deforestation (mainly in the Amazon). The trend is for these contributions to global climate change to increase because of present patterns of energy consumption.

The requirement of dramatic increases in energy supplies would also lead to near-term environmental impacts that may appear less globally catastrophic but are quite serious. Thus, many hydroelectric projects cause the submergence of forests as well as soil erosion in the catchment areas; coal-based thermal power plants are a major cause of acid rain, and nuclear plants produce high-level wastes that not only create long-term disposal problems but can be reprocessed and used for weapons.

Thus, the conventional approach to energy is disastrous both for developing countries and for the world at large. The implementation of conventional wisdom is making energy unaffordable for crucial development needs and causing serious near- and long-term environmental problems, apart from aggravating societal inequities, eroding self-reliance and threatening peace. It is producing global warming that is likely to make the planet uninhabitable use of climatic changes. A new approach is imperative; it is a matter of survival.

THE NEW PARADIGM FOR ENERGY

The new paradigm for energy planning is frankly normative -- the goals are built in from the start. For a developing country, the goal must be a process of ”sustainable development• that involves economic growth as a necessary condition, but not a sufficient one. In addition, the growth should have three features:

(1) it should lead to the satisfaction of basic human needs,
(2) it should be in harmony with the environment, and
(3) it should strengthen self-reliance.

In making the energy system compatible with these goals, the new approach unequivocally rejects the necessity of the energy- GDP correlation. You can achieve growth with negligible or no increases in energy -- energy-GDP decoupling is possible ”if• there are

- o structural changes from more energy-intensive activities to less energy-intensive activities ”and/or•
- o efficiency improvements,

i.e., if energy is viewed as a ”means• to an end. But, the emphasis has to shift to energy services like lighting, cooking, comfortable space conditions, transport, etc., to perform tasks and satisfy needs. The important thing is to scrutinize energy demand and to identify better ways of meeting this demand because the present ways are often unsustainable. The aim is to increase energy services. Efficiency improvements therefore are an integral part of the new approach. They must be constantly compared with supply increases bearing in mind new technologies.

The focus in this alternative is on end-uses -- what end- uses, for whom, with what efficiency. The insistence, however, is that end-use analysis should steer us towards the goals of a sustainable world and the sustainable development of developing countries. It is this goal-seeking approach that is a distinctive feature of the alternative approach. An energy strategy is acceptable only if it is compatible with such goals. Energy ”is• a major problem, but ”not• the only problem. We must pursue those solutions to the energy problem that are consistent with the solutions to the other problems.

The alternative approach to energy futures has universal applicability. It seeks to address the energy problems of developing countries, of industrialized countries and the world in an integrated fashion -- this is the second distinctive feature of the alternative.

IMPLICATIONS OF THE NEW ENERGY PARADIGM FOR DEVELOPING COUNTRIES

The new paradigm has many important implications for developing countries.

(1) Energy is used very inefficiently in all sectors of developing countries but particularly in the industrial and domestic sectors. Industry is largely based on energy- inefficient designs/equipment imported from the industrialized countries during an era of cheap energy. And, the residential sector is characterized by a dependence on biomass for cooking and on kerosene for lighting, both at very low efficiencies. Thus, there are tremendous opportunities for energy efficiency improvements.

(2) After the sharp escalation in energy prices of the 1970s, the industrialized countries have moved away from energy- intensive industries. Most developing countries cannot make the same structural shifts because these countries have to industrialize. Fortunately, their stocks of equipment are not as enormous as in the industrialized countries. Hence, they need not find it so difficult to modernize. They can exploit much more easily the new technologies that will permit dramatic improvements in industrial energy efficiencies. Thus, the industrial sector in developing countries is an ideal environment for technological leapfrogging to an energy efficient future.

(3) In the matter of energy, ”the true indicator of• ”development is the level of energy services provided•; it is ”not• the magnitude of energy used. For, it is the level of energy services (the amount of light, heat, motive power, etc.) that determines the quality of life and the extent to which basic needs are being satisfied. Energy services, in turn, depend upon end-use devices (stoves, furnaces, lamps, motors, engines, etc.) to convert energy inputs into the ”useful energy• required to provide energy services. Useful energy is simply given by the product of the efficiency of the end-use device and the energy input:

Useful Energy = Efficiency of end-use device x Energy input

The goal of development requires a sustainable increase in the level of energy services and there are four options for achieving such increases:

”Option 1• : Increasing the magnitude of energy inputs through increased supplies from conventional centralized sources (hydroelectric, coal and nuclear power plants, and oil and coal fuel) and keeping the efficiencies of the end-use devices at present levels.

”Option 2• : Increasing the magnitude of energy inputs through increased supplies from non-conventional decentralized sources (mini- and micro-hydroelectric, biogas and producer gas power plants, solar water heaters, etc. and in the not too distant future photo-voltaic devices) and keeping the efficiencies of the end-use devices at present levels.

”Option 3• : Increasing the efficiencies of the end-use devices and keeping the magnitude of energy inputs constant.

”Option 4• : Increasing both the efficiencies of the end-use devices as well as the magnitude of the energy inputs through improvement of present supplies, development of non-conventional decentralized renewable sources and an increase of new conventional supplies.

The conventional approach to energy restricts itself to ”Option 1 with its exclusive emphasis on supplies• of the centralized variety (hydroelectric, coal-based and nuclear electricity, coal and oil). However, the harmful environmental impacts of the centralized supply options are escalating.

To counter this environmental degradation due to centralized supplies, ”Option 2 adopts an exclusive emphasis on renewable• ”sources•. But, this option is only an environmentally benign version of Option 1 -- it is just as supply-obsessed. ”Option 3• ”has an exclusive emphasis on conservation• and implies that conservation alone will do the needful.

”Option 4 is the new paradigm for energy planning•. ”It• ”involves a rejection of all the three extreme positions• ”represented by Options 1,2 and 3•. The new approach insists on an assessment of whether supply increases or efficiency improvements are more effective from the point of view of economics, environment, self-reliance, etc. In other words, the question must be asked and an answer obtained as to whether it is cheaper, more environmentally benign and more conducive to self-reliance to save a kilowatt or generate a kilowatt.

(4) In a vast number of situations, this balanced approach of insisting upon a fair competition between supply increases and efficiency improvements is revealing that the conservation alternatives are cheaper, more environmentally benign, ”and• quicker.

(5) The old-fashioned supply options are becoming increasingly unaffordable because their marginal costs are continuously increasing -- it is more expensive to produce the next kilowatt than the previous one!. Precisely at a time when the populace is rising in protest against their environmental degradation, the conventional options are demanding impossibly large investments and creating the impression that energy supplies are the constraint on development.

(6) If opportunities for efficiency improvements are systematically identified and exploited whereever cost-effective, the magnitude of energy demand can come down sharply. In this context, energy supplies need not become a constraint on growth. As Gandhi said: "The world has enough for every man's need, but not enough for everyone's greed!"

This point may be illustrated by an interesting thought experiment that estimates what would be the per capita energy requirement if the developing countries achieved a level of energy services or activities corresponding to Western Europe in the 1970s (Table 1). Of course, this energy requirement would depend significantly on the energy technologies that are utilized. So, the thought experiment examined what would be the per capita energy demand if the most energy-efficient technologies that are commercial or near commercialization are deployed for all activities. By multiplying the specific energies resulting from these technologies (Table 2) by the activity levels (Table 1) and summing the product over all the activities, it turns out that the total per capita energy requirement would be about 1 kW of final energy (Table

3). But, this 1 KW is only some 10% greater than the 0.9 kW per capita final energy (including 0.45 kW per capita of non-commercial energy) utilized by the developing countries in 1980. Hence, it is not the magnitude of energy that is a constraint on the achievement of significantly higher standards of living in the developing countries.

(7) Energy in such a perspective can be forged into an instrument for development. But, for that to happen, energy planning must start from people, particularly the poor, their basic needs, the energy services that must be provided to satisfy these needs, the energy activities corresponding to these services, the efficient end-use devices required for these activities. Only after all this should the task of matching supplies to the lowered demand be placed on the agenda.

(8) In fact, with the decreased demand that results from using energy more efficiently, a greater variety of supply options becomes possible. These supply options may include biomass, but biomass cannot be used in the traditional way with low efficiencies. A process of modernization of biomass sources and/or devices is vital. If this modernization is achieved, then by moving to efficient sources/devices for cooking and lighting in the domestic sector, developing countries can release enormous amounts of biomass to establish a major base for renewable supplies of energy.

(9) In such a scheme of things, rural energy has to have a crucial place. Unfortunately, this aspect of developing country energy futures is over-simplified thus:

Energy for developing countries = Rural energy = Cooking for energy = Firewood stoves.

Whereas this logic may be a necessary condition, it is certainly not sufficient. Firewood may well be an essential fuel today, but it must only be a transitional fuel to a single-cooking-fuel society. Firewood must not be the cooking fuel of the poor in a society in which the rich cook with efficient and convenient fuels such liquefied petroleum gas. Such a dual-fuel situation would only aggravate the dual society of the elite and the masses that characterizes most developing countries and constitute a politically unsustainable situation.

Energy is also required in rural areas to improve the quality of life and to raise incomes via employment generation. In the list of activities necessary for improving the quality of life are the provision of drinking water, the illumination of homes and the facilitation of efficient smokeless cooking with alternative fuels and/or stoves. Employment generation can be achieved on farm through agriculture and/or off farm through rural industries based on the processing of agricultural products or residues and/or of inorganic materials such as building materials.

Energy for rural centres can be supplied from distant centralized plants via transmission/transport networks or from locally available decentralized sources. Both economic and environmental considerations must play a part in the decision- making. In the case of electricity, transmission and distribution grids are proving as expensive as generation and in addition leading to losses greater than about 20%. This means that the establishment of rural energy centres based on decentralized sources would not only make villages self-reliant with respect to electricity, but also avoid the T & D losses.

There is also the question of renewable versus non-renewable sources for electricity generation. Currently, biogas and producer gas are two biomass-derived renewable sources that are economically viable for the decentralized generation of electricity in villages. Both biogas and producer-gas technologies have shown the well-known learning curve that characterizes technology dissemination. This learning process displays the following pattern. The first generation of devices has tended to fail in the field because enthusiasts with inadequate expertise prematurely introduced technologies that were not yet ready for dissemination. The second generation of technologies is the result of far more competent technical work, but the dissemination process may not be sufficiently enlightened. Finally, the third generation of technologies is the result of both technical and managerial competence.

(10) Thus, if we adopt innovative energy strategies, our energy future can be far brighter than it appears to the conventional supply-siders.

ELECTRICITY FOR KARNATAKA

Let us illustrate this approach with the case of the Karnataka State in South India. A committee constituted by the Government of Karnataka for preparing a "Long Range Plan for Power Projects in Karnataka 1987-2000 AD" submitted a report in May 1987.

Its projection methodology, however, was full of shortcomings. In contrast to an actual consumption of 7,554 GWH in 1986-87, the Committee argued that the real demand must have been much higher2. In particular, it computed the demand for HT

But, two serious criticisms of the Committee's methodology have been put forward:

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[2] The estimation of true demand is trivial when there are no power cuts -- the demand can be equated to, and measured by, the actual consumption. The problem, however, is more complicated when there are power cuts. The true demand has to be estimated -- it cannot be measured -- from what the consumption would have been in the absence of power cuts. industries from their contract entitlement. This approach led to an estimate of 15,500 GWH for the `true' 1986-87 demand. With this as the base, the Committee simplistically used an overall growth rate of 9% to project the demand into the future. The result is a projection of 47,520 GWH for the year 1999-2000 corresponding to an installed capacity of 9,379 MW. In order to achieve this projected demand, the Committee argued for a staggering expansion of centralized supplies and an astronomical investment of $16.66 billion.

- o the use of 100% of the contract entitlement for estimating the true base year demand of HT industries ignores the fact that the consumption was much lower (by as much as 20%) in periods when there was no power cut because there are factors other than power -- the availability of finance, raw materials, labour and markets -- that determine the capacity utilization of an industry,
- o the projection does not take into account the possibilities of reducing energy consumption norms through energy conservation by means of efficiency improvements, fuel substitution, etc.

Some of these other options have been made concrete in the recently proposed Perspective Plan for the State. If five conservation measures, viz.,

- modernization (from an energy-efficiency point of view) of Karnataka's power-intensive industries,
- incorporation of frictionless foot-valves and HDPE piping in irrigation pumpsets,
- replacement of inefficient incandescent bulbs with modern compact fluorescent lamps,
- replacemwnt of electric water heaters in homes with solar water heaters, and
- use of LPG instead of electricity for cooking,

had been implemented, the 1986-87 deficit of power would have actually become a surplus of 458 MW. ”Thus, there are options• ”other than the centralized supply options for bridging the• ”demand-supply gap•.

By implementing the five conservation measures listed above, the 1999-2000 demand can be brought down to a figure as low as 14,646 GWH corresponding to an installed capacity of 3,976 MW.

Thus, the case for major expansion of conventional centralized supplies depends upon one's attitude towards the demand projections that are used to justify these supplies. If these projections are treated as sacred "black boxes", then no attempt is made to open up the boxes in order to reveal and scrutinize their contents of assumptions. No wonder that these projections are invariably viewed as unalterable destiny offering no other option except that of constructing massive centralized supplies.

When, however, the projections are made `transparent', it turns out that their underlying assumptions can be adjusted to yield any result, justify any conventional source and fulfill any prophecy. Instead of making such arbitrary projections, it is far better to construct scenarios of what can be achieved through deliberate goals, strategies and policies. In particular, it is possible to develop scenarios based on an integration of conservation and the exploitation of decentralized renewable sources, with conventional centralized sources providing the needful after the above measures. Such an integration has to be based on an evaluation of the economic, environmental and self- reliance implications of conservation, decentralized renewable supplies and conventional centralized supplies.

For instance, the life-cycle costs per kW saved through compact fluorescent lamps, solar water heaters and frictionless foot-valves and HDPE piping have been compared with the plots of life-cycle costs per kW generated for decentralized renewables (small hydel, biogas- and producer gas-driven engine-cum-gensets) and for nuclear, coal-based and hydro-electricity. This comparison leads to three important conclusions:

- Saving is associated with much lower life-cycle costs than generation -- this result is in agreement with the experience accumulating in many countries (both industrialized and developing) that conservation alternatives are one-third to one-half cheaper than the centralized options. (Incidentally, conservation is also ”quicker• and more environmentally benign.)

- The life-cycle costs of generation rise with interest rate because the impact of the larger front-end capital costs of generation projects increases with interest rate. In contrast, the life-cycle costs of conservation fall with interest rate. This difference is because the smaller doses of capital investments required for conservation are spread out over time and therefore the farther into the future these investments are made, the smaller are their present values.

- The difference between generation and conservation life-cycle costs increases with interest rate. This means that the less the availability of capital, the more should conservation be preferred, and therefore, ”it is precisely in capital-starved developing countries• ”like India that there should be a greater emphasis on• ”conservation• -- this contradicts the popular belief that conservation is a luxury that is more appropriate for developing countries.

The costs (in $/kWh) of saving or generating energy through the above-mentioned technologies have also been compared. The comparison shows that, if the principle of least cost planning is adopted, then the consideration of options for bridging the demand-supply gap should take place in the following sequence:

conservation (efficient motors, improved irrgigation pumpsets, compact fluorescent lamps) --> decentralized sources (small hydroelectric, cogeneration, producer gas and biogas plants) --> centralized sources (hydroelectric including rehabilitation and compensatory afforestation costs, natural gas, coal and nuclear)

[Of course, economics alone cannot be the sole criterion of choice of options. It is also necessary to consider environmental impacts. When this is done, it appears that these environmental impacts increase in the same order as the costs. What is good economics is also good ecology, and ”vice versa•.]

It is suggested therefore that the demand-supply matching process should be carried out as follows:

- determine how much of the unmet demand can be satisfied with least-cost conservation measures on the consumption side and with improvements of the efficiencies of the present supplies,

- then deploy non-conventional decentralized renewables to meet as much of the remaining demand as possible,

- and finally, if there is still unmet demand, put the conventional centralized supply options on the agenda for consideration.

GUIDELINES FOR FORMULATING ENERGY POLICIES IN DEVELOPING COUNTRIES

If energy policies are to be consistent with the new paradigm, it is necessary that some important guidelines should be followed in the formulation of energy policies.

(1) ”Shift in focus from energy consumption to energy• ”services•: The level of energy services, rather than the magnitude of energy consumption, must be considered as the true indicator of development.

(2) ”Priority for energy services for basic needs•: In advancing development by increasing the level of energy services, first priority should be given to those energy services that satisfy basic needs, i.e., there should priority for energy services that

- improve the quality of life of the poor,
- generate employment and reduce poverty, and
- influence vulnerable sectors.

(3) ”Comparison of supply increases with efficiency• ”improvements and other conservation measures•: Since the conventional approach emphasizes energy consumption, its attention turns to supply increases which are then differentiated into conventional centralized sources and non-conventional sources. Conservation becomes a separate issue. As a result, conventional and non-conventional supply increases and conservation measures become separate decisions handled by separate offices/departments/ministries with separate budgets. In such a context, empires and satrapies develop. And, in the ensuing conflict over funds, conventional supplies (with the strongest lobbies) get the biggest budgets, non-conventional sources, much less, and conservation has to be content with the crumbs.

But, a given energy service, say, lumens of lighting, can be obtained either by increasing conventional or non-conventional supplies or by using more efficient devices. For us to know which is the best way of obtaining that service, they must be compared with each other. Hence, sound management requires that tenders must be called, not for augmenting supplies, but for providing the energy service.

(4) ”Least•-”cost planning•: If there is concern for least- cost planning, then the competition between supply increases (of conventional and non-conventional sources) and conservation measures must be fair. All three contenders -- conventional and non-conventional sources and conservation measures -- must be compared on the same terms of credit (including interest rates), benefits, incentives, subsidies, etc. At present, the competition is certainly not fair -- the advantages are heavily weighted in favour of conventional sources and against conservation measures with non-conventional sources in between.

This means that there should specific policies for promoting this fair competition through

- the elimination of subsidies to energy supplies
- correct pricing of supplies based, for instance, on long-run marginal costs
- generation of sound databases for the comparison.

(6) ”Promotion of Conservation•: An industry for promoting energy services -- as distinct from supplies -- does not exist. To nurture such an industry and thereby facilitate fair competition between supply increases and conservation measures, it is essential to promote the latter.

Energy consumers who are unaware of conservation possibilities must be helped with information, demonstrations and education. There are also energy consumers who are knowledgeable about conservation opportunities but cannot afford the initial front-end capital costs. This category requires help in the form of loans for investments on conservation measures which can then be recovered through the recurring energy charges. Finally, there are energy consumers for whom energy constitutes only a small fraction of their total expenditures even though the total energy consumption of such consumers is a major societal problem. In this case, social intervention in the form of regulations, equipment standards, energy performance labelling of equipment, etc is imperative.

(7) ”Development of Packages of Policy Instruments•: A variety of policy instruments are available for the implementation of energy policies:- market forces (operating through prices), subsidies, concessions of various types, administrative allocation of energy carriers, equipment and capital, taxes on energy carriers, regulations, standards, labelling of appliances to reveal energy performance, data and information, research and development, etc. Depending upon the area/sector and the region, each one of these instruments has its own degree of (in)effectiveness. Hence, it is important that a specific package of policy instruments is assembled for each energy policy.

(8) ”Power and Limits of the Market•: Whatever the virtues of the market as an allocator of capital, raw materials and manpower, the fact is that market forces cannot be depended upon to safeguard equity, externalities (in particular the environment) and long-term interests. Hence, special policies have to be devised to protect the poor, the environment and the long-term.

With such policies, energy futures will become more a matter of scenarios (intended sequences of future events) than of projections (estimates of future trends).

PRIORITIES FOR DEVELOPING COUNTRIES

Several priorities emerge from the alternative approach described above.

The first priority is that developing countries should assign overriding importance to the task of satisfying the basic needs of their populations, particularly the needs of the neediest.

In doing so, the second priority is that developing countries must cross the hurdle of the severe ”capital constraints• that is coming in the way of conventional energy futures -- the energy sector is becoming unsustainably expensive and new approaches are necessary.

The third priority is that of ”resource constraints•. The only way around these constraints is efficient resource utilization.

The fourth priority is an environmentally benign approach that minimizes the local and near-term environmental impacts of energy production and utilization that otherwise are becoming intolerable.

These four national priorities are in fact a derivative of need-oriented, self-reliant and environmentally sound development, i.e., they constitute the essence of sustainable development.

In addition, there is the global priority of preventing energy from making the world an uninhabitable place -- a veritable hell on earth.

If the above ranking of priorities seems perverse, inverted and all wrong, it is only because conventional supply-biased energy futures compel a trade-off between the priorities. The worst trade-off which can be recommended is one in which developing countries are urged to assign the highest priority to preventing destruction of the global climate at the expense of urgent national development tasks. The only response that such recommendations are likely to elicit is that the industrialized countries which are primarily guilty for the build-up of greenhouse gases must assume responsibility for warding off the climatic catastrophe.

Fortunately, such a head-on collision between industrialized and developing countries is quite unnecessary. The development vs global climate dilemma is only a planetary-cale version of the development vs environment dilemma. The resolution of the development vs global climate dilemma is through energy-efficient futures that permit an emphasis on the urgent priorities of need-oriented, self-reliant and environmentally sound development whilst incidentally making significant positive contributions to the problem of global climate. It is only such strategies for averting the disaster of climate change that are likely to find acceptability in the developing countries. There is an analogous situation in the case of technologies -- it is only those technologies that simultaneously solve several problems that find acceptability. Similarly, it is only those solutions to the problem of global climate that simultaneously address development priorities that are likely to find acceptability.

In conclusion, the main submission here is that energy futures compatible with the achievement of a sustainable world and of a sustainable development are achievable and within our grasp. The choices that are proposed require imaginative political leadership. But, they represent far less difficult and hazardous options for this leadership than those demanded by the conventional approaches to the world's energy future. Above all, this energy future is more a matter of choice than of destiny.

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Table 1: Activity Levels for a Hypothetical Developing Country in a Warm Climate, with Amenities (except for Space Heating) Comparable to Those in the WE/JANZ Region (Western Europe, Japan, Australia and New Zealand) in the 1970s

”Activity•	”Activity Level•
Residential	4 persons/HH
Cooking	Typical cooking level w/LPG stoves
Hot Water	50 l of hot water/capita/day
Refrigeration	1 315 l refrigerator-freezer/HH
Lights	New Jersey (US) level of lighting
TV	1 color TV/HH, 4 hours/day
Clothes Washer	1/HH, 1 cycle/day
Commercial	5.4 sq. m of floor space/capita (WE/JANZ ave, '75)
Transportation	
Automobiles	0.19 autos/capita, 15,000 km/auto/ year (WE/JANZ ave, '75)
Intercity bus	1850 p-km/capita (WE/JANZ ave,'75)
Passenger train	3175 p-km/capita (WE/JANZ ave,'75)
Urban Mass Transit	520 p-km/capita (WE/JANZ ave,'75)
Air Travel	345 p-km/capita (WE/JANZ ave,'75)
Truck Freight	1495 t-km/capita (WE/JANZ ave,'75)
Rail Freight	814 t-km/capita (WE/JANZ ave,'75)
Water Freight	1/2 OECD Europe ave, '78
Manufacturing	
Raw Steel	320 kg/capita (OECD Europe ave, '78)
Cement	479 kg/capita (OECD Europe ave, '80)
Primary Aluminum	9.7 kg/capita (OECD Europe ave, '80)
Paper and Paperboard	106 kg/capita (OECD Europe ave, '79)
Nitrogenous Fertilizer	26 kg N/capita (OECD Europe ave, '79/80)
Agriculture	WE/JANZ ave, '75
Mining, Construction	WE/JANZ ave, '75

SOURCE: J.Goldemberg, T.B.Johansson, A.K.N.Reddy and R.H.Williams, ”Ambio•, ”14•, No.4-5 (1985) 190-200 and ”Energy for a Sustainable World•, Wiley-Eastern Limited, Delhi, 1988.

Table 2: Technological Opportunities for a Developing Country in a Warm Climate to Use Currently Best Available or Advanced Energy Utilization Technologies

”Activity•	”Technology, Performance•
Residential	
Cooking	70% efficient gas stove
Hot Water	heat pump WH, COP = 2.5
Refrigeration	Electrolux Refrigerator/Freezer, 475 kWh/year
Lights	Compact Fluorescent Bulbs
TV	75 Watt unit
Clothes Washer	0.2 kWh/cycle
Commercial	Performance of Harnosand Building (all uses, ex. space heating)
Transportation	
Automobiles	Cummins/NASA Lewis Car @ 3.0 l/100 km
Intercity bus	3/4 energy intensity in '75
Passenger train	3/4 energy intensity in '75
Urban Mass Transit	3/4 energy intensity in '75
Air Travel	1/2 US energy intensity in '80
Truck Freight	0.67 MJ/t-km
Rail Freight	Electric rail @ 0.18 MJ/t-km
Water Freight	60% of OECD energy intensity
Manufacturing	
Raw Steel	ave, Plasmasmelt & Elred Processes
Cement	Swedish ave in 1983
Primary Aluminum	Alcoa process
Paper and Paperboard	Ave of 1977 Swedish designs
Nitrogenous Fertilizer	Ammonia derived from methane
Agriculture	3/4 of WE/JANZ energy intensity
Mining, Construction	3/4 of WE/JANZ energy intensity

SOURCE: J.Goldemberg, T.B.Johansson, A.K.N.Reddy and R.H.Williams, ”Ambio•, ”14•, No.4-5 (1985) 190-200 and ”Energy for a Sustainable World•, Wiley-Eastern Limited, Delhi, 1988.

Table 3: Final Energy Use Scenario for a Developing Country in a Warm Climate, with Amenities (except for Space Heating) Comparable to Those in the WE/JANZ Region (Western Europe, Japan, Australia and New Zealand) in the 1970s, but with Currently Best Available or Advanced Energy Utilization Technologies

	Average Rate of Energy Use (Watts/Capita)		
″ Activity•	″Electricity•	″Fuel•	″Total•
Residential			
Cooking		34	
Hot Water	29.0		
Refrigeration	13.5		
Lights	3.8		
TV	3.1		
Clothes Washer	″_2.1•	__	__
Subtotal	51	34	85
Commercial	22	-	22
Transportation			
Automobiles		107	
Intercity bus		26	
Passenger train	4.5	32	
Urban Mass Transit	2.0	8	
Air Travel		21	
Truck Freight		32	
Rail Freight	5		
Water Freight	__	″_50•	___
Subtotal	12	276	288
Manufacturing			
Raw Steel	28	77	
Cement	6	54	
Primary Aluminum	11	26	
Paper and Paperboard	11	24	
Nitrogenous Fertilizer	-	36	
Other¼b	_″65•	″212•	___
Subtotal¼c	121	429	550
Agriculture	4	41	45
Mining, Construction	__″-•	_″59•	__″ 59•
TOTALS	210	839	1049

SOURCE: J.Goldemberg, T.B.Johansson, A.K.N.Reddy and R.H.Williams, ″Ambio•, ″14•, No.4-5 (1985) 190-200 and ″Energy for a Sustainable World•, Wiley-Eastern Limited, Delhi, 1988.