# SMALL AND MICRO- HYDEL POWER PLANTS TO THE RESCUE

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LARGE DAMS are today India's most controversial environmental issue. Silent valley has already been given up. Groups are protesting against another half a dozen.

The key issue is people. Energy and Water Planners are stressing hydro-power and canal irrigation but have made no study of how many people will be displaced.

The collossal Narmada Basin Development Programme which involves the building of 31 large dams, may end up costing Rs 25,000 *crores*. It will also displace a million people.

The cost of forest lost is also high. Large dams have drowned half a million hectares of forests - about a tenth of the area that has benefited from canal irrigation.

Three small reservoirs have transformed the economy of a village near Chandigarh. There is no soil erosion, no deforestation and no one has been displaced. The lesson: water conservation, yes; big dams, no.

Large dams are no more referred unthinkingly as the temples of India's progress. They are not, of course, whited sepulchres but their destructive consequences are now being increasingly recognised. Even so, bigger investments are being made in them. In the light of the recent experience, questions are now being raised about the viability of large dams which have often proved to be ecological disasters. Can there be ecologically sound and economically viable engineering alternatives to large dams? If dams are inevitable for a large country faced with the task of feeding its growing millions and for meeting its energy requirements, can the destruction they cause be minimised and adequately managed?

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The amount of controversy generated by the big dams can be gauged by the fact that after, on-again, off-again status that lasted seven years, the Kerala Government finally called off the Silent Valley Hydel Project in November, 1983. The Silent valley controversy marks the fiercest environmental debate in the country and is likely to establish a precedent wherever any major developmental project - particularly a dam - threatens the ecological balance. What Silent Valley has achieved, therefore, is to lay down a new paradigm: *''development without destruction.''*

The drought that Kerala and other Southern States faced in 1982-83 underline this lesson. While Kerala has been considered 'surplus' state in power generation, it had to impose the biggest power-cuts in living memory when the monsoon failed. And this as even power engineers now admit, was because of the widespread denudation of forests in the catchment areas of hydel projects in the state. For the first time, the connection between forests and the retention of water has been made painfully clear to the people of Kerala.

Narmada Valley Project which envisages the construction of two major dams - the Sardar Sarovar Project in Bharuch district of Gujarat and Indra Sagar Project in Khandwa district of Madhya Pradesh. There is little justification for the Indra Sagar Project which will submerge as much area as it is meant to irrigate. What is generally not known is that when the cost-benefit analysis of this project was done, the cost of rehabilitating over 3 *lakh* people of the Narmada Valley who will be displaced form their land and the environmental cost of loss of forest estimated as Rs 39,113 *crores* (as reported by Ministry of Environment) was not considered. Another cost that has not been considered is the loss of 55,681 hectares of prime agricultural land.

After examining the controversial Tehri Dam Project an alternative scheme Micro Hydel Power Generation for Rural Hilly areas is suggested in the following pages.

### The Tehri Project

*The Dam* : This is a 260.5 metre high dam on the Bhagirathi in the Garwal Himalayas.

*Power :* 2400 MW Peaking Power

1500 MW Firm Power

*Cost :* Rs 4,200 crores (March'90 estimate)

Rs 4,900 crores (1992 estimate)

*Location :* Known seismic zone

The structure, according to Tehri Hydro Development Corporation is designed for an earthquake of magnitude 7 on Richter Scale, whereas renowned Seismologists have recommended that the Government take into account the chance of an earthquake beyond 8 on Richter Scale.

The approximate energy release in terms of explosive power of TNT is:

90700 tonnes of TNT for 7 on Richter Scale, and

2,86,15,850 tonnes of TNT for 8.5 of Richter Scale.

Even a layman's case is that a structure designed for 7 magnitude can hardly withstand the pressure of an earthquake of 8.5 magnitude. Given the number of people living downstream, the risk factor is extreme.

Shivaji Rao, a member of the Environmental Appraisal Committee, said that the 'Flood surges due to the failure of Tehri Dam', in a technical paper before the Institution of Engineers, Visakhapatnam on June 5, 1990.He observed :

> It is estimated that flood waters will reach Rishikesh in an hour after the burst and Hardwar in another 20 minutes & wipe out Deoprayag, Rishikesh, and Hardwar and their environs by more than 70 metre high battering of water. While Meerut and its environs will be destroyed by a 10-metre flood wave within 6-hours, Bulandshahar & its environs will be ruined by a 7 metre flood wave within 12 hours of the failure of the Dam. Such failures will result in the deaths of millions of farmers & destruction of roads, railways and irrigation systems in U.P. worth about Rs 20,000 crores. The earthquake of June 1990 in Iran which was of magnitude 7.3 on Richter Scale destroyed the Raksht Dam thereby killing 1 lakh people & destroying a lot of property.

Also the Russian Experts from Minvodkhoz who are exporting the know-how for this project, have brought hunger and disaster by flooding an area equal to that of France in the name of big dams.

### Small is powerful

There are thousands of places in the hilly regions of India where small hydroelectric power generators ranging from a few kilowatts to several megawatts could easily serve remote rural settlements. But small hydropower development in India has been almost totally neglected, although the first small hydroelectric plant of 200 kw capacity, was installed in Darjeeling in 1887.

In comparison, China has over 88,000 small hydro-power stations with a total installed capacity of 6,929 mw. in 1980 which generated approximately one-third of all the electricity consumed in rural areas in that year. Over 86,000 stations had an installed capacity of less than 0.5 mw each, and accounted for 60 per cent of the total installed capacity of small hydro units.

Smaller units can be built, maintained and operated by rural communities and need not become part of the national grid. A 0.5 mw. station can energise 100-watt bulbs in 5000 households; in other words a small hill village can be well off even with a 0.1 mw. unit. However, in 1980, India had an installed capacity of only 220 mw in small hydro units, most of them in Uttar Pradesh, Himachal Pradesh, Jammu and Kashmir, Arunachal Pradesh, West Bengal and Sikkim. These units ranged in size from 5 kw to 6,800 kw. Less than 10 per cent of the installed capacity was represented by units of a size less than 500 kw. and less than 2 per cent was in units of sizes of 100 mw or less, which are actually classified as micro hydel units.

A detailed survey of small hydro potential has yet to be conducted. According to an official estimate, this potential is about 2,000 mw in the hilly areas but this is definitely an underestimate especially if sites for microhydel units - less than 100 kw - are included. Another 3,000 mw worth can be set up to utilise the small falls that dot irrigation canals in the plains.

In China, the people are encouraged to participate in small hydel development. A small station is financed mainly by the local community itself and subsidies - one-quarter to one-third of the total investment - by the government. In recent years, commune and brigade-run stations can be built with low interest loans from the Bank of Agriculture while country-run stations can obtain medium or short-term loans from the People's Bank of China. The small hydel plants are gradually integrated to form a local grid and eventually even integrated into the national grid when certain necessary conditions are satisfied.

In early 1983, the Ministry of Energy announced that Rs 100 crores - a pittance when compared to the money spent on large power projects - had been allocated by the Planning Commission for the promotion of small hydel units. But the commission soon pack-tracked and told the ministry that state governments should find their own funds for small hydel units.

Micro-hydel units offer enormous scope for local innovation.

The main problem that these organisations face is spare parts. Equipment purchased from the cities has to be regularly repaired and serviced and every small snag becomes a crisis. Once the local people are trained in servicing and operating the small stations - and even to introduce homemade innovations - there is no reason why the units should not turn to be a really pragmatic and environmentally healthy answer to local power shortages.

What follows now is a suggested scheme outlining the basic technical principles.

**S[illegible] for the micro-hydel power plant**

*Elements*

1) Diversion dam cum balancing reservoir

   While under construction, either the water flow can be diverted and dam be made on the river bed; or the river flow can be diverted sufficient to flow past the dam which can be constructed on the shore. Boulders can be used for this purpose.

2) Penstock:

   The water fed from diversion dam cum balancing reservoir is led to the power house to run hydraulic turbine through a pressurised penstock pipe. High density polyvinyl pipes can be used. It should also be designed considering the water hammer pressure. A small tank must be used to take care of sudden opening/closure of valve and restrict water hammer pressure in.

   Suitable bends and expansion joints are also required for proper alignment of the penstock.

For an application to rural hilly areas, three kinds of hydro-turbine systems can be suggested. They are as follows.

***Water wheel***

They are based on the principle that the 'buckets' at the periphery of the wheel get filled with the moving water continuously, hence causing rotation of the wheel. They are of two types.

a) Overshot wheel: the buckets in this case are filled with water at the top of their rotation and empty as they approach their lowest rotation. Although, efficiencies of 80% were obtained with these wheels, their speeds were slow, they generated little power for their size. They are also incapable of operating with rising tail water and turbulance. However, the only commercially operating overshot water wheel was developed by Fitz Water Wheel Co. of Pennsylvania in New England. It is 13 ft in diameter, 6 ft wide and is said to be capable of developing 22.4 KW at 8 rpm.

b) Undershot wheel : it receives its energy from the impact of a flowing stream of water on its flat or curved radial vanes. Its maximum efficiency is 20%. Water wheels can be made of wood, so they are a good prospect for rural hilly areas.

### *Peltron turbine (impulse)*

In this case the pressure (potential energy of the water is converted completely to kinetic energy in a nozzle. The high-velocity stream of water is then directed onto hemospherical buckets to overcome the resistance of the load and transfer energy to the rotating turbine. A peltron turbine in New England again, the only one in place operates under a head of 36.8 m and is connected to a 5 kw generator at a speed of over 1,000 rpm.

It can also be applied to the specific case of rural hilly waters in the scheme discussed later. It will, however, have high friction losses in pipes (penstock) due to high velocity; lesser life due to high impact and lastly difficult maintenance.

### *Kaplan turbine*

It has a propeller (resembling the propeller of a ship) through which water flows and sets the latter in rotation.. The water enters the turbine laterally, is deflected by the guide vanes and flows axially through the propeller. It is, however, used for very low heads and high flow rates and hence is not very efficient directly for the specific case of hilly riverets.

### *Francis turbine*

Energy input is partly pressure and kinetic energy. Water first enters the volute, which is an annular channel surrounding the runner, and then flows between the fixed guide vanes, which give the water the optimum direction of flow. It then enters the runner and flows radially through the latter i.e. towards the centre. The runners are so arranged that the energy of the water is largely converted into rotary motion and is not consumed by eddies and other undesirable flow phenomena causing energy losses. The guide vanes are usually adjustable so as to provide a degree of adaptability to variations in water flow rate and in the load of the turbine.

The losses in penstock due to velocity are considerably lesser compared to peltron due to partly pressure and kinetic energy input. The life hence is more due to lesser impact. We will use this turbine for the proposed schemes as a result of the above advantages. Turbine discharge is disposed off to the riveret through the tailrace channel, which should be accordingly designed.

The power house contains the turbine, governor (for speed inlet regulation of the turbine), valve for emergency stop, pressure oil system for both the governers and the inlet valve, generator, control system (suitable for unattended operation, semi-automatic) and a distribution system (for distribution of power).

### Local implementation

Although most of the discussion has centred on manufactured devices, small scale hydro-electric systems lend themselves to significant cost reduction through local enterprise and innovation. Thus,

(i) The dams may be made of earth, stone or logs. Hundreds of such dams have been used in last 25 years or more.

(ii) Penstocks may be made of reinforced concrete or of wood planks strengthened by iron straps.

(iii) Turbines may be made of wood, though if there is a rudimentary iron and steel industry, these more enduring materials may be used.

The units now available should be examined with the aim of making them simpler and cheaper. It may be possible to eliminate the governers and much of the switchboard equipment. The general simplification problem should be explored.

### Storage plants

Energy shortage becomes very essential for all year round supply of power to villages in hilly areas where water supply fórm riverets and rain is surplus only during certain seasons.

Mechanical energy from shaft during surplus power conditions can be stored in the form of kinetic energy (flywheels) or potential energy (hydraulic systems, compressed air, etc.).

Hydraulic storage generally takes the form of hydro-electic pump-back systems, where water is pumped to a higher level during periods of excess generating capacity and in turn generates electricity in its downward flow during periods of short supply. It is feasible where,

(a) construction labour is cheap, and

(b) land is plentiful enough to be effectively used this way.

Energy stored as compressed air usually involves the use of ordinary compressors but may be achieved with isothermal hydraulic compression systems. The latter tend to be more efficient and are probably more applicable in developing nations because of their simplicity and lack of machinery with moving parts.

### Cost and power considerations

For a single unit turbine plant:

$$P = \frac{WQH}{75} \times n \times 0.746 \text{ kw}$$

where W - density of water = 1000 $N/m^2$

Q - discharge

H - head

n - efficiency

For a particular case of Netarhat Micro Hydro Electric Project having the following data:

a) Minimum discharge: 0.028 cumec (1 cusec)

b) 90% dependable : 0.08 cumec discharge

c) Design flood: 38 cumec discharge

***Head***

| | | |
|---|---|---|
| a) | Gross Head Maximum : | 36.9 metres |
| | Minimum: | 33.7 metres |
| b) | Net Head Maximum : | 32.4 metres |
| | Minimum : | 29.2 metres |

***Power***

| | | |
|---|---|---|
| a) | Firms power : | 30 kw |
| b) | Installed capacity : | 50 kw |

***Estimated cost***

| | | |
|---|---|---|
| a) | Civil work : | 15.4 lakhs |
| b) | E & M works : | 17.75 lakhs |
| c) | total cost : | 35.01 lakhs |

Note : The transmission costs are negligible since the plant is in close proximity of the consumers.

### Legislation

Till the 1970s environment was primarily defined in terms of pollution and its physical and biological effects. However new perceptions and fresh insights related to development and environment have broadened the context tremendously to include a host of problems such as-floods and famines caused by overuse of land and soil, deforestation, diseases caused by unsafe water supplies and polluted air, malnutrition among the young and vulnerable, extraordinary pressure on our natural resources caused by our increasing population etc. as environmental problems.

This new perception, clearly links environment with development and therefore, extends the spectrum of environmental dimensions to include not only the biophysical components, but also the sociocultural, economic, political and administrative components. Once this inter linkage is clearly understood, it is easy to deduce that for the sustenance of a sociopolitical system, aimed at the poeple's welfare, protection and conservation of environment are as important as economic development and growth. So when the environment deteriorates, it is a sure sign that the quality of life is also deteriorating. Protection and improvement of environment are therefore, national imperatives for sustainable development. This has been recognised in our Constitution and legal provisions governing environment. An overview of the legal framework would facilitate a better appreciation of our basic environmental issues-the crisis and its solution.

The basic foundation for environmental legislation as well as State policy relating to environment in India is enshrined in our Constitution. Article 48 A of the Constitution enjoins the State to take measures to protect and improve the environment and to safeguard the forests and wildlife of the country. Likewise, Article 51A (g), under the provisions relating to fundamental duties specified in the Constitution, makes it a fundamental duty of every citizen to protect and improve the natural environment including forest, lakes, rivers and wildlife and to have ecological compression. The preceding two decades have witnessed enactment of a number of legislations directly related to the environment. Important among these are the Wildlife (Protection) Act 1972, the Forest (Conservation) Act, 1980, the Water (Prevention and Control of Pollution) Act 1974, the Water Cess Act, 1977.the Air (Prevention and Control of Pollution) Act, 1981, the Environment (Protection) Act, 1986, and the Public Liability Insurance Act, 1991.

Besides these environmental legislations, it is interesting to note that the basic criminal laws of India, namely, the Criminal Procedure Code, 1898 as revised in 1973 and the Indian Panel code 1860 as well as some of the mercantile laws like the Merchant Shipping Act, 1958 have also sought to regulate environment albelt in a limited way. Sections 133 and 144 of the Criminal Procedure Code empower the state organs to instantly prevent any injury or nuisance to public safety and public Interest following from action or ommission causing pollution which the authorities concerned identify and interpret as such. Likewise, Section 269, 277, 219 and 426 also provide respectively for protection of environment by punishing negligent acts likely to spread infection or disease dangerous to life activites which corrupt or foul the water of any public spring or reservoir, pollution of waterbodies other than shrines and reservoirs as may be deemed a public nuisance, and any pollution to a waterbody which can be treated as a mischief. The Merchant Shipping Act provides for action against marine pollution specifically.

These legislations do empower the State agencies to prevent deterioration of environment and also cost responsibilities on them to promote and improve our environment. However, the basic issues governing the state of environment anywhere centre around the growth, composition and dispersal of the pollution and the nature and level of their economic activities and well-being.

There is an urgent need of revision of the abovesaid environmental legislation as well as state policy relating to environment in India, which deal with the matter differently and incompletely.