POWER FROM SARDAR SAROVAR

An inefficient plan

A. K. N. REDDY, of the International Energy Initiative, and **GIRISH SANT**, an energy analyst, argue that a least-cost planning exercise for electricity does not justify the power component of the SSP.

The Sardar Sarovar Project (SSP) has both irrigation and an electrical part, this article restricts itself to the electrical part.

Any review of the electrical part of the SSP project has to first take note of the fact that the approach to energy in general, and electricity in particular, is undergoing a fundamental change. The old paradigm is breaking down and a new paradigm is emerging. The old paradigm was based on the following belief:

Development = Economic Growth = Energy Consumption = Demand projection = Supply Increase = Centralised Mix + Grid Transmission and Distribution.

This belief assumed that economic growth is correlated with the magnitude of energy consumption. It also restricted itself solely to centralised supplies for meeting projected demand without comparing the costs of such supplies with alternative options. In particular, the belief ignored energy conservation (involving end-use efficiency improvements mid energy carrier substitutions), environmental impacts and decentralised renewable sources as an integral part of the energy planning exercise. Even if these energy interventions were brought in, it was only as after-thoughts, add-ons and retro-fits.

Environment-Development trap

The so-called developers pursue economic growth, to achieve which they insist there must be increases of energy consumption. When, however, this energy is produced, there are a number of side effects, particularly environmental degradation. Seeing the environment degrading, or expecting it to degrade, the environmentalists oppose the energy projects. Thus, a conflict grows in intensity - the developers say that the environmentalists are preventing development and progress, and the environmentalists say that the developers and planners are destroying the environment making further development impossible and the development process unsustainable. The two sides are locked in battle. This conflict — the environment-development trap — cannot be resolved within the framework of the conventional paradigm based on the assumption that an energy-GDP correlation is inevitable and imperative.

The financial requirements of the electricity system are several times more than what can be provided by the suppliers of capital. This capital crisis has also been experienced at the level of the Central Government and at the level of' the States. Thus there is an enormous mismatch between what the electricity sector would like and what can be allocated by the planners. No wonder that the electricity sector has been compared to Bakasura, the demon of Indian mythology, who had an insatiable appetite and however much he was fed, wanted more. And there is no certainty that private sector sources from abroad can satisfy this appetite for capital requirements at terms that are reasonable and healthy for the system.

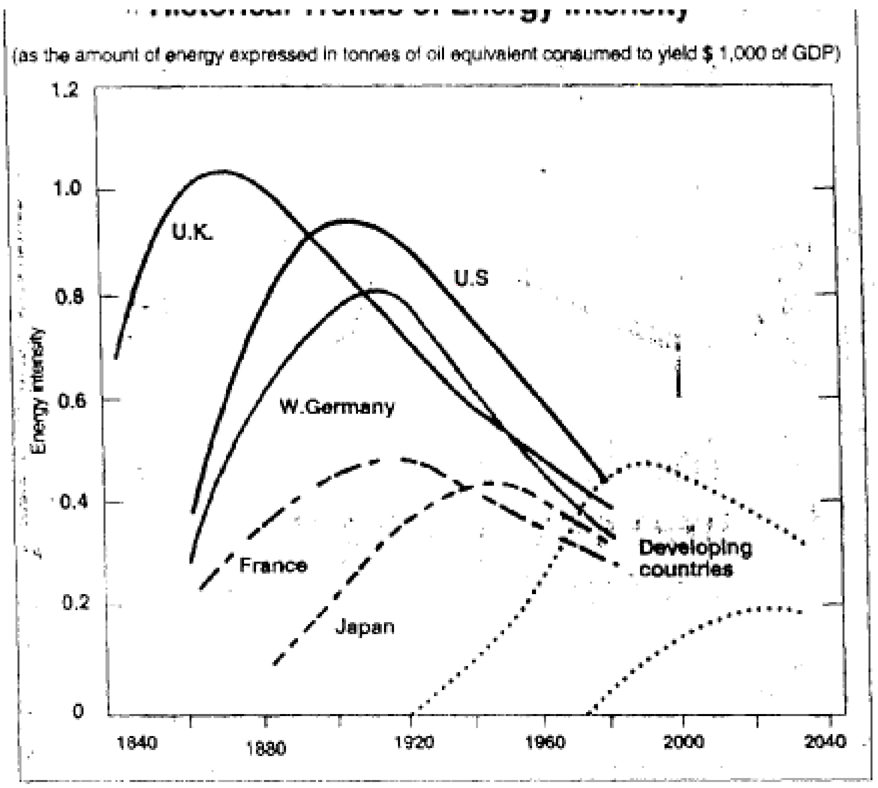
The root cause of the environment-development trap and the capital crisis threatening the electricity system is the conventional energy paradigm or mindset dominating the thinking of virtually all energy decision-makers and planners not only in India but in most other developing countries.

The way out of the crisis is through a new paradigm for energy-in which it is recognised that what human beings and their individual and collective activities require is not energy *per se* but the work that energy performs and the services that energy provides illumination, warmth, "coolth" (to coin a word), mobility, etc. In this approach, it is the level of energy services - and not the magnitude of energy consumption - that must be taken as the indicator of development. Thus, development does require a substantial increase of energy services. But, such increases can be achieved not only by increasing the supply of energy to the devices (lamps, heaters, air conditioners, vehicles, appliances, etc) hut also by increasing the efficiency with which these devices provide energy services and/or, shifting to more efficient energy carriers.

When energy is used efficiently, the expansion of energy supplies to increase the level of energy services can be partly avoided.

It is also crucial to emphasise energy services for the poor. Electricity, therefore, must acquire a human face and become an instrument of development. Electricity planning must acquire a development focus and an end-use orientation directed towards energy services. Electricity for whom? Electricity for what? Electricity how (efficiently)? Become central questions. What is required, therefore, is a new paradigm for energy - a development-focused end-use-oriented service-directed or DEFENUUS paradigm to defend us against the crisis.

The energy characteristics of an economy can be described by its energy intensity which is the energy consumption required to increase its GDP by a unit amount. The energy intensities of economies show an interesting pattern - they first rise, reach a-maximum and then fall. However, in general, the maxima (of energy intensities) reached by countries have progressively decreased over time, i.e., the later the country industrialised, the lower its maximum. This very interesting phenomenon is due to the fact that the energy required to produce a unit quantity of material such as steel, materials, etc., and the quantity of materials such as steel, cement etc. required to perform a particular function, say hold up a building, have both decreased with progress in materials, science and technology. Hence, developing countries must not copy the worst," i.e., the early industrialisers which show the highest maxima; they need not even "copy the best", i.e., the latest industrialisers (e.g., Japan) which show the lowest maxima; they can even "beat the beat " through technological leap-frogging.



Thus, reduced coupling between GDP growth and energy consumption through efficiency improvements and carrier substitutions is not a "luxury" that can be enjoyed only by the industrialised countries - as is commonly believed. Underlying this mistaken belief is the assumption that energy conservation means decreases in the levels of energy services inevitably resulting from decreases in energy consumption levels which are much lower in developing countries. If, however, efficiency improvements (leading to decreases in energy consumption) are implemented to achieve increases in the energy services, then it is obvious that energy conservation does not necessarily mean decreases in the level of energy services.

Even at India's present stage of development, efficiency improvements are possible in all sectors and with all end-uses of energy. Whether it is motor drive systems, lighting, cooling, heating, etc., there is always a menu of technological options for each of these tasks. Further, the different options are associated with different costs and energy efficiencies, and quite often the higher efficiency option has a higher initial cost even though the so-called life-cycle coat, i.e., the cost over the entire life of the device, is lower. When energy is used efficiently, the expansion of energy supplies to increase the level of energy services can be partly, if not completely, avoided. Hence, the adage: a kilowatt hour saved is a kilowatt hour generated, which is not strictly accurate because the energy saved is at the consumption end of the transmission distribution system whereas the energy generated is at the generation end, and in between are all the T & D losses. In fact, if the T & U losses are 22.5 per cent a kilowatt hour saved is equivalent to more than one 1.29 kilowatt hour generated.

Very often the life-cycle costs of saving energy are only one-third to one-half the costs of generation. Nevertheless, the coats of saving energy must be carefully compared with the costs of producing energy. Also, the magnitude of energy that can be saved must be taken into account. All this means that it is necessary to pursue integrated electricity planning and identify a least-cost mix of saving and generation options for energy.

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Thus, the new challenge to electricity systems in India is to reduce the coupling between GDI' growth and energy consumption by identifying and implementing a least-cost mix of generation and saving options for increasing energy services. Apart from including saving options in this integrated electricity planning, the generation options must not be restricted to centralised options and/or fossil fuel/non-renewable options. Decentralised options must be included for consideration as well as renewables particularly because the costs of electricity from sources such as biomass, wind, photovoltaic, etc., are falling rapidly.

Least-cost planning for electricity involves four important steps:

(1) Construction of frozen efficiency scenarios which do not assume efficiency improvements and electricity substitution to estimate the requirements of energy in some future horizon year.
(2) Listing of options (for meeting energy requirements) ensuring that the list includes options for saving energy as well as options for energy generation with both centralised and decentralised systems.
(3) Ranking of options in the order of increasing unit cost (Rs/KWh) preferably taking into account the environmental costs, i.e. internalising the externalities,
(4) Defining the "supply" mix by taking the cheapest technology and making it the first element of the mix, and when its potential is exhausted, going to the next cheapest technology, and so on, climbing this cost-supply staircase till the energy requirement is met. All the technologies lying on the cost supply staircase up to the (frozen-efficiency) energy requirement are the components of the supply mix that have to be used to meet the demand requirements. In this process, there must be no favourites at all. If, for instance, a conservation measure comes into the mix, it is accepted; if it is too expensive, it rules itself out.

Last cost planning is becoming increasingly standard in the industrialised countries. In India, a least-coat electricity plan has been made for Karnataka and Maharashtra. The Karnataka and Maharashtra least-cost planning exercises show that the least-cost mix of options to meet the requirement consist of three components; (1) efficiency improvements and carrier substitutions, (2) decentralised sources and (3) clean(er) centralised sources.

From such exercises, two important lessons are emerging: (1) neither efficiency improvements nor decentralised sources, either singly or together, can meet the whole requirement, but (2) when both efficiency improvements and decentralised sources are included in the supply mix, the demand for centralised sources is drastically reduced.

By and large, in the past, the energy establishment and the energy planners in India had ignored least-coat planning. But, now that the capital crisis is acute, there is a favourable environment for searching for least-cost solutions.

Let us now turn from these general and global considerations to the Sardar Sarovar Project (SSP) which involves a 455 ft embankment that would create a reservoir that would lead to the submergence of 240 villages, 40,000 families, and 39,000 hectares (of which 13,744 hectares is prime forests). We understand that the electrical part of the Sardar Sarovar Project

(SSF) ii-counts for 56.1 per cent of the costs. This electrical part of the SSP may be considered to consist of three components:

- Conventional generation from a 436 ft embankment reservoir.
- Pumped storage generation from the same 436 ft reservoir.
- Generation from a 19 ft increment in height to the 436 ft.

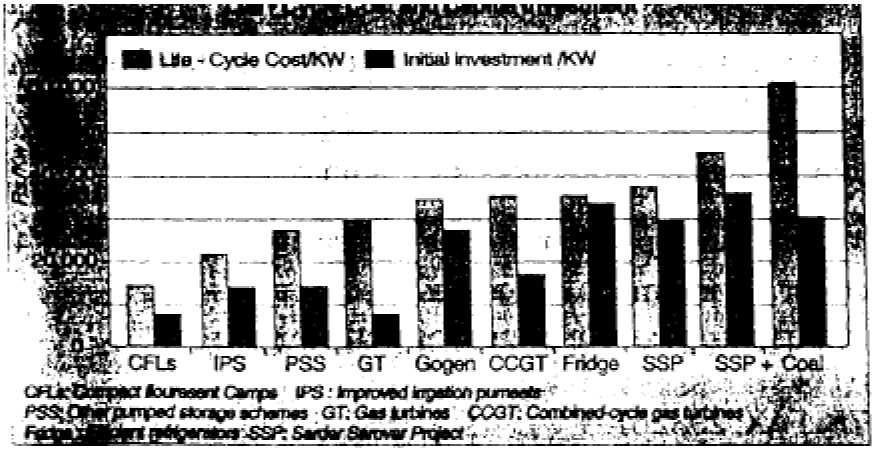
Conventional generation

If one thinks of a hydroelectric project as being bas-rd on a waterfall with a high head, then it is important to note, that the SSP is not such a project it is, in fact, a mega-tank where the head is created by the will or embankment of the tank. Further, if the down-stream canal system is built and in place when the dam is built, then the water can he evacuated from the reservoir as and when required for irrigation and other end uses of water - and there would be little water available for electricity generation. However, it is envisaged that the canal system cannot be completed before 15 years, before which all the water cannot be evacuated for irrigation.

It is perhaps this mis-match between the gestation periods of the dam and the irrigation system (the canal system and some upstream developments) that has led to the idea of generating electricity from the un-evacuated water. An electrical capacity of 1,450 MW hag been installed for this purpose in the Canal Head Power House (CHPH) and the River Bed Power House (RBPH). Unfortunately, due to the seasonably of the water flow into the reservoir, the available firm capacity (on a continuous basis) is much less - 439 MW with 415 MW from the RBPH and 24 MW from the CHPH.

A typical hydroelectric plant is most valuable for the peaking capacity that it offers through the water that can he released for power generation as and when there is demand for power. In tile initial years after commissioning, the SSP can provide 1.460 MW of peaking capacity. However, as the irrigation systems are completed and start competing for the water in the reservoir, there will be a significant decline in the peaking benefits. Consequently, after 15 years, the generation will be restricted almost completely to the uncontrolled floods during the monsoon. Hence, for peaking purposes, the conventional generation component of the SSP is in effect a hydroelectric project with a limited lifetime of only 15 years and even during that lifetime, it has a declining capacity. The situation may actually be worse because the estimate of (he electricity generation assumes large release-, from the upstream Narmnda Sagar Project the delay of winch will decrease the conventional generation by about 25 per cent. Further, it appears that the water flow of the river is actually 17 per cent less than assumed — this will decrease the available capacity.

In the initial years the SSP can provide 1,450 MW of peaking capacity. However, once the irrigation systems are completed there will be a significant decline in peaking benefits.



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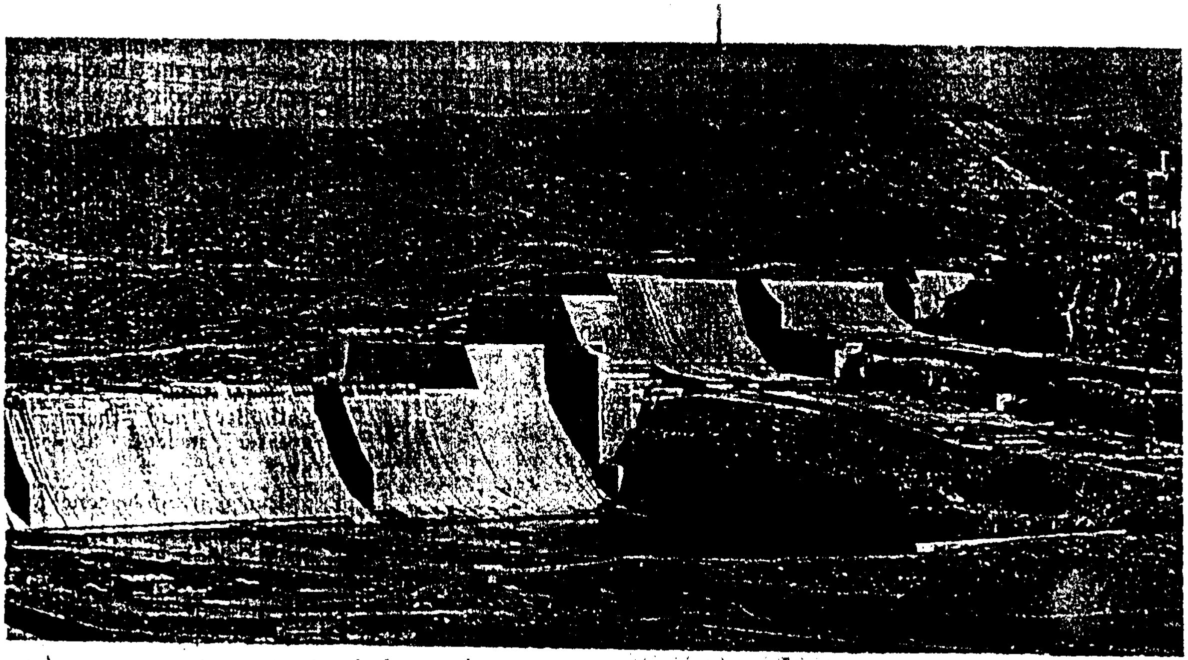
To compensate for the shortcomings of the conventional generation, to utilise the reservoir storage capacity, and to generate power during the periods of peak demand when it is badly needed, the SSP has a scheme for pumped storage (PSTOK) pumping the water into the reservoir when there is surplus power in the grid, and running it down into the turbines and generating power during the hours of peak demand.



Shailendra Yashwant

The scene at Kevadia: is the river-bed power house needed?

Unfortunately, the SSP PSTOR scheme has not been compared with other PSTOR possibilities in the western India region. If such a comparison were made, the SSP PSTOR scheme is bound to fare badly because of the low head available in SSP compared to the high heads possible in other projects (for instance, the Pimpalgaon Joge PSTOR Scheme costs about 25 per cent less per unit electrical output than the SSP). The high heads of other schemes also mean less water needs to be pumped and stored, and therefore less submergence — a. 1,450 MW PSTOR scheme with the characteristics of the Pimpalgaon Joge

PSTOR Scheme would require less than 0.6 per cent of the submergence of the SSP.

The SSP PSTOR scheme has also not been compared with a number of other conventional supply schemes such as gas turbines and cogeneration of surplus electricity for instance in sugar factories and other factories with cogeneration potential. Finally, the SSP PSTOR scheme has not been compared with avoiding capacity expansion through end-use efficiency improvement* and demand-side management (DSM) alternatives. This omission is particularly serious because it is well-known that the evening peak in, Indian electricity systems is largely due to lighting, and drastic reductions in peak demand can be achieved by adopting- efficient lighting devices.

Generation from a higher dam

Though the suggestion of a 19 ft increment to the height of the dam came from the Narmada Water Disputes Tribunal award, the extra energy it will yield (230-350 million units) is less than 10 per sent of the total energy. For this marginal benefit, a tremendous price has to *be* paid - 5 villages and an additional 9,500 ha will be submerged, mostly in Maharashtra and Madhya Pradesh. So, there is a trivial amount of energy produced at enormous human, social and environmental cost - all because there are as yet no vested interests to twist in efficient lamps, improve irrigation pump sets and implement cogeneration in sugar factories, or because the governments are too lazy to perform, these tasks.

To summarise our assessment of the three components of the electrical part of the SSP:

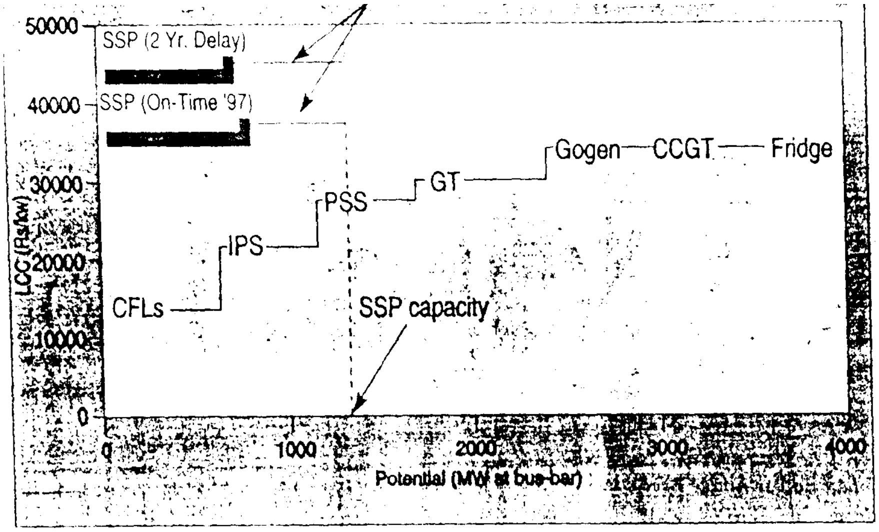
There seems no justification whatsoever for the negligible generation from the 19 ft. increment in the dam height.
The conventional generation declines rapidly to a trivial capacity that is hardly worth it.

The SSP PSTOR scheme - to compensate for the weaknesses of the conventional generation - is so intrinsically inappropriate and expensive compared to other supply-side and DSM schemes that it *is* like "throwing good money after bad".

The economics of eight alternative energy options are notably superior to that of the SSP.

Let us now look at the costs of the SSP power compared with other conventional centralised generation alternatives [other pumped storage schemes (PSS), gas turbines (GT), combined-cycle gas turbines (CCGT), coal-based thermal, power plants as well *as with* demand-side management [compact fluorescent lamps (CFLs), improved irrigation pumpsets (IPS), efficient refrigerators (FRIDGE)] and decentralised generation alternatives [cogeneration (COG EN)] appropriate for the Western Region.:

The results of the quantitative analysis are summarised in the accompanying figure which gives the cost for each option in Rupees per kilowatt of supply expansion or saving. The energy options are evaluated on the basis of their life-cycle cost and first cost per kilowatt added/saved at the bus-bar. The figure shows that only coal-based thermal power would be more expensive than the SSP and that, after coal-based thermal power, the SSP is the most expensive choice.



Next, let us consider a least-cost "supply" mix, i.e., mix of supply expansion and saving options, to provide the sample power benefits that the SSP claims to achieve. Presently, the western region is faced with serious power 3hortages in the period of peak demand (in the evening) although the base-load capacity significantly exceeds base demand. Therefore, what must be explored is the cost of adding (or saving) a kilowatt (Rs/kW) during hours of peak demand.

The cost-supply curve (see Figure) indicates the costs and the potentials of eight generation and saving options, ordering them by increasing life-cycle costs (Rs/kW). For comparison, the cost and potential of the SSP is also marked to provide the yardstick for comparison. The area under the curve yields the total life cycle cost for each option. The coat-supply curve leads to several conclusions. (1) The capacity claimed by SSP can be achieved at a much lower cost with a combination of a few of the eight alternatives, and specifically fit about 49 per cent of the coat with a combination of efficiency improvements in lighting and irrigation pump sets and other PSTOR schemes. (2) With the same capital outlay as that estimated for the SSP, a least cost mix of the alternatives can yield 65 per cent more electrical benefits than the SSP (3) An enormous realistic potential of over 4,000 MW - roughly 2.7 times what has been claimed to be the output of the SSP - is available by utilising energy options cheaper than the SSP. (4) In addition, these other options also result in much smaller social and environmental impact than the SSP which has become controversial primarily because of its social and environmental impact. Incidentally, unlike other hydroelectric power projects, the SSP cannot be considered a renewable source because conventional generation will come down to negligible levels as the irrigation systems develop, and pumped storage will increase with the pumping being done with electricity generated to a considerable extent from the combustion of fossil fuels.

Thus, the economics of the eight alternative energy options are notably superior to that of the SSP. The achievable power potential is also many times the potential of the SSP. Additionally, the alternatives provide greater environmental and social compatibility and therefore greater societal acceptance.

Hence, it can be concluded that:

SSP is not needed for power generation for the western region if alternative energy options (excluding coal) are implemented.

Even if the amount of power claimed by the SSP is considered to be essential, the SSP is not the least-cost, or even a low-cost, option.

On the basis of the present allocations of project coat for irrigation and power, the power component of the SSP is not justified from the economic point of view.

In order to make the power component of the SSP economic, the present allocations of project cost for irrigation and power will need to be substantially altered in which case the irrigation component will have to be reevaluated.

Even if SSP is proven to be essential for irrigation and other benefits, the extra 19 feet of the dam (which is responsible for 27 per cent of total submergence) is unjustified.

To conclude, since decision-making involves the identification of feasible options/alternatives and the choice of the best option/alternative, any review must consider all the options - not only those that were considered by the formulators of the SSP, but also those that were earlier ignored either deliberately or innocently. It is human to make mistakes in decision-making and in reviews of decisions- but we must ensure these mistakes are small and reversible, not gigantic and irreversible.

In Calcutta the height of the new Howrah Bridge was fixed on the assumption that ocean-going ships would pass under it. Before the bridge was built, it became clear that would not happen because the Hooghly port would decline and the importance of Haldia port would increase. But, the decision-makers, reviewers of decisions and implementors stuck to their erroneous assumption. Today, no ocean-going ships are passing under the bridge! The result was enormous in fructuous expenditure of which the only beneficiaries were the steel/cable/structural manufacturers, the erection contractors, etc. Fortunately, there was little human and environmental damage. In the case of the Sardar Sarovar Project it is different.