

# ENERGY FOR A SUSTAINABLE WORLD

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## 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 DEVELOPMENT.

A profound change is taking place in the way we think about energy, and for that matter, about every other natural resource including land, water, forests, etc. We are in the midst of a fundamental transformation in our paradigm or pattern of thinking for energy. This revolution is occurring because the old and still largely conventional paradigm is threatening the sustainability of the world. And, a new development-focussed end use oriented service directed paradigm for the use, demand and supply of energy (and other resources) is emerging.

The situation is best described by an amended version of the opening paragraph of A TALE OF TWO CITIES by Charles Dickens: "It is the worst of times, it is the best of times,

it is the age of foolishness, it is the age of wisdom,  
it is the epoch of incredulity, it is the epoch of belief,  
it is the season of Darkness, it is the season of Light,  
it is the winter of despair, it is the spring of hope, ...."

To appreciate the situation better, we must clarify both the conventional paradigm and the criteria of sustainability.

## THE CONVENTIONAL PARADIGM FOR ENERGY

Let me first describe the conventional paradigm briefly. It 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. Thus, there is an almost exclusive emphasis on the supply aspects of the energy system, Efficiency improvements are either lip-service, nominal, after-thoughts, add-ons or retrofits to the analysis.

The primary goal of energy planning according to this approach is to make this energy supply expansion possible. Even if the "energy system that this approach is bringing about is sustainable, the central question is whether the world that it is leading to, sustainable.

## THE ENERGY THREAT TO THE SUSTAINABILITY OF THE WORLD

In the spirit of Pontius Pilate, we must ask therefore: what is sustainability? I submit that the necessary and sufficient conditions for socio economic change to lead to a sustainable world must include

- (a) satisfaction of basic needs of the peoples of the world,
- (b) economic viability,
- (c) self reliant interdependence of nations, and
- (d) harmony with the environment.

Looked at from this point of view, it is clear that the sustainability of the world is being threatened in various ways but particularly by energy systems. These systems have acquired the following characteristics:

- the poor, especially in the developing countries, do not have adequate energy services to satisfy their basic needs, while the rich, even in developing countries, are using energy wastefully,
- the costs of energy are becoming prohibitively large,
- there is increasing dependence for crucial energy sources on some countries and regions of the world, as a result of which peace is endangered,
- energy production systems are damaging the local environment,
- the global environment is under serious threat from the possibility of global warming due to the build up of greenhouse gases in the atmosphere, and
- nuclear war (not necessarily between the super powers) is the other energy related global catastrophe that is possible even though it is currently being obscured by the preoccupation with global warming.

Thus, energy systems are responsible for equity, economic, military and environmental threats to global sustainability. An energy vs global sustainability dilemma has arisen in their pursuit of energy consumption, both the industrialized and developing countries are jeopardizing the sustainability of the world. This is a conclusion that emerges irrespective of whether we see the situation from the perspective of the industrialized or the developing countries, but I would like to approach the problem of a sustainable world from the standpoint of the developing countries.

## THE TREND OF ENERGY CONSUMPTION IN THE DEVELOPING COUNTRIES

On the basis of the conventional approach to energy, 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.

## ENERGY AND THE ECONOMIC CRISIS OF DEVELOPING COUNTRIES

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. The World Bank pointed out at the 14th WEC that, if the requests of all the developing countries are added up, the demand from the electricity sector alone is a staggering \$100 billion per year when all that is available by way of loans from international, multi lateral and bi lateral funding is \$20 billion per year. Clearly, the current pattern of growth of energy systems in developing countries is economically unviable.

The problem has larger ramifications. The developing countries are depending on loans and aid for the capital requirements of the energy sector. As a result, energy has a significant bearing on the debt crisis that affects both the industrialized and developing countries because of the adage: "small loans are the problem of the borrower (debtor), but large loans are as much the problem of the lender (creditor)!"

## THE GLOBAL ENVIRONMENTAL IMPACT OF ENERGY CONSUMPTION IN THE DEVELOPING COUNTRIES

The energy supply projects that would be necessary to meet the enormous demands for energy would have serious global environmental impacts. Even now, the energy systems of developing countries are significant as far as the global atmosphere is concerned. Though the industrialized countries were largely responsible for the changes in the global atmosphere and are still major contributors of greenhouse gases, the current contribution of the developing countries is not irrelevant.

Developing countries accounted in 1987 for about 43% of the carbon pumped into the atmosphere, of which about 24% arose from deforestation (mainly in the Amazon) which shows no signs of decreasing. Fossil fuel consumption, which today contributes some 15% of all fossil fuel derived emissions, is growing steadily, and is likely to double if present patterns of consumption continue. The trend is for the contributions of developing countries to greenhouse emissions to increase because of present patterns of energy consumption in these countries.

Thus, a situation has been reached where, even if the industrialized countries stabilize their emissions of greenhouse gases, the developing countries can on their own degrade the global atmosphere.

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.

## NUCLEAR POWER

In this context, it is being argued that since nuclear power is non polluting as far as carbon emissions and the greenhouse effect is concerned, it is the cleanest energy source and "the answer to the problem of global warming. Its other characteristics are also being emphasized, viz., that nuclear power does not lead to forest loss and that it does not pollute the atmosphere with particulates and emissions that cause acid rain.

The question of safety and reactor accidents has assumed importance after the accident at Chernobyl contaminated vast areas of Europe. As long as we cannot conceive of all the ways in which reactor accidents can occur, we cannot rely solely on automatic safety mechanisms we must provide for manual override. And the moment we permit operator intervention, we cannot avoid some fool doing a foolish thing. Some feel that nuclear power is too unforgiving a technology. Maybe the present generation of reactors are unsafe, but the significant developments that are taking place in nuclear reactor technology cannot be ignored. Inherently safe reactors are being designed and will soon be available.

But, reactor safety is only one of the problems with nuclear power and in fact, not the main problem. Nuclear plants produce high-level wastes which create long-term disposal problems that have not yet been solved.

Above all, the high-level wastes produced by nuclear plants can be reprocessed and used for weapons a fact that leads to the assertion that there is an intimate, inevitable and inexorable link the power bomb nexus between nuclear power and nuclear weapons. This link is direct through the use of power generation as a springboard for weapons production leading to what has been termed latent proliferation through which countries advance step by step to weapons capability without either declaring or displaying such an intention until the last step when it is too late for stop. The link can also be indirect through the theft of weapons usable material (remember the purchase by "unknown" parties in West Germany of such material with a sum of 2 million deutsche marks). If we want to save the world, not only from the potential dangers of global warming, but also from nuclear destruction, nuclear power is not an option to be considered lightly.

## ENERGY, ENVIRONMENT AND DEVELOPMENT

The requirement of dramatic increases in energy supplies would also lead to local 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 and water logging and salinity increases in the downstream areas. And, coal-based thermal power plants are a major cause of atmospheric pollution acid rain.

Within developing countries, the global energy vs sustainability conflict takes the form of an energy vs development trap that is the inevitable consequence of the conventional paradigm for energy systems. According to this paradigm, per capita energy consumption is the indicator of development, and therefore there has to be a dramatic increase in the energy consumption of developing countries. But, these increases are leading to three major threats:

- a skewed distribution of the benefits from energy systems
- mounting costs
- degradation of the local environment.

Those who promote this conventional paradigm (let us call them the developers) argue that the environmental degradation has to be suffered in the interests of development and that it cannot be avoided except by halting development. Those who oppose this paradigm argue that the environmental costs of this strategy are so enormous that the environment will become inhabitable and the process unsustainable. There seems no way out of this environment vs development trap, and indeed the dilemma cannot be resolved within the framework of the conventional paradigm.

#### RESOLUTION OF THE DEVELOPMENT VS ENVIRONMENT CONFLICT THROUGH A NEW PARADIGM FOR ENERGY

The development vs environment conflict can only be resolved through a new paradigm for energy use. This 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

- structural changes from more energy-intensive activities to less energy-intensive activities "and/or
- 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.

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.

In the context of developing countries, the true indicator of development is the per capita level of energy "services (and "not the per capita energy consumption). Development implies therefore major increases in energy services in the developing countries. Such increases can be achieved with far less increase in energy consumption by harnessing "mixes of energy conservation, renewable sources and current energy production systems. The significant contributions from conservation and renewables advance development "without jeopardizing planet sustainability because they imply much less impact on the local and global environment. To realize such contributions, two steps are necessary

- (1) the adoption of development focussed end use oriented energy service directed (DEFENDUS) energy strategies that ensure consideration of energy conservation and renewable sources, and
- (2) technological leapfrogging.

#### AN EXAMPLE OF A DEVELOPMENT FOCUSSED END USE ORIENTED ENERGY SCENARIO

An excellent case study of the issues being discussed is provided by the recent efforts at electricity planning in the state of Karnataka (South India). In particular, the May 1987 report of the Committee for preparing a "Long Range Plan for Power Projects in Karnataka 1987-2000 AD" (LRPPP), serves as a clear cut example of the failure of the conventional consumption obsessed supply biased approach to energy planning. The LRPPP plan demanded that, in order to meet its energy requirement of 47,520 GWh and 9,397 MW in 2000 AD, the state should spend an astronomical sum of about \$16.625 billion (@Rs.16/\$), develop a great deal of infrastructure (better transmission lines, coal transportation linkages, railway facilities, etc.), construct massive centralized power generation facilities (including a 1000 MW super-thermal coal based power station and about 2000 MW of nuclear power), raise funds from the World Bank and the Central Government, divert at least 25% of Karnataka State's Plan for power and appeal to private industry to set up generation facilities. In return, the LRPPP plan promised that energy shortages will continue up to, and into, the next century. In other words, conventional plans are no longer solutions; they are exercises in profligacy.

An alternative scenario for the electricity sector of Karnataka has, therefore, been developed on the basis of the development focussed end use oriented energy service directed (DEFENDUS) paradigm. This DEFENDUS scenario for energy demand and

supply focusses on people based development through the promotion of energy services, and proceeds by identifying technological opportunities for better utilization of energy through a scrutiny of the end uses of energy, and adhering to a least cost approach to the mix of energy supplies. It turns out to be as promising as the LRPPP and other conventional plans are gloomy. In particular, even though the DEFENDUS scenario involves the illumination of "all homes in Karnataka, an emphasis on employment generating industry, the energization of irrigation pumpsets up to a limit imposed by the groundwater potential, and the establishment of decentralized rural energy centres in all the villages of the state, it comes out with energy and power requirements in the year 2000 AD which are only about 38% and 42% respectively of the LRPPP demand.

This reduction in requirement is partly (59 %) due to a development focus and partly (41 %) due to simple efficiency improvement and carrier substitution measures. These measures consist of the replacement of inefficient motors and incandescent bulbs with efficient motors and compact fluorescent lamps respectively, the substitution of solar water heaters and LPG stoves for electric water heaters and electric stoves, and the retro fitting of irrigation pumpsets with frictionless footvalves and HDPE piping.

To meet its demand, the DEFENDUS supply scenario involves a "mix of efficiency improvements and electricity substitution, decentralized generation technologies and conventional centralized generation technologies in an approximately 40:40:20 ratio. But, the reduced demand for centralized generation technologies means that the environmentally controversial technologies nuclear power plants, coal based thermal power plants and hydroelectricity can be largely avoided.

The overall bill for the DEFENDUS scenario has been estimated it is only about "one "third of the cost of the conventional approach which means that the latter would lead necessarily to a much higher unit cost of energy. Even allowing for a five year preparation period before efficiency improvements and electricity distribution measures are introduced, the DEFENDUS scenario involves a shorter gestation time. This is because it depends largely on efficiency improvements and electricity substitution and on decentralized technologies that can deliver energy and power almost immediately. And finally, the DEFENDUS scenario is about 200 times far more environmentally benign in terms of millions of tonnes of CO<sub>2</sub> pumped into the atmosphere every year.

#### IS THERE HOPE FOR SUCH CHANGES?

What are the prospects of the cheaper, quicker, more environmentally sound and more equitable DEFENDUS scenario being adopted? Such a scenario is so obviously superior that it (or some variant of it) should be chosen if rationality prevailed. Energy decision making, however, is not always done on the basis of rationality alone; there are often powerful vested interests that have grown along with the conventional electrical supply industry. But, it appears that the supply lobby can no longer procure as easily as before the capital to carry through its exorbitantly expensive schemes particularly because the bankability of these schemes is being eroded by rising costs and environmental safeguards. Further, the funders are being confronted with alternative scenarios presented in increasingly quantitative detail. Whether these funding institutions will be able to resist these more cost effective and environmentally sound alternatives may well depend upon the popular support that

the development focussed end use oriented scenarios can muster. But, the fact is that however difficult it may be to implement these alternative scenarios, the conventional plans are impossible to sustain.

Thus, the real hope for such changes lies in the convergence of a multitude of interests:

- (1) International aid agencies because they are finding the bill for the supply approach impossibly high
- (2) Industrialized countries threatened by the global environmental consequences of conventional energy strategies in developing countries,
- (3) Energy analysts who can now present alternatives with concrete proposals backed by numbers and not as emotional hand waving arguments.
- (4) Environmental movements within developing countries supported by counterparts in the industrialized world,
- (5) Developmental activists who see that energy from supply biased strategies is not trickling down to the poor, and
- (6) Above all, the underprivileged sections of humanity who find themselves being bypassed by the conventional approaches to energy.

#### CHANGES REQUIRED TO PROMOTE A SUSTAINABLE WORLD

”New guidelines for Energy Strategies: The new paradigm requires the following set of guidelines:

1. A shift in emphasis from energy consumption (kWh) to energy services (lumens).
2. Priority for energy services for basic needs.
3. Comparison of conventional centralized supply increases with both renewable sources and efficiency improvements on the same terms and as part of the same decision making process.
4. Least-cost planning based on cost-supply curves.
5. Promotion of renewable sources and efficiency improvements.
6. Development of packages of policy instruments for the implementation of renewables and efficiency improvements.
7. The power of the market is that it is an excellent allocator of money, materials & manpower, but the market also has its limits with respect to safeguarding equity, environment and the long term.

”Energy related Institutions and Utilities in Developing Countries: These institutions must ”inter alia

1. promote proven financing schemes (designed to convert initial capital investments into recurring energy charges) so that individual and industrial consumers can surmount the capital constraints that inhibit them from adopting efficiency improvements,
2. improve the efficiency of fuel wood use and ultimately shift to high efficiency gaseous fuels,
3. shift to less harmful fossil fuels (such as natural gas) and fossil fuel technologies when fossil fuels are unavoidable.
4. change (if necessary through the stimulus of international and local financial institutions) their charters from suppliers of energy to vendors of energy services

as envisioned by Edison a century ago.

[1] "International Funding and Aid "Agencies: These agencies must

- (a) include global environmental impacts in their evaluation of projects,
- (b) compare supply increases and efficiency improvements on the same terms and as part of the same decision making process and
- (c) provide financial support to conservation and renewables.

"Industrialized Countries: These countries have several major responsibilities re: developing countries including

- (1) prevention of the export of cost ineffective, environmentally malign and globally damaging energy technologies,
- (2) special support and assistance for biomass production (especially afforestation) and biomass based energy technologies,
- (3) funding of environmentally benign energy technologies including renewables, public transportation, lower impact fossil fuel technologies,
- (4) support for energy conservation programmes,
- (5) the initiation/establishment/strengthening of indigenous capability in the areas of energy analysis and planning and of energy technologies.