Re-Assessing the Role of Large Dams in Meeting Power Demand

Presentation to the

World Commission on Dams

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December 1998

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1. Common Arguments for the Hydro-Projects

The conventional power sector planning aims at providing reliable grid supply to consumers all over the country at the least cost. To achieve this, it largely concentrates on mega projects, which are considered suitable for large grid systems. The large hydro projects form an important part of the project portfolio in conventional power systems. Large hydro are said to be advantageous for following reasons. They are:

- Clean (low social and environmental costs),
- Renewable source of energy,
- Having high untapped potential (estimated at 60 GW in the country),

and are also claimed to be

- Cheap.

It is difficult to call the large hydro projects clean if we consider the social and environmental impacts they make. Other presentations would talk about these aspects in more details. Hence, this presentation more specifically looks at the other two aspects, viz. costs and potential of large hydro.

First, large hydro projects take more than ten years to go through various stages, i.e. from planning to execution. In case of the Narmada valley, inspite of the planned potential of over 2,140 MW of capacity, only 90 MW had been added in the period of 25 years before the popular opposition to the projects and the limitations on government support became serious constraints. This indicates that there are a number of practical difficulties and limitations for realisation of the techno-economic potential of hydro-power. At the national level, even without considering the possible large delays[1], only 1,900 MW of annual capacity addition from hydro is planned for the 9th Five year plan (1997 to 2002) (GoI, 1997-98). This needs to be considered in the context of official projections of capacity addition need of more than 8,000 MW per year and possibilities of reduced demand by more than 30,000 MW over the next ten years, from efficiency measures. Thus, similar to the case of solar energy, though the potential of large hydro appears to be very large, in reality, it's role in meeting power demands of the grid is constrained.

The second advantage claimed in case of the large-hydro projects is its cost effectiveness. It is well know that the cost advantage of hydro projects vary drastically from case to case basis. It depends on the site, water availability, particular needs of the power system and availability of other options in technologies / fuels (such as gas and liquid fuels). Further, while weighing the advantages of hydro-projects, one should be extra cautious about the high probability of time and cost overruns (WB, 1996). These overruns make it problematic to compare the estimated cost of the hydro projects at design stage with those of the other projects. In India, during the 8th Plan period, the hydro-power sector recorded the worst achievement in capacity addition (in proportion to the target). Only 27% of the targeted hydro capacity could be added in the plan period (GoI, 1997-98). In addition, in India, it is often found that hydro-projects are compared with options that are not really comparable and that the list of competing options considered for comparison is very limited. For example, one of the peaking hydro plant that we analysed, was justified on the basis of the comparison with a thermal plant that was assumed to be operating at less than 20% PLF ! (Maheshwar DPR, 1989) The options such as peaking gas turbine (GT) or pumped storage were not considered in the comparative analysis. The comparative costing, usually done well before making the investment decision, is not reworked while actually executing the decision. Hence, contrary to the usual practice, a rigorous and timely analysis is required to establish the cost effectiveness of large hydro power even from the conventional planing perspective, leaving aside the debate on "externalities".

[1] Large delays in hydro-power have been due to problems related to funds availability, geological surprises, inadequate R&R plans and environmental issues etc. In the 8th plan despite proposed capacity addition of the same order, only 27% of it could be realised.

Most project assessment studies do not account for the full cost of the acceptable R&R package or the full environmental cost. Incorporating these could radically change the economics of large hydro. Reworking of cost-effectiveness of hydro-projects needs to account for these factors.

Thus, it is essential to look beyond the usual arguments about the cost effectiveness and potential of large hydro projects. The role of large hydro needs to be re-assessed in a wider perspective and through planning methodologies that are more inclusive as far as technological/fuel choices as well as planning processes and mechanisms are concerned. Apart from these general factors, many specific factors will have to be considered in dealing with a particular power system of a state or a country. In this presentation, we will elaborate on how, largely in the Indian context, the role of large hydro is changing and the steps that we feel are needed for properly assessing the role, viability of large hydro-power.

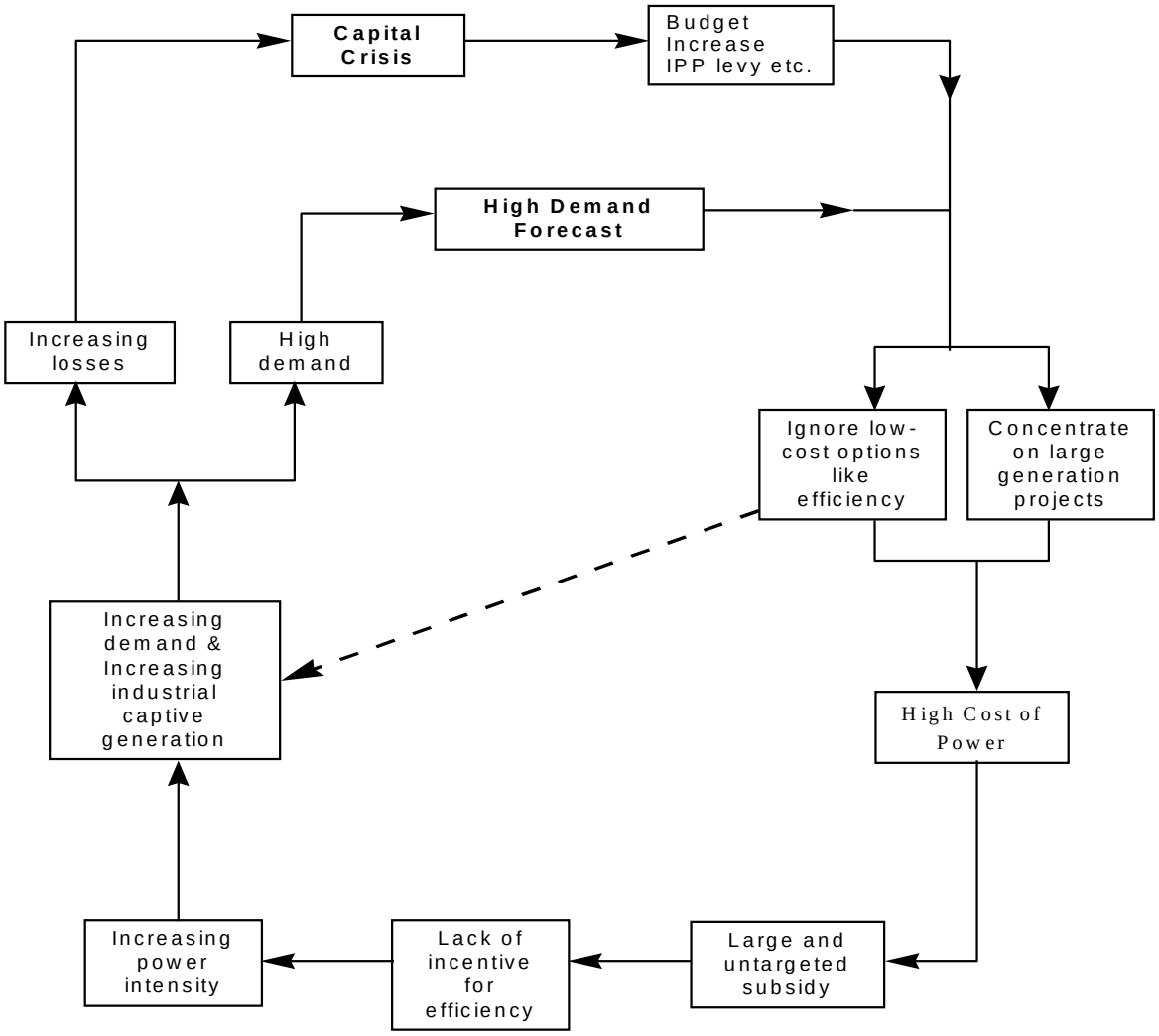
2. The Underlying Logic and Its Critiques

Underlying these claims of certain advantages of the hydro-projects is the logic that guides the planning methodologies that are employed currently in the power sector. The Conventional logic of the power sector for the hydro-power, applied in the case of India, goes as follows.

There exist large peaking shortages (>18%) along with energy shortage (~10%) and, simultaneously, the demand is increasing rapidly (at a rate of 7% p.a.). As a result, emphasise on peaking plants is essential. Hydro power is considered to be the one of the most appropriate peaking sources. In this context, in the case of India, it is pointed out that proportion of hydel generation is falling steadily, which ideally should be 40% of the total installed capacity. The planning process then focuses on addressing the capital crisis.

In fact, this logic involving sole reliance on supply through centralised generation with an emphasis on hydro-projects, needs to be seen as an integral part of the paradigm that currently governs the power sector. It is essential to understand this in order to be able to investigate the role of the hydro power in the near future. This conventional paradigm guiding the power sector could be visualised in terms of a vicious cycle, as shown below in figure 1.

Figure 1 : The Vicious Cycle



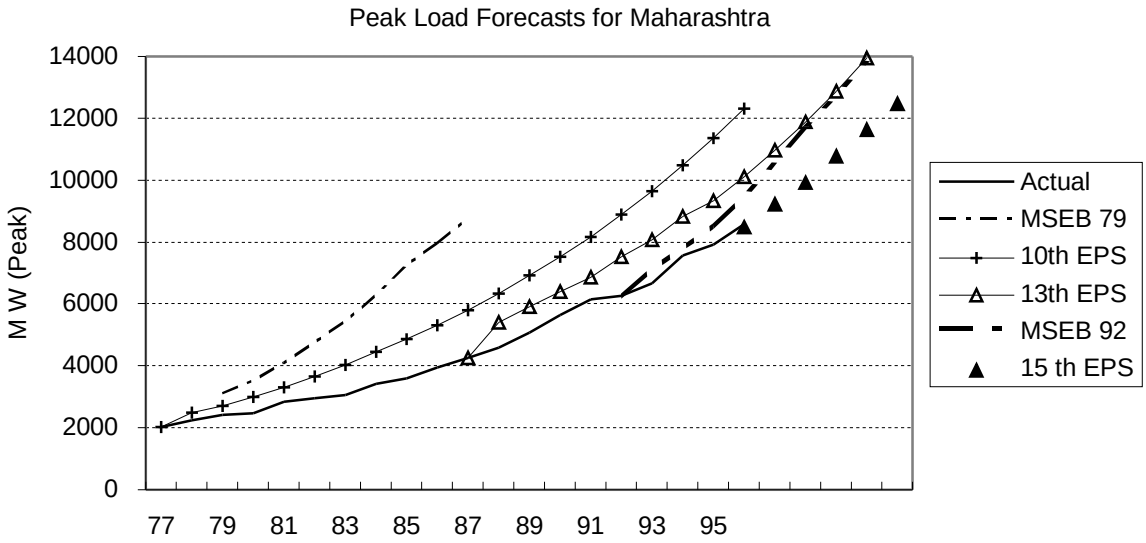
The Vicious Cycle

The power sector planning starts with a high demand forecast and the painful realisation of the capital crisis. The planners tend to concentrate only on the mega generation projects, which are seen as the only means to bridge the wide gap between demand and supply. In the process, several low cost options receive in-sufficient attention, as each of it is said to be too small to bother about. While implementing the large projects, some get delayed due to shortage of funds or, at times, due to problems related to implementation. As shown later, the neglect of low cost options lead to high cost of power. Due to the large in-equity in the Indian society, there is a strong demand for subsidised tariff, especially for agricultural and residential sectors. Because they are politically convenient, large and ill-targeted subsidies are offered. This leads to disincentive for consumers to use power in an efficient manner. At the same time no action is taken to improve the efficiency of power utilisation. This, in turn, leads to rapidly rising demand and increasing financial losses in the sector. This situation re-enforces the high demand forecasts and capital crisis, completing a vicious cycle. If the power sector has to come out of this vicious cycle, substantially different approach needs to be adopted. Such an approach would involve re-defining the current emphasis and paying close attention to the changing mandate of the power sector. The following section briefly explains the components of the above process.

The first step of planning exercise, the energy demand forecast (EDF) studies, assume that all demands that are finally out on the grid are justifiable demands that need to be satisfied to bring about development. By adding them up, the planning exercise arrives at a "need" based projection of demand, without accounting for even the tariff elasticity of the demand. At the state level, the demand projections are worse. Figure 2 shows the historic

demand projections and actual demand met for the respective years for one state, that did not have much power shortages.

Figure 2 : Peak Load Forecasts and Actual Demand



The capacity addition plans that follow, restrict the list of candidate options only to the large centralised projects. This leaves many cost-effective options to meet demand for services un-attended. At times, even some of the centralised supply options are ignored. The highly economical options aimed at improving supply side efficiency are rarely considered in the usual planning exercise. In fact, several plans consider deterioration of plant performance. For example, the Working Group on Power (for the 9th Five year Plan) made projections of capacity addition requirement on the assumption that plant performance would deteriorate.[2] This was despite the fact that measures to improve supply-side efficiency have played a major role in the recent past. The over-projection of capacity addition needs and the lack of sufficient emphasis on even the supply-side efficiency improvements can be established using a quote from the 9th Five year Plan document. It states :

> *"At the beginning of the Eighth Plan, the energy deficit was 7.8% and peak deficit of 18.8%. With the targeted capacity addition of 30,538 MW ... a peaking deficit of 20.7% and energy deficit of 9% (was expected). However, at the end of the Eighth Plan period, with the actual capacity addition of 16,422 MW, the peak deficit was restricted to 18.0% and energy deficit to 11.5% mainly due to a marked improvement in Plant Load Factor (PLF) of the thermal plants." (emphasis added)*

In addition to these limitations, the capacity addition projections made during the planning exercise do not consider limitations on the available finances. As a result, the next level of planners (such as the Planning Commission) have to lower the targets for capacity addition. The planning then shifts to finding sufficient financial resources to implement the plan. Earlier, it simply meant asking for increased government budgetary support. Since early 1990s, in the wake of limitations on the government finances, a new route of allowing IPPs (Independent power producers) was discovered. But even private developers are finding it difficult to obtain finances in absence of government guarantees. Hence, now, the central government has proposed to impose a levy on all power generated as a means of resource generation. All the while, emphasis on building more of large projects continues.

[2] The reason for such anomaly, is more to do with internal dynamics of planning rather than the knowledge of planners.

Despite the recent attention and action to increase supply-side efficiency, the planning exercises usually continue with their supply bias. At best, capacity released through efficiency improvements is seen as a means to reduce the "gap" between the projected and actually realised capacity addition.

Recently, the planning processes has been decentralised to the level of states to a large extent. Some of the state level plans have even more serious problems. One state having large peaking shortage, has signed agreements for adding 1,300 MW of oil-fuelled power plants that would run as base load plants. Contracting them as peaking plants would have been ideal and would have also given substantial financial benefit compared to the present plan. Similarly, most plans do not consider the likely impact of increasing captive power generation in industries.

Some sanctioned projects get delayed due to lack of funds or implementation problem. Such delay re-enforces the shortage psychosis. A few projects also get held up due to the popular opposition because of problems related to R&R or serious environmental impacts (which are rarely considered in full). These projects then become contentious issues. The ensuing heated debate, which is usually portrayed as environment v/s development debate, effectively sidelines real issues.

Removing such anomalies is essential for strengthening the financial health of the sector and it would radically redefine the need for added capacity as well as our emphasis.

The Recent Context

Issues Related to Commercialisation of the Power Sector

Till the last decade, it was considered that "the basic responsibility of the power sector is to provide adequate electricity at the least economic cost, while ensuring reliability and quality of the supply". But, in the process, the power sector is making large operating losses, over US $ 2.5 billion p.a. (estimate for 1996-97) (Planning Commission, 1997). These losses are increasing rapidly and, at the same time, the capability of the state to absorb these losses is declining. Now, it will be impossible to add new capacity, in any major way, unless the power sector is able to recover the cost. Hence, the commercial viability has become an important goal of the power sector. Already, in several states, the main reason for power shortages is the lack of paying capacity of utilities. To make matters worse, in the near future, the cost of supply is going to increase rapidly due to addition of several IPP projects. SEBs will have to pass on this tariff impact to the consumers.

Hence, despite being politically difficult, it is becoming essential to rationalise tariff (which includes tariff increase for some sections). This is especially critical for sector like agriculture that receives the bulk of the subsidy and accounts for over 30% of total consumption. Changing from the connection-based tariff system to consumption-based tariff system and increase in revenue is essential. A tariff increase of over 500% for agricultural sector is being talked about. This is expected to reduce the agricultural consumption. But the demand forecasts do not consider the tariff sensitivity of demand.

On this back-drop, the sector has three options. First option is to continue with the 'business as usual' (BAU) mode, i.e. to continue with: (a) present emphasis on large projects and the related neglect of low cost options and (b) irrational tariff. In the BAU scenario, industries will continue to opt out of the grid, agricultural consumption will rapidly increase leading to high financial losses to the sector making it impossible to add new capacity in a major way. This will lead to an overall power shortages.

The second option involves tariff rationalisation and management improvements. This would help improve the financial situation of the sector along with some reduction in demand. But this relief will come at the cost of pricing out many of the rural consumers. This needs to be seen in the context of the prevailing ground reality wherein more than 50% of the irrigated land is being irrigated using electrical pumps (TERI, 1996-97). The pricing out can lead to substantial social tensions, and associated heavy social cost.

The third route, which is the most desirable one, involves carrying out tariff and management improvements, choosing the low-cost options (for demand-supply matching) and trying to improve, on a priority basis, the end-use efficiency and to reduce peak loads. It is essential that, instead of planning project to meet all demand (attempt a very low LOLP) put on the grid, we should try and prioritise the demands of different consumers. This route can lead to the increase in electricity bills within manageable limits, while being able to meet most of the reasonable demands for power.

Private Sector Involvement

The limitations on the public resources and continued losses of the power sector has resulted in according an increasing role to the private sector in the power generation. This has meant increased cost of capital (because of the higher rates of profits from the project). The private sector is also unwilling (and unable) to take large risks.

This has several implications especially for the high-risk and long-gestation projects such as large hydro. The high cost of capital implies a preference for low gestation projects. The power demand situation is highly uncertain in several Asian countries. The uncertainty of industrial growth, increasing cost-effectiveness of captive generation are some of the factors driving these trends in India. Insufficiently worked out R&R plans that lead to popular opposition are also adding to the uncertainty of hydro projects. As a result, the private sector is less keen of getting involved in the large hydro project, unless the variety of risks are covered by the government. The Ninth Five year Plan acknowledges very low interest of private sector in the hydro projects, "on account of hydrological and geological risks". The plan recommends that public sector investments should be directed on a priority basis to hydro (along with T&D improvements and improvement of power plant performance). This

implies that highly cost-effective options of supply-side efficiency would have to compete with large-hydro for accessing the limited public funds.

3. Breaking the Vicious Cycle

Any effort to find resolution of the problems mentioned above and to re-assess the role of the large hydro project in the overall power planning should begin from investigation of ways to break through the vicious cycle described above. The following section focuses on two steps to break the vicious cycle: (a) expanding the choice of technologies and fuels considered during the planning exercise and (b) incorporating newer methods and mechanisms for planning for and building the power projects.

Expanding the Choice of Technologies and Fuels

Supply as well as demand side efficiency improvements have a very large and cost-effective potential in India. Following three examples indicate the range of options and their sizeable potential :

It is estimated that agricultural consumption can be reduced by more than 40% if suitable improvements in pumps and piping are made (Boothra K C, Bajaj N K, 1994; Jain P.C. 1994; Patel S.M. and Pandey M.K., 1993; Sant Girish, Dixit Shantanu, 1996). In addition, simple improvements in irrigation practice (that do not require major investments) can reduce water (and, hence, power) use by another 20%. The cost of saved energy is usually less than a quarter of the cost of supply.[3]

Similarly, the household contribution to peak (which is about 30% of peak) can be substantially reduced by lighting improvements. Most utilities have not aggressively perused the TOD (time of day) tariff for industries despite availability of low cost electronic meters.

The national appliance standards for efficiency are not mandatory and the existing standards need an urgent upgradation. The standards for pipe sizing, for example, are optimum for the electricity cost of Rs 0.5/kWh, while the actual cost of supply is at least four times higher. If the standards were optimised and made mandatory for all new agricultural pump connections since 1991, by today India could have saved power equivalent to the production of 800 MW base load plant. Upgradation of standards (without making them mandatory) can also lead to substantial savings. (Sant Girish, Dixit Shantanu, 1996) Several other examples exist, of means to collect such low lying fruits.

The above list is not exhaustive by any means. There are several other low-cost options for meeting the demand for more power. Following list gives potential of some of the important once.

- The T&D losses are over 30% and which can be reduced to less than 15%. Implying a potential of avoided capacity addition of nearly 13,500 MW.[4]
- A World Bank study in 1991 pointed out that ".. demand unserved in FY 89 could have been reduced by approximately 50% through improved co-ordination in systems operation". The study further concludes that "Improvements in the efficiency of system operations could provide approximately 10% of sector investment requirements through the Eighth and Ninth Plans. It is important to stress that the savings could be obtained for very little cost (and without any increase in tariffs)". (WB 1991) Most of these improvements, including development of national grid are yet to be carried out.
- The 12,000 MW oil based projects that are planned can be converted to peaking plants. This would be an economic decision.
- Studies by several researchers have shown significant potential of demand side efficiency improvements. (Sant G., Dixit S., 1998,(a); Reddy Amulya Kumar N., et. al. 1991; Nadel S. et. al., 1991). Even the WB study for the state of A.P. estimates that demand side efficiency improvements can reduce need for capacity addition to the tune of 20% of present capacity in the next decade (ESMAP, 1998). Taking the conservative estimate of the WB study, a capacity addition of 18,000 MW can be avoided nation wide in the next decade.

[3] The sector is also important because the irrigation loads in post monsoon season coincide with the annual peak period.

[4] The savings are estimated as 15% of present installed capacity.

- The impacts of tariff rationalisation and of power plant performance improvement are not included in the above list, but are likely to be sizeable.

All these options are substantially low-cost options. Most of them do not require major institutional restructuring. Taken together, they represent a potential that is substantially higher than what is hoped to be added in the form of hydro-power plants (30,000 to 40,000 MW in next decade). Some of these would deliver primarily peaking benefit.

Despite such a situation, these options do not get the deserved priority. The planning techniques such as integrated resource planning (IRP) ensure that all available options are systematically included in the planning exercise and it ranks these options in the order of their costs. Adoption of techniques and tools such as IRP will halt the un-due emphasis on long-gestation, centralised, bulky and high-cost projects such as hydel power projects.

Beyond Conventional Processes and Mechanisms

The Integrated plan described above can potentially offer very large benefit. But when such plan is done along with peoples' participation, the benefits as well as the ease of implementation can be substantially increased. One personal experience in this regard will help clarify the point. Once, we were talking to a group of villagers about energy conservation, when they were quick in pointing out one such opportunity for conservation that would be missed by most power planners. In a nearby village, a small irrigation dam was rendered useless due to minor defects in the gate and canal. The repairs were pending for a long time. Helpless farmers in the command area of the dam dug up wells and started using electric pumps with estimated consumption of 4 million kWh (Sant G., Dixit, S. 1998,(b)) The repair of dam gate could save all these. This example is indicative of the several inter-sectoral opportunities for efficiency improvement.

As mentioned earlier, the ability of farmers to pay for power is critical for sustaining agricultural development. It is argued that even paying for fuel and operational cost of grid power is a big burden for most farmers. But surveys by some researchers have shown that farmers are willing to pay in kind. For example, by delivering say 1.2 Kg of woody biomass to the power station per kWh consumed (if the power station is not too far). To get the necessary amount of electricity, farmer can obtain required biomass from agro residues or by allocating less than 10% of land for biomass production. This is economical for him, as his net production increases despite allocating some land for biomass generation. This seems a very promising source for affordable power in India. And it can only be done with co-operation and participation of people. In such situations, the small-sized biomass based power generation will have a major role, in providing affordable power to farmers.

Such opportunities for involving people in integrated power planning to increase the affordability of power for rural population need to be looked into.

4. Steps in Alternate Planning

Considering these issues, we feel that immediate action should be taken to rationalise power tariff (including metering of all electricity supplies) and implementation of proven low-cost options such as supply-side efficiency and some of the demand-side measures (market as well as non-market based). An integrated least cost plan should be worked out in an participatory manner. Such plan should focus on maintaining the affordability of power, especially for the rural consumers. The first two measures will give some breathing space and will improve the financial position of the power sector. The projects that pass the test of the least cost plan should then be taken up.

After re-evaluating the cost, risks, and impelentability of hydro projects, if they pass the test of the least cost techniques they can be taken up for the next step of planning. The next step involves testing the options for social and environmental costs. This is the most contentious arena. Here, there are no standardised methodologies for articulating costs and benefits on which consensus has been arrived. In the absence of such a consunsual test, the only way to ensure a just and rational decision is to adopt a just and rational procedure on which consensus could be arrived. Such procedures should be democratic, transparent, and particiaptive. Following should be important steps in such a procedure. The complete and detailed information on the technical design, R&R plan, and other important aspects of the project should be made public. This should be followed by processes such as public hearings, open negotiations that ensure informed and genuine consent of

affected people. Considering the possibility of differences, a dispute resolution procedure needs to be evolved. This procedure should have a prior consent of the affected persons by the project. Until such mechanisms (for disseminating information, feed back and dispute resolution) do not exist, we should not go ahead with the project.

Putting together such processes or arriving at an acceptable R&R mechanism is going to take time. It is not worth risking our money in bulky hydel project until these steps have been successfully taken. Fortunately, the low-cost options does offer us the necessary time cushion. We should utilise it to complete the detailed studies of various dam projects, of all aspects starting from hydrology, environmental costs and revised cost benefit analysis and possible R&R plans.

To summarise, we feel that though hydro would continue to play a significant role in power sector, new large dams seems to have serious limitations. If options suggested by rational, integrated planning are opted for, role of hydro options other than large-hydro projects will be substantially more significant than today. These options include the pumped hydro schemes, augmentation of capacity at base load hydro stations (to convert them to peaking), river run-off plants and small hydro (with limited social and environmental impacts).

5. Challenges of the New Paradigm

Until now, this presentation was restricted largely within the conventional boundaries of the power sector planning. But as its last part suggests, the dual compulsion of reducing the overall (economic, social, and environmental) cost of the power while augmenting energy availability, forces power planners to move beyond the conventional boundaries. They have to resort to new approaches, which investigate the hitherto neglected factors such as the nature of energy services required and pay attention to the quality of various forms of energy and its matching with the services required. These approaches naturally lead power planners into the ambit of not only energy policy but also development policy. Investigations into these factors raise questions about the conventional assumptions about the 'power-energy-development' linkages. The next obvious step is the question: what exactly is power or energy required for? Or, in other words, what exactly is development? In the changing times, the power planners cannot overlook these issues.

Based on our experiences, we feel that work of power planner should begin from understanding the very definition of development. Defining development in terms of gross domestic product (GDP) or even human development indices (HDI) is known to have serious limitations. These definitions and the related polices mainly rely on the 'trickle-down' mechanism of development, whose total failure could be witnessed in the rapidly increasing number of poor in the World in general and in India in particular. Commensurate with the growing compulsion that the development should provide immediate, tangible, substantial relief to those who need it most, development should now be essentially seen as "security of livelihoods to all". With this clear idea of development, the focus of development policies should shift to 'strengthening, augmenting, and enhancing livelihoods opportunities' for all, especially for those whose livelihoods are under threat or stress. This, in turn, requires that the energy and power policies should be aimed at providing, at affordable rates and with top priority, power and energy necessary for this strengthening, augmenting, and enhancing of livelihoods activities.

This new paradigm changes the arena of power and energy planning drastically. It demands an integrated view towards planning for all inputs that are necessary for livelihoods security -- water, land, energy, and biomass[5]. This will have to be in line with the mainstay of the new development strategy which could be articulated in terms of the following major points of emphasis--decentralisation, rural industrialisation based on biomass and renewable sources, energy self-reliance, recycling of energy and materials, primacy of local institutions. This integrated view, on one hand, will create new opportunities for making energy/ power available, such as hybridised energy systems of conventional and non-conventional as well as centralised and de-centralised sources. It can also open up the possibility of using part of irrigation waters for energy plantations and re-payment of energy cost through biomass. But, on the other hand, the integrated view will also pose new challenges, for example of evolving appropriate and new institutional and financial mechanisms, (at times) technological innovations, and developing new economic relationships.

[5] These inputs are essential especially of rural poor and disadvantaged.

In the routine work, power planners, even if they want to, do not get opportunities to work on these challenges. In this context, we now look to the WCD process with a lot of expectation. We see WCD as a rare phenomenon that will help and facilitate research and analysis on the above-mentioned new opportunities and fundamental challenges. We sincerely hope that the WCD process will not take a narrow perspective and restrict itself to limited issues such as comparison of proved and achievable potentials of hydro v/s DSM/IRP while remaining within the constraints of present institutional structures. Otherwise, its prime objective of investigating 'development effectiveness of dams' will remain unfulfilled.

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References :

Boothra K C, Bajaj N K; 1994, "Energy conservation in agricultural electric pumping system", National Seminar on conservation of energy in agricultural pumping systems, December 1994; Organised by Central institute for rural electrification, Hyderabad.

ESMAP, 1998, "India : Environmental Issues in the Power Sector" Report No. 205/98, UNDP/ESMAP, The World Bank, 1998

GoI 1997-98, "Ninth Five Year Plan" Volume II, Government of India, 1997-98

Jain P.C. 1994, "Energy conservation awareness through high efficiency of utilisation in pumping systems", National seminar on conservation of energy in agricultural pumping systems December 1994, Organised by Central Institute for rural electrification, Hyderabad.

Maheshwar DPR, 1989, "Narmada Basin Water Development Plan : Maheshwar DPR, Vol. VI A, March 1989.

Nadel S. et. al., 1991, "Opportunities for Improving End-use Electricity Efficiency in India". Nadel, S.; Gopinath, S. and Kothari, V. Washington DC: USAID, 1991.

Patel S.M. and Pandey M.K., 1993 "Report on complete rectification's of agricultural pumps in Gujarat state", Institute of Co-operative Management, Ahmedabad, 1993.

Planning Commission, 1997, "Annual Report on the Working of State Electricity Boards and Electricity Departments" Power and Energy Division, Planning Commission, Government of India, 1997

Reddy Amulya Kumar N., et. al. 1991, "A Development-Focused End-Use Oriented Electricity Scenario for Karnataka" Reddy, A.; Gladys S.; Balachandra, P. and D'Sa, A., Economic and Political Weekly (April 6 & 13, 1991).

Sant G., Dixit S., 1998,(a); "Least Cost Power Planning : Case study of Maharashtra State"
Sant Girish and Dixit Shantanu, Paper submitted to 'Energy for Sustainable Development'.

Sant G., Dixit, S. 1998,(b) "Towards an Efficient and Low Cost Power Sector" Draft Chapter on Energy, Prepared for the Task Force on Narmada Valley set up by M.P. State Government, 1998

Sant Girish, Dixit Shantanu, 1996; "Agricultural Pumping Efficiency in India : the role of standards", Energy for Sustainable Development, Vol. III, No.1, May 1996

TERI, 1996-97, "TERI Energy Data Directory and Yearbook 1996-97" Tata Energy Research Institute, New, Delhi, India

WB, 1989, "India Power Sector Efficiency Review : Vol. I Main Report" 1989, The World Bank

WB, 1991, "India : Long term issues in the power sector : Executive Report", Volume I, 1991, The World Bank

WB, 1996, "Estimating Construction Costs and Schedules : Experience with Power Generation Projects in Developing Countries" World Bank Technical Paper No. 325, Energy Series, The World Bank, 1996