URJA BHARATI

(Special Issue on Small Hydro Power Development)

सत्यमेव जयते

Ministry of Non- Conventional Energy Sources

14, C.G.O. Complex, Lodi Road, New Delhi-110003

Vol. 3 No. 2 August 1992

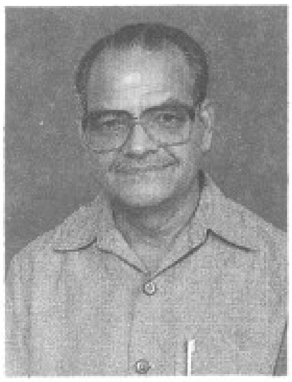
CONTENTS

URJA BHARTI — SPECIAL ISSUE ON SMALL HYDRO DEVELOPMENT

Cover photo courtesy : Arun Kumar — MoNES

(A view of River Lakshman Ganga, on way to the Valley of Flowers, in U.P. hills. There are mini/micro hydel projects both upstream and downstream of the river view)

EDITORIAL BOARD



सत्यमेव जयते

राज्य मंत्री
योजना एवं कार्यक्रम कार्यान्वयन
(स्वतंत्र प्रभार)
एवं
गैर-परम्परागत उर्जा स्रोत मंत्रालय
नई दिल्ली-११० ००१
भारत

MINISTER OF STATE FOR
PLANNING & PROGRAMME IMPLEMENTATION
(INDEPENDENT CHARGE)
AND
MINISTRY OF NON-CONVENTIONAL ENERGY SOURCES
NEW DELHI-110 001
INDIA

Dated: AUGUST 6, 1992

Message

Energy is one of the most important inputs in the process of development. It appears from both historical and cross-sectional inter country studies that energy consumption and economic output are highly correlated. In its quest for increasing availability of energy, India has adopted a blend of conventional—thermal, hydel & nuclear-sources, and of late, emphasis is also been laid on development of non-conventional energy sources.

2. Energy from small hydro is probably the oldest and yet, the most reliable of all renewable energy sources. In India, our ancestors have used this energy for grinding foodgrains for centuries; with the result that our expertise in this sector today is at par with the most developed nations in the world. The advantage of this resource is that it can be harnessed almost every where in India—from any nearby Stream or canal—in the most environmentally benign manner, and without encountering any submergence, deforestation or resettlement problems.

3. In order to provide a sharper focus to this resource, the Government of India have given the responsibility of developing small hydro upto 3 MW to the Ministry of Non-Conventional Energy Sources (MoNES). MoNES has already declared this a thrust area for its 8th Five Year Plan and has announced numerous incentives to spurt activity in this Sector. Dissemination of information is an important part of this endeavour. I am very happy, therefore, to learn that **Urja Bharati** is coming out with a special number on **Small Hydro Power Development** which will catalogue all these incentives and inform its readers about the latest in this sector. I wish all success to this effort.

(SUKH RAM)

सचिव
भारत सरकार
अपारम्परिक ऊर्जा स्रोत मंत्रालय

Secretary
GOVERNMENT OF INDIA
MINISTRY OF NON-CONVENTIONAL ENERGY SOURCES

ब्लाक नम्बर 14, केन्द्रीय कार्यालय परिसर, लोधी रोड, नई दिल्ली- 11000
BLOCK NO. 14, KENDRIYA KARYALAYA PARISAR, LODI ROAD
NEW DELHI-110003

Dated: August 6, 1992

Message

Small hydro programme is a thrust area for MoNES in Eighth Five Year Plan. To make this programme successful, numerous policy measures have already been announced. These include, capital subsidy for projects in remote areas, soft loans and financial assistance for training courses. On the technical side, MoNES has already taken initiative to:

* Induct state of art technologies in the country. Siphon intake technology, for example, has already been successfully used in one low head project and three more are under construction.
* Accelerate electro-mechanical and civil works standardization efforts to reduce costs. A World Bank/UNDP funded study to standardize irrigation canal/dam based schemes from 3 meters to 30 meters head into only 6 type-designs has been completed. A similar study to standardise hill hydro schemes through a possible UNDP/GEF funding to the tune of US $ 7.52 million has been initiated.
* Announce incentives for preparation of DPRs (Detailed Project Reports) through reputed consultants so that a ready shelf-of-projects is made available.
* Evaluate existing DPRs/Feasibility Reports/On-going projects at MoNES cost by engaging consultants so as to learn from existing experience as well as decide on the need for central techno-economic interventions, if any.
* Increase manufacturing base for hydro equipment as also small generator; there are by now 10 manufacturers for turbines and five for generators.
* Publish standard guidelines on small/mini/micro hydro power projects.
* Generally attempt to prove the superiority of small hydro over other alternatives available in remote and non-grid connected areas.
* The Department is also negotiating with World Bank a loan of around $70 million to take up projects coming out of the study already undertaken.

I am very happy to learn that the August 1992 issue of Urja Bharati will be focussing on some of these development for the information of our valued readers. I would be personally grateful to suggestions/ reactions on this issue, which would help us to improve our small Hydro programme even further.

K. Venkatesan

(K. VENKATESAN)

EDITORIAL

Energy is a vital input for economic and social development. Indeed it is the fulcrum on which rests the future pace of growth and development. As the tempo of development increases, the demand for energy also increases.

Since independence India has multiplied electricity generation capacity over 50 times—from a meagre 1362 MW in 1947 to over 69,000 MW in 1991-92. Units generated have also leaped from 4 billion units to around 280 billion units, in the same period. However, pressures of a developing economy necessitate a considerable increase in generation capacity with every passing year. Indeed, despite a per capita consumption as low as 208 kg oil equivalent (compared to 5000-8000 kg. for developed countries), India is still facing an acute energy shortage—this is currently of the order of 8.5%, with a peaking shortage of 17.7% in 1991-92 for the country as a whole.

In its quest for increasing availability of energy, the country has adopted a blend of thermal, hydel and nuclear sources. Of late, emphasis is also being given on non-conventional energy sources—biomass, solar, wind, small hydro etc.

Small, mini or micro hydro is one of the well recognised renewable source which can provide electricity especially for the rural, remote areas and hilly terrain in our country in a cost effective and environmentally benign manner. A potential of nearly 5000 MW has been identified from the small hydro source, of which only a fraction could be harnessed so far. The development of small hydro (upto 3 MW) energy potential has been identified as a thrust area during the Eighth Five Year Plan by the Ministry of Non Conventional Energy Sources (MoNES).

It is to highlight the importance of the small hydro energy resource available in the country and to attract both public utility organisations and private entrepreneurs to come forward for tapping this resource, that this quarterly issue of Urja Bharti is being devoted primarily to the mini, micro & small hydel energy development. It is a matter of privilege that an institution of the eminence of University of Roorkee (Alternate Hydro Energy Centre) has come forward to bring out this special issue in coordination with MoNES Government of India.

The economics of a mini hydro scheme may also be of interest to the prospective public utility organisations and private entrepreneurs interested in the programme, and therefore a summary appraisal of a specific case by IREDA at the time of considering financial assistance, is also indicated in the following annexure which indicates reasonable internal rate of return, especially with the support provided by Ministry of Non-Conventional Energy Sources or with soft term assistance from IREDA.

D.K. MITTAL
JOINT SECRETARY
MoNES. Govt. of India

Annexure

SUMMARY APPRAISAL OF A PROPOSED MINI HYDRO SCHEME (2 x 1 MW) IN THE STATE OF ORISSA (BY IREDA):

Project Details :

Capacity	— 2 x 1 MW
Hydrological Data :	
— Design/Maximum Discharge	— 20 cumecs
— Design Head	— 11.81 m
— Availability of flow	— 350 days
— Annual energy generation	— 59.50 lacs units
— Utilisation	— to be fed in 11 kV local grid
Project cost/Performance	
Cost of project	— Rs. 4.13 crores (of which promoters contribution Rs. 1.39 crores)
Cost of installation	— Rs. 18,300 per kW (as per CEA pattern)
Cost of generation	— Rs. 1.16 per unit (as per CEA pattern)
Sales	— Rs. 50.57 lacs per annum
Gross surplus	— Rs. 44.90 lacs per annum

Financial/Economic Indicators:	Without Subsidy	With MoNES * interest subsidy
DSCR	0.87	1.09
IRR	9.9%	13%
Employment (Direct)	Fourteen persons	
Energy conservation	4344 tonnes/yr of coal equivalent worth Rs. 18.46 lacs	

* Interest subsidy has been discontinued. Capital subsidy is being offered discribed subsequently.

SMALL HYDRO POWER
Some Major Issues

Commodore Narindra Singh

The utility of small hydel power stations for rural uplift needs no emphasis as such installations are invariably in rural and the remote and hilly areas of the country. Through standardization, adoption of canal or cluster approach so as to achieve larger volume and turnover, and careful planning to achieve short gestation periods, small hydro installations can prove to be competitive with thermal, diesel, gas based or large hydel stations. Besides being highly reliable, small hydel power projects also have the distinct advantages of being environmentally superior requiring no resettlement or leading to deforestation or submergence and have reduced transmission and distribution losses. Such installations also do not contribute to the infamous greenhouse gases or cause damage to the stratospheric Ozone layer. A big thrust is, therefore, being given to rapid maximisation of micro, mini and small hydel schemes, both on canal falls and irrigation dams and natural falls in hilly regions of the country. This strategy has shown distinct results both in reducing capital and recurring costs and commissioning schedules since Feb. 1989 when the subject matter was transferred to the then Department of Non-Conventional Energy Sources.

SMALL HYDRO POTENTIAL

2. The potential of small hydro power (upto 5 MW capacity) was estimated by the Central Electricity Authority over a decade ago to be of the order of about 5000 MW. This potential remains largely untapped.

APPROACH TO MAXIMIZATION OF SMALL HYDRO CAPACITY

3. A large decentralized programme can only succeed if the grass-root and other appropriate levels are involved in its planning and implementation. At the same time, in a capital scarce society every renewable energy system has to establish a niche for itself based on its own economic and social merits. Costs on small hydro schems can be controlled if the electromechanicial equipment, constituting 50-75% of the project cost, can be reduced in size, complexity and bulk through adoption of state-of-art technologies on the one hand and, achieving 'Volume effect' through a large number of such equipments being ordered for supplies on the other. This is necessary in order that equipment manufacturers can tool up, manufacture, supply and commission state-of-art technology at competitive prices with reasonable profitability. The second significant component of the project costs relates to civil works. Here again the approach has to be to avoid large by pass channels, carefully design the layout, increasing the available head by combining adjoining drops and designing the civil works which minimize excavations and requirement of steel and concrete, while enabling operation of the equipment at the full supply level. The third important, but not insignificant, cost component relates to the recurring costs.

The small decentralized hydel stations cannot remain cost effective if loaded with high man power costs. The technology must, therefore, be sufficiently automated not requiring continuous watch keeping and with controls which ensure safety of equipment and life in case of grid or other systems failure.

With the above approach, we have endeavoured to closely interact with and involve Electricity Boards, State Nodal and other agencies implementing small hydel projects, the equipment manufacturers, consulting engineers and financial institutions. As a consequence, a large number of proposals have been initiated in the past few years which are being examined and carefully studied to bring them under an overall umbrella of standardization with attached benefits. Interest in the development of micro/mini and small hydel projects is now evident everywhere in the country and indeed also with the multi-lateral and bi-lateral financial and donor agencies.

UTILISATION OF SMALL HYDEL POTENTIAL:

4. 11/ projects with installed capacity upto 3 MW have been commissioned in India since independence with an installed capacity of 86.52 MW. Another 111 projects are under construction and installation with an aggregate capacity of 127.50 MW. the Eighth Plan proposals envisage a further capacity addition of 256 MW

DEVELOPMENT OF INDIGENOUS MANUFACTURING CAPACITY AND CAPABILITY

5. The effort has been to put the engineering manufacturing concerns in the forefront of small hydel development, as distinct from trading houses. State-of-art technologies having already been developed in the world, Indian engineering concerns were enabled to import such technologies and gradually modify to suit local conditions and markets. For instance in the western developed economies, materials are cheap whereas skilled labour is highly paid and expensive. The reverse is the case in India. The product mix of material and labour costs for various components for equipment and machinery to remain cost competitive may be different. Therefore tools of value

Commodore Narindra Singh is Advisor in the Ministry of Non-Conventional Energy Sources, New Delhi-110003

engineering will need to be applied meticulously by our industry to optimise their products and services to suit local conditions.

INCENTIVES OFFERED BY MoNES

6. With a view to encourage cost effective small hydel stations and standrardisation efforts, a number of incentives have been extended as described elswhere in this issue.

STANDARDISATION APPROACH

7. In a vast country like India, with diverse terrains and agro-climatic regions, the opportunities offered and problems posed by small hydel development vary vastly. Therefore, the small hydel stations at irrigation canal falls and dams, mostly in foothills and plains, being easily accessible and close to regional electricity grids and with lower head drops but larger flows require a different technical and management solutions vis-a-vis micro, mini and small hydel stations in remote and hilly regions which are largely non-grid connected and having relatively higher head but lesser water flows. In terms of capital and recurring costs the hydel installations in remote and hilly regions, often not easily accessible, are more costly. However such installations have the distinct advantage of replacing diesel based power generation, and if, through suitable incentives, popularised for cooking and other domestic services can save valuable forests, biodiversity and prevent soil erosion, besides improving quality of life in disadvantaged regions.

As regards standardisation, the canal fall and irrigation dam sites have been found to vary between 3 to 30 m head and 5 to 50 cumecs discharge. Below 3 m head such sites are not considered to be cost effective at present. Adopting six type designs, the design head drops have been standardised for 3, 4.25, 7, 10, 13, 15, 21 and 30 m whilst the design discharge adopted are 5, 7.5, 12, 22.5, 30 and 50 cumecs. The corresponding generator sizes have been standardized in 350, 650, 1000, 1250, 1500, 2000, 2500 and 3500 kW ranges. Invariably for grid connected systems, induction alternators are now prescribed as these do not require expensive governing systems and thus help to make the grid connected small hydel stations very cost effective.

For the non-grid connected micro, mini and small hydel stations, a formulation for standardisation is being worked out. However, for the micro hydels, the generator will invariably be of 50 kW or 100 kW rating and beyond that the generator ratings mentioned above for the mini and small installations will be used. Non-grid connected systems will however be fitted with synchronous alternators so that load variations can be taken care of without affecting voltage and frequency.

ADDITIONALITY OF FINANCIAL RESOURCES

8. With a view to making grid connected small hydel stations on canal falls and irrigation dams bankable, the World Bank was invited to examine this sector along with the Govt. of India. A study conducted jointly by the UNDP/World Bank Energy Sector Management Assistance Programme (ESMAP) on the canal falls and irrigation dams in the states of Andhra Pradesh, Karnataka, Kerala, Punjab and Tamil Nadu had concluded that 52 such sites between 3 to 30 m head offer economic solutions if developed adopting the standardised designs and equipments as mentioned in the preceeding paragraph. The World Bank is now expected to a give a loan of US$ 70 million for this activity through our financing agency Indian Renewable Energy Development Agency Ltd. (IREDA). This activity would, by now, have been blooming but for a World Bank belated condition to encourage only the private sector concerns. It is proposed to utilise World Bank financing, when made available, for similar canal falls and irrigation dam sites in other states in the country.

As regards the micro, mini and small hydel stations with their local distribution systems in remote and hilly regions, the Global Environmental Facility (GEF) was approached with a project proposal which helps to develop technologies and systems and address the global concerns of global warming and biodiversity. The GEF has agreed in principle to finance a project on "Optimising Development of Small Hydel Resources of Hilly Regions" in the country with a grant of US$ 7.52 million under the GEF fund of UNDP. The formalities for execution of this scheme in hilly areas are being firmed up.

CONSTRAINTS/MAJOR ISSUES

9. Power generation and distribution, though on the concurrent list, is basically a state subject specially for schemes with a capital outlay not exceeding Rs. 25.00 crores which can be taken without clearance from the centre. The endeavour, therefore, is to promote the activity by providing requisite assistance to the State Govts. In view of the World Bank conditionality that the schemes posed for World Bank financing should be mainly implemented by private developers, the State Governments have been requested to lay down policy and guidelines to enable private sector generation. Fairly good progress has been made in this direction in some of the States like Karnataka, Tamil Nadu and Gujarat. Similarly for the non grid connected systems, it is necessary that entrepreneurs be allowed to operate as licensees of the State Electricity Boards to generate power and distribute and sell it at prices which ensure economic viability of the project and provide electricity to the disadvantaged hamlets, populations and small scale industry in the remote and hilly regions of the country.

Under both these schemes it is intended to accelerate the pace of development and to reach grass-root levels to achieve involvement of the people and to ensure success of the schemes for micro, mini and small hydel development.

SMALL HYDRO POWER DEVELOPMENT IN INDIA

An Overview

Arun Kumar

Background

Energy from flowing waters is probably the oldest renewable energy technique known to mankind. In India, the earliest reference to extraction of mechanical energy from natural streams dates to the 12th century. The transition to electrical energy, however, could be made possible only by the 19th century; which is quite on par with similar developments elsewhere in the world. In fact, whereas the World's first ever small hydro electric station was installed in USA in 1882, the first such station in India, of 130 kW, was set up in Darjeeling hardly 12 years later in 1897. This was followed by two 100 kW units in Shimla in 1908 and so on. Since independence, however, the tempo of developing such small stations has somewhat slackened, with the result that by 31st December, 1991, the installed capacity of small hydro plants upto 3 MW unit size was hardly 82 MW in some 113 projects.

The worldwide revolution in oil exploration and processing coupled with huge urban and industrial need for electrical energy, which could only be met by big hydro or thermal stations, are some of the factors contributing to this situation. However, in recent years, questions of environmental degradation, siltation of reservoirs, relocation of oustees and long gestation periods associated with big dam based hydro projects have forced a re-look at this entire issue of big vs. small hydro development all over the world including India. In the coming two years in India alone, more than 109 MW capacity, it is estimated, can be commissioned in this sector with the right mixture of financial and technical assistance. Against an estimated potential of 5000 MW, however, this is nothing much to talk about. We can definitely do much more than this, if we want to convert this extremely reliable of all renewable sources of energy into the most cost-effective solution for, at least, our remote, far flung and hilly areas.

It was probably in this background that the subject matter of small hydro development upto 3 MW capacity, was shifted to the Dept. of Non-Conventional Energy Sources (DNES) from the Department of Power in February, 1989. Lately, DNES has been intensively considering and evolving a number of incentives for developing this sector. But, a natural question is, why should incentives be at all necessary for such a sector as small hydro, where basic technologies have been available for centuries? Briefly, the reasons are :

a) The technologies involved in the development of small hydro, being miniaturised versions of larger stations, are more expensive than big hydro on per kw basis. This is not something unique to this sector, as price differences between such products, as a 20″ color TV and a 14″ or 3″ color TV (calculated on per inch basis) would readily indicate. While various approaches tried out by DNES and elsewhere can try reducing these costs by cutting out on unnecessary investigations, safety requirements and other redundancies, there are obvious limits to such exercises.

b) The per kw administrative and managerial costs are higher for small hydro projects, than for big hydro as a minimum complement of staff has to be deployed regardless of the size of the project.

(c) While for reasons of environment, safety and reliability, there is a world wide movement towards the sector of small hydro, (almost reminiscent of the present day movement towards desktop or portable PCs from the yesteryears mammoth centralised mainframes), the Indian SEBs and other Investor Organisations are still hesitant, for the reasons mentioned above at (a) and (b), to look at this sector with any great enthusiasm.

d) Incentives are also necessary for levelling the field at the fiscal level, as small hydro is the only sector among renewable energy technologies, which does not as yet enjoy either 100% depreciation under the income tax or any exemptions or concessions under the Excise, Customs or Sales Taxes. Many SEBs have, therefore, for justifiable reasons found it more beneficial to invest in a sector like Wind than small hydro, inspite of the fact that the latter has certain inherent advantages such as the ability to provide energy round the clock, availability of rugged indigenous equipment etc.

e) Finally, incentives are necessary to spur demands in this sector to a level when economies of scale start operating and when intense competition among manufacturers makes continuation of any such incentives superfluous.

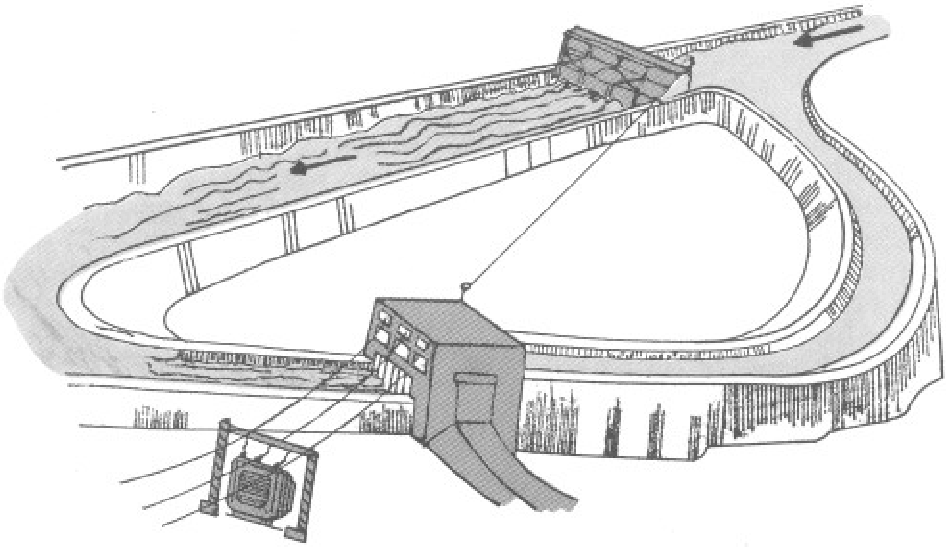
Working Group Recommendations

Taking all these factors into account the Working Group set up by the Planning Commission for the 8th Plan for DNES came to recommend a target of over 831 MW for small hydel against a DNES share of Rs. 824.60 crores. While resources to this extent may not be available, a case for a minimum budgetary support of at least Rs. 300 crores, which should then attract an additional investment of Rs. 430 crores form financial institutions etc.; thus ensuring a total inflow of around Rs. 730 crores or so to this sector by 1997, has already been made. The revised 8th Plan for this sector has been formulated accordingly.

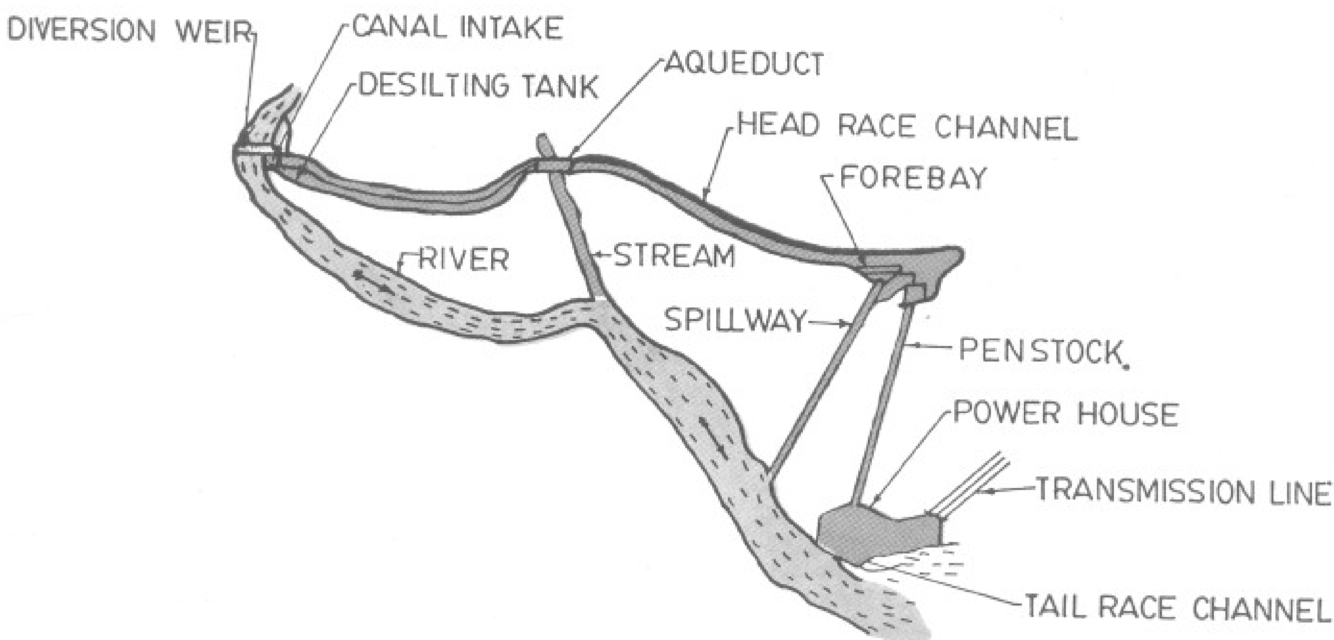
Priorities

In any case, before implementing any programme, one will have to determine its various components and the inter-se priority allocated to them. For the small hydro development programme, these have been tentatively delineated as follows and therefore the proposed budgetary support could be allocated as shown below :—

Shri Arun Kumar is Deputy Secretary (Small Hydro Power) in the Ministry of Non-Conventional Energy Sources, New Delhi-110003.



Small Hydro Power Development on Canal Falls



Typical Arrangement of Small Hydro Power Station

Priority	Sector	Inter-Sector allocation (%)	Funds (Rs. in crores)	Capacity (MW)	Phasing (1992-97) (Fin/Physical) I	II	III	IV	V
I	Repair/modification of existing small hydeo projects leading to cost effective increases in capacity	10%	30.00	60	1.0 (2)	3.0 (6)	5.0 (10)	9.0 (18)	12.0 crore (24) (MW)
II	Development/Improvement of traditional water-mills with a view to make electricity generation possible at a village entrepreneur's level	5%	15.00	10	0.75 (0.5)	1.5 (1)	2.25 (1.5)	3.0 (2)	7.5 crore (5) (MW)
III	Small hydel potential of perennial streams in hill areas — largely decentralised	30%	90.00	36	7.5 (3)	12.5 (5)	17.5 (7)	22.5 (9)	30.5 crore (12) (MW)
IV	Small hydel potential of irrigation canal falls and dams — largely grid connected	50%	150.00	150	10.0 (10)	20.0 (20)	30.0 (30)	40.0 (40)	50.0 crore (50) (MW)
V	R&D, Manpower Devt., Data bank activities etc.	5%	15.00	—	0.5	1.5	2.5	4.5	6.0 crore
	Grand Total :		300.00	256	19.75 (15.5)	38.5 (32)	57.25 (48.5)	79.0 (69)	105.5 crore (91) (MW)

Explanations :

I priorities sites are expected to have the shortest gestation periods and give the most effective value for money because no new site surveys or environmental clearances may be required. @ 1 crore/MW with DNES share limited to 0.5 crore/MW, the allocations proposed can thus lead to the creation of 60 MW capacity.

II priority sites will be requiring very little financial outlays but will lead to tremendous multiplier effects in the economy of far flung hilly villages. @ Rs. 15000/gharat with DNES share limited to Rs. 5000/gharat, the outlays proposed can easily lead to the upgradation of 10,000 gharats and also almost 10,000 kw of installed capacity; apart from providing for training, demonstration etc.

III priority sites are expected to serve remote, hilly and mostly unelectrified areas with setting up of local grids even though their implementation may be more time consuming with higher per KW installed costs. @ Rs. 5 crore/MW, therefore, with DNES share on an average limited to Rs. 2.5 crore/MW, this could lead to the harnessing of some 36 MW of new capacity.

IV priority sites will conserve hydro energy presently being dissipated away; help in improving hydel/thermal mix and above all, help in meeting agricultural electricity loads in times when they will be required the most. Because of better infrastructural support, easier availability of credit from bodies like World Bank etc. is n. likely for these sites. @ Rs. 3 crore/MW, therefore, with DNES share limited to Rs. 1 crore/MW this sector can easily yield over 150 MW within the outlays proposed.

Manufacturing Infrastructure :

India, as is well known, has a rather proud policy of strict self-reliance in which imports, even for critically needed items, are discouraged in favour of import substitution efforts either through indigenous R&D or through technology transfer contracts against set limits of royalty or lumpsum payments or both with prominent foreign firms. In the field of small hydel development, this has already resulted in technology transfer tie-ups with 9 prominent manufacturers of the world. These are as follows :

Sl. No.	Name of Party	Foreign collaborator/ country
1.	M/s Jyoti Ltd.	M/s Escher -Syss of Switzerland - now expired
2.	M/s Best & Crompton Engg. Ltd.	M/s DUMONT Neyrpic of France
3.	Boving Fouress Pvt. Ltd.	M/s Boving & Co. of UK
4.	Flovel Ltd.	M/s Tempella of Finland — now expired.
5.	Larsen & Toubro Ltd.	M/s Voith of West Germany
6.	Punjab Power Generation Machines Ltd.	M/s Voest-Alpine of Austria
7.	Steel Industrial Kerala Ltd.	M/s Koessler of Australia
8.	Bharat Heavy Electricals Ltd.	M/s Neyrpic of France — now expired
9.	Triveni Engineering Works Ltd.	M/s Esac Energie of France

Typically, these foreign collaborations had to follow rigorously laid down phased manufacturing programmes in which the import content was to be reduced from an average of 30% in the first year of manufacture to less than 10% in the 5th year of manufacture. At the present level of production, however, it is found that the manufacturers are still required to import items such as Runners, Governors, Runner Servomotors, Self Lubricating Bearing, Spherical Bushes, Shaft Seals, Sliding Pads, Gear Boxes, Flexible Couplings, Frictional Couplings, Shrink Disks, Turbine Bearings, Stainless Steel Plates, Compact Rod Seals etc. Most of these imports, however, have to be resorted to under specific import licenses and subjected to relevant import duties; which have been considerably liberalised after the budget of 29 February, 1992.

Against this, items which have been indigenised to some extent and are no longer imported in any great quantities are : Wicket Gate Servos, Shrink Discs, Flexible Couplings, Frictional Couplings, Pumps, Hydraulic Power Plates, Cranes, Butterfly Valves, Spherical Valves, Compressors, Bulb Housing Domes, Seamless Pipes, Generators, Control Panels Gear Boxes, Transformers, Oil Circuit Breakers etc.

General Concessions for renewable energy equipment

However, for other renewable energy equipment, such as those running on solar, wind, etc., Government of India has given a host of concessions which include permission to depreciate 100% of the capital cost in the first year of purchase under the Income Tax Act, import without any licence and generally with duties ranging from 0 to 40%, total exemption from Central Excise and Sales Taxes and now concessional finances from many financial Institutions. It goes without saying that such benefits, if extended to the manufacturers of small hydel machinery would help in the reduction of their prices by at least 25% and will in turn give a big thrust to the entire sector. DNES has, therefore, made necessary recommendations in this regard already and also in the meanwhile announced a new financial strategy with the approval of Commission for Additional Sources of Energy (CASE.)

The details of the already announced schemes are as follows :

I. Capital Cost subsidy :

All small hydro projects in grid connected areas are now eligible for 25% capital subsidy on the reasonable cost of civil and electro mechanical expenses. For non-grid connected areas, i.e. where the grid be more than 2 kms. away, the subsidy can be upto 50%. There subsidies can be availed of by any investing organisation, public, joint, cooperative, private or voluntary.

(CASE decision of 26 January 1992)

II. Incentives for preparation of DPRs :

DNES has also announced (on 10 May 1991) a scheme of sharing 50% of the costs incurred on DPR (Detailed Project Report) preparation, subject to a limit of Rs. 10,000/- plus Rs. 100/- per kw of investigated capacity plus TA/DA for a maximum of 3 persons for two site visits. The scheme, in the beginning, was only available for Government/public agencies, but has now been extended to other organisations, including from the private sector. (Details are available at following page as incentives for Preparation of Detailed Project Reports (DPRs).

III. Evaluation of DPRs/on-going Works :

A scheme of providing techno-economic assistance for evaluating DPRs and on going projects has also been launched (on 10 May 1991) by DNES. At the moment, DNES is engaging consultants to evaluate DPRs before an investment decision is taken. In addition, consultants have been sent to have a look at some on-going projects and to advise DNES on the need of techno-economic interventions, if any, required. The consultants' fees are paid by the DNES @ 10,000/- per DPR/on-going work evaluation for projects upto 1000 kw plus TA/DA for a maximum of two persons for one site visit.

IV. Soft Loans :

Indian Renewable Development Agency (IREDA), a public sector undertaking under the administrative control of DNES, separately provides soft loans to all categories of investors @ 12.5% with a rebate of 0.5% for prompt repayments, 3 years moratoria and ten years repayment period. There is also a possibility of a World Bank loan of US $ 70 million being routed through IREDA for financing approx. 110 MW capacity in this sector on the same terms.

V. UNDP/GEF Assistance :

A proposal to optimise small hydro resources of the hilly regions of India has already been cleared in principle by the Global Environmental Facility with a grants-in-aid of $ 7.52 million. The project, when launched, will attempt making a Master Plan for the entire Himalayan and sub-Himalayan region from J&K to Arunachal Pradesh; instal some 20 high priority demonstation projects totalling 5 MW in three different pilot project areas, upgrade 500 watermills, and in general, prove the techno-economic-environmental superiority of small hydro in reducing carbon emissions (and thereby global warming) by providing electricity for cooking and heating purposes etc.

Conclusion :

While more such schemes are presently, under formulation, it is necessary to underline that DNES' role in all these matters is that of an apex body facilitating coordination, bunching of similar orders for making volume production of required components possible, standardisation of equipment and even tendering procedures, fixing of minimum efficiency requirements and technical specifications etc. than of direct participation in tender evaluations or project execution. DNES is also required to take the lead in introducing and adapting relevant R&D results achieved anywhere in the world to Indian conditions for the benefit of the indigenous industry and implementing agencies. The constant endeavour should be to bring about the introduction of state—of-the-art-technology in the most cost-effective manner through value engineering and volume production of standard equipments which only a central organisation like the DNES with a macro view of the entire matter can achieve.

The step of involving IREDA is expected to lead to the active involvement of all other kinds of national and international financial institutions, which will hopefully make small hydel development a 100% commercially viable technology by 2000 AD

INCENTIVES FOR PREPARATION OF DETAILED PROJECT REPORTS (DPRs)

(Circular no. 6/1/30/90-SHP dated May.28,1992 from MoNES)

1. Objective

(a) to encourage preparation of Detailed Project Reports (DPRs) for Small Hydro Projects (up to 3 MW capacity).

(b) to create a shelf of projects invaluable for standardisation for E&M equipment and civil designs; arranging financial packages and where necessary induction of state of art technology.

(c) to accelerate SHP development through better management of costs and project durations.

2. Scope and Implementation

(a) Applicable to Investor organizations in the public, private, cooperative, non-governmental or joint sectors.

(b) Admissible both for DPRs preparation in-house or by hired engineering consultants.

(c) Limited to not more than two sites at a time by small consultancy agencies.

(d) Effective date 10 May 1991 for Govt./Public sector Investor Organizations and the date of issue (28 May 1992) for others.

3. Scale of Incentives

DNES grant-in-aid amounting to :—

(a) Rs. 10,000/- plus Rs. 100/- per kW of economically feasible capacity.

(b) Travelling allowance as per personal entitlement of the employee of the consulting organization but not exceeding the entitlements of the highest grade in the Govt. of India and limited to a maximum of two site visits/project for a maximum of three persons/site visit, unless specifically approved otherwise.

(c) Total grant-in-aid not to exceed 50% of DPR preparation fees payable by Developing/Investing Agency.

(d) For example, for a 500 kW scheme, if the consultancy fee or in house costs amount to Rs. 1,50,000/-, DNES share will be limited to 50% of this amount i.e. Rs. 75,000/- or Rs. 10,000/- plus Rs. 50,000/- (@ Rs. 100/- per kW) plus TA/DA at actuals, whichever is lower.

4. Procedure for Sanctions and Releases

(a) Requests to be on the prescribed application format on the letter head of the Developer/Investor organization.

(b) Screening of request and recommendation from State Govt./ Nodal Agency responsible for SHP development.

(c) Release of incentives to be made on reimbursement basis, i.e., only after the report is accepted by the DNES.

(d) Board, lodging and local transport at the site to be met by the Investing organization.

5. Quality and Content of DPRs

(a) DPRs to be prepared conforming to "Guidelines for Development of Small Hydro-Electric Schemes" laid down by CEA, IS: 12800 (Part 3) of December, 1991 and as amplified/amended by DNES.

(b) Modifications/deviations made by the consultants to be brought out clearly in the DPR.

(c) Each DPR must accompany two albums with atleast 24 coloured photographs in each to clearly bring out all aspects of the project relating to approach to the area; source and run of water; penstock; power house, and tail race locations evacuation of power; beneficiary area and any special features.

6. Presentation of DPRs

(a) Three copies of the draft DPR neatly typed and bound, with an album of colour photographs to be submitted to DNES well within the approved duration.

(b) After vetting of DPR seven copies of the duly vetted DPR with two albums of coloured photographs to be submitted.

(c) The Consulting Organization may be requested to make an audio-visual presentation to the DNES Technical Committee to SHP Development, for which additional travel allowance as at 3(b) will be admissible.

7. Miscellaneous

(a) The sanction for DNES grant-in-aid will be subject to the general terms and conditions of MoNES for SHP Projects-grants/assistance.

(b) The Grantee Organization may be required to executing "Bond", if applicable under Govt. of India General Financial Rules.

(c) The cost for preparation of DPRs may be capitalized if and when construction of SHP is taken up at the site.

APPLICATION FORMAT

1. Name of Investor Organization :
2. Postal Address :
3. Telex No. : Fax No. :
4. Name of Chief Executive with Designation :
5. Tel. : Office : Res. :
6. Name of Project :
7. Location (incl. District, State) :
8. Whether grid-connected; and the distance of grid :
9. Nearest Rail head with distance :
10. Nearest road head with distance :
11. Name of Consultant :
    (Please attach bio-data information on separate sheets)
12. Address with Tel. No. : Telex : Fax :
13. Total cost of DPRs :
    i) DPR preparation :
    ii) TA/DA : (Attach separate sheet with details)
14. Incentive Admissible from DNES :
    a) for DPRs —
    b) for site visits —
    (limit to 2 site visits @ 3 persons/site visit)
    Total =
15. Payment terms for the contract :
    a) Advance with sanction —
    b) After utilisation of advance —
    c) After completion —
    d) After acceptance —
16. Payment schedule requested from DNES
    a) With sanction —
    b) After utilisation of the advance —
    c) After completion of the DPR —
    d) After acceptance of the DPR —
17. Project period (in months) :
18. No. of projects being handled by the Consultant :
19. Enclosures :
    i) Clearance from the State nodal agency allotting the site for DPR preparation.
    ii) Terms and conditions offered to and accepted by the consultant.
    iii) 10 copies of the DPRs (if ready) with dates of completion.
    iv) Bio-data of the Consultant, if not already sent to DNES.
    v) Calculation sheet for DNES share.

SMALL HYDRO — THE STATE OF ART

Devadutta Das

Historical Perspective

The relationship of water with man is a primordial one-primarily as a life-giver and secondarily as a life-style multiplier. Energy in flowing water has been exploited from time immemorial to meet some of the energy requirements. The earliest use of hydro-energy most notably, has been the utilisation of ocean and river currents for transportation. Subsequently hydro-energy was utilised for grinding corn and with the dawn of the industrial revolution was used to provide motive power. The most efficient utilisation of hydro-energy dawned on the mankind on a fateful day in 1882 at Appleton, Wisconsin, USA when a 12 kW hydroelectric generator coupled to a hydro-turbine produced electrical energy for lighting lamps in the neighbourhood. Since then, the development of hydro-energy in meeting the growing energy needs of the mankind has never looked back essentially on account of the versatility and convenience of the electrical energy on one hand, and the cheapness and renewability of hydro-energy on the other.

Though in the initial phases of the hydro-electric production, micro, mini and small hydroelectric stations played a crucial role, the economy of scale spurred the growth of medium and large hydroelectric stations, evidently at the cost of the former. The oil embargo of 1972, triggered the world attention to looking for alternative energy sources. Small hydro which had hitherto given way to development of medium and large hydro, engaged the attention more than any other new and renewable sources of energy as its technology was a well-tried and well developed one having undergone the development over a long period of about twenty five decades, and therefore needing a very little gestation time from contemplation to implementation.

Planning Perspective

"Smaller the size, higher the cost", which almost pushed small hydro out of serious commercial consideration in the past is equally valid even to-day. Therefore, planning of SHP is one of the most complex activity due to the razor-thin financial benefits over costs, usually associated with such projects. In MHEPs, it is not even unusual to have revenues incommensurate with the costs. It is, hence, necessary, to identify the shortcomings of SHP to enable adoption of appropriate corrective measures at the planning stage. The unfavourable conditions usually associated with SHP are :

— High specific cost (i.e., high capital cost per kilowatt installed capacity).
— Low load factor especially when used in remote rural locations feeding isolated load.
— Little or no-peaking capacity
— High operation and maintenance cost.

A first step in reducing the high specific cost has been taken by adopting standardised turbines. The standardisation of turbine runners in a few standard runner diameters has resulted in standardisation of layout of powerstation, thereby reducng the cost in designing and manufacturing of turbine and associated equipment and in standardised civil works. Use of induction generators in place of synchronous generators wherever technically feasible can also result in decrease in cost. The operation and maintenance cost can be reduced by using simple and robust machine with little requirement for operational supervision. The cost of operating and maintenance staff generally constitutes a major proportion of the operation and maintenance cost and the same can be reduced by adopting semi-automatic control scheme with fail safe features.

The factor that outweighs all the above corrective actions is the low load factor commonly associated with autonomously operating stations. Thus power marketing is critical to successful operation of SHP and hence it should be critically examined at the planning stage.

The SHP units can be operated in parallel with the utility grid, and in autonomous configuration feeding isolated load system.

The energy output of SHP to most utility systems is not of major importance if the SHP does not have storage or pondage facility. The dependable discharge can only provide a capacity addition to the system. If the discharge in the stream is not dependable, the hydro-energy from the SHP can only supplement energy availability in the system.

When the SHP is planned for isolated system operation with no pondage, the installed capacity if decided on the basis of minimum flow results in minimum cost of generation. When the SHP is planned to operate in parallel with the grid, the installed capacity if decided on the basis of least alternate source cost consideration its operation results in replacement of an incremental thermal energy with a higher cost (Figure 1). These two approaches to planning the installed capacity of a SHP has almost been universally accepted.

Once the installed capacity is decided, the next step involves the determination of the number of units. It is generally expedient to have all the units of equal size and limit the number of units to not more than three. Single unit installation has the disadvantage of total loss of power generation in case of unit-forced-outage which may not be tolerable in case of autonomously operating units.

In some cases, there is a tendency to instal units of different capacities to suit to the streamflow pattern but it results in

Shri Devadutta Das is Professor (Hydroelectric) at Water Resources Development Training Centre, University of Roorkee.

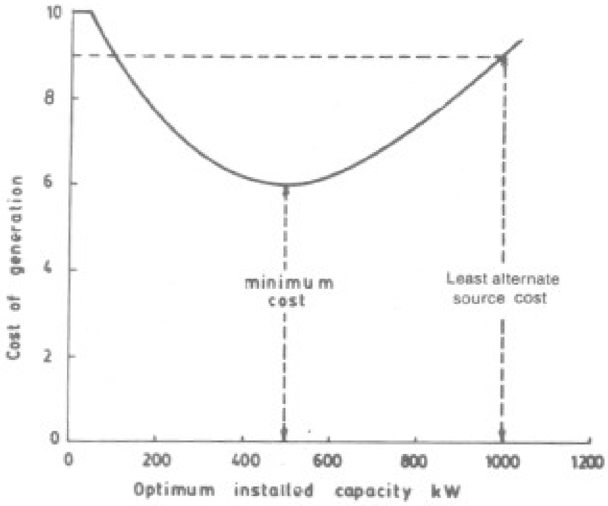


Fig. 1 : Installed Capacity of SHP

different sizes of units and an increase in inventory. Such a choice is only desirable if there is a substantial accrual of benefit in terms of increased energy production which can off-set the increased cost of inventory. Sometimes use of dissimilar unit sizes can be justified if similar units are used atleast in some other power stations in a cluster-development.

The superposition of design discharges of an installation with equal unit rating on the flow-duration curve of the stream is shown in figure 2(a) and with unequal unit ratings in figure 2(b).

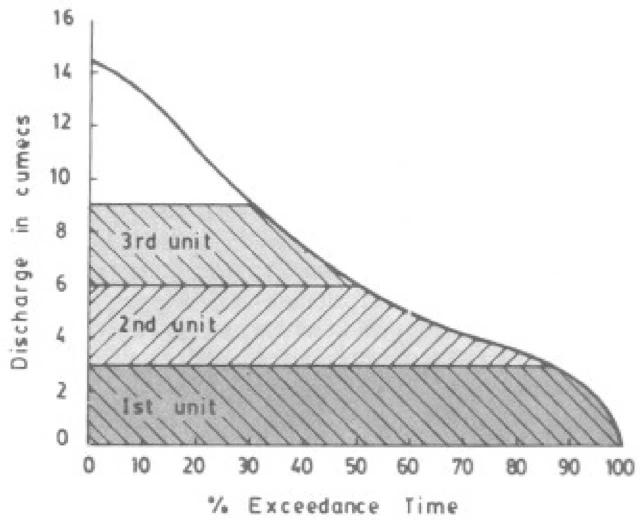
Brief Small Hydro Electric Engineering Practice

Classification based on installed capacity:

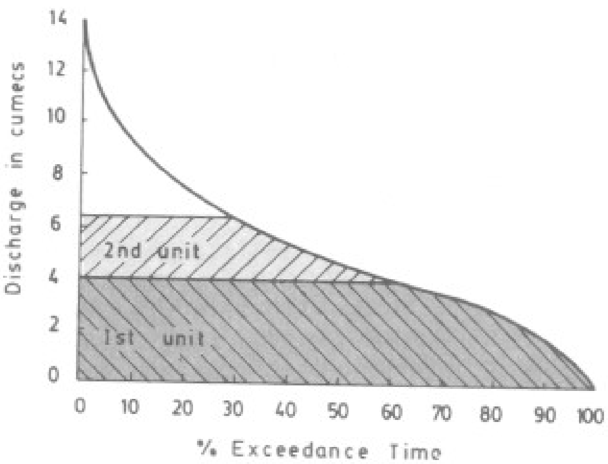
Micro	:	Upto 100 kW
Mini	:	101 to 2000 kW
Small	:	2001 to 15000 kW with unit size within 1001 to 5000 kW

Classification based on head.

Ultra low head	:	below 3 metres
Low head	:	3 metres — 40 metres
Medium/High head	:	above 40 metres



(a) EQUAL SIZED TURBINE GENERATING UNIT



(b) UNEQUAL SIZED TURBINE GENERATING UNIT

Fig. 2 : Flow Duration curve showing installation of (a) equal and (b) unequal sized turbine generating unit.

Components of Small Hydroelectric Scheme

The basic and common components of a hydroelectric scheme (open channel on conduit flow) are:

(1) Diversion and Intake structure
(2) Desilting Chamber
(3) Water Conductor system
(4) Forebay and Balancing Reservoir
(5) Penstock
(6) Surge Tank (If necessary)
(7) Power House Comprising of Turbine, Generator, inlet valve and other auxiliary systems like cooling water, drainage and dewatering systems, Auxiliary Power System and equipment, Emergency and Standby power system and equipment, Lighting system and equipment, Instrumentation Protection and Control system and equipment Ventilation system and equipment, station grounding, Fire fighting equipment and system.
(8) Tail Race

Most often it is said that the small hydropower stations are being planned and designed as a miniature version of large hydrostations thereby making the former costlier. This is not generally true as can be seen from the above list of components. The components are essentially constant, for the physical process of generating electricity from stream or river remains the same be it micro, mini, small, medium or large.

The only plausible variation in the design that could be and ought to be adopted in case of micro, mini and small hydropower station as different from that of large hydropower station lies in the degree of risk that the designer is desirous of taking, the degree of risk being inversely proportional to the capacity of the power station. It is also suggested that innovations, or more precisely, improvisations should be adopted to bring down the cost of the small hydro power stations. But they also introduce an element of risk. Thus, the planning and design of small hydropower station as distinct from that of a medium or large hydropower station depends more on the attitudes and attributes of the designer.

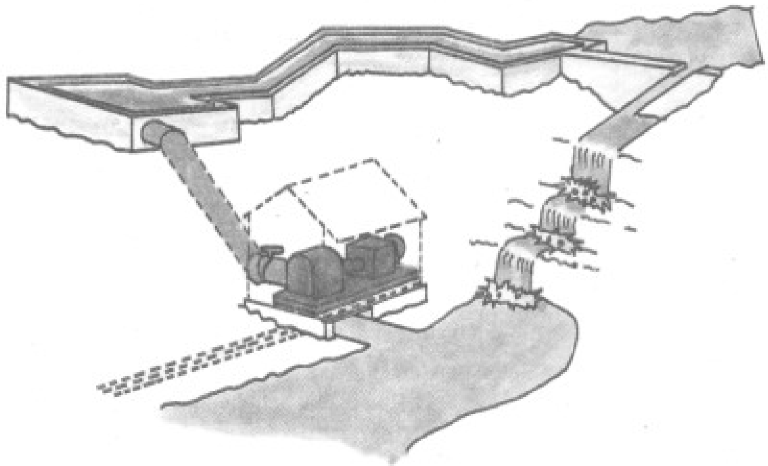
Hydro Turbine

The hydro-turbine is the key element of a hydroelectric station as the techno-economic success or otherwise of the latter depends on the techno-economic performance of the former. Further, as mentioned earlier, the dimensions of the power station is dependent upon the diametre of the turbine-runner.

The turbine technology has almost reached a stage of maturity undergoing evolution over a long period of almost twenty five decades. Many hydro prime-movers have appeared during this time and most of them have either disappeared or sub-systems assimilated into other turbine technology enriching the latter.

The hydro-turbines are classified into two broad generic types namely, impulse and reaction.

Impulse turbines use the velocity of water to drive the turbine runner, whereas, the reaction turbines use the pressure energy inthe water flowing through the turbine. Depending upon the variations in their constructional features, they are further subdivided into the following types.

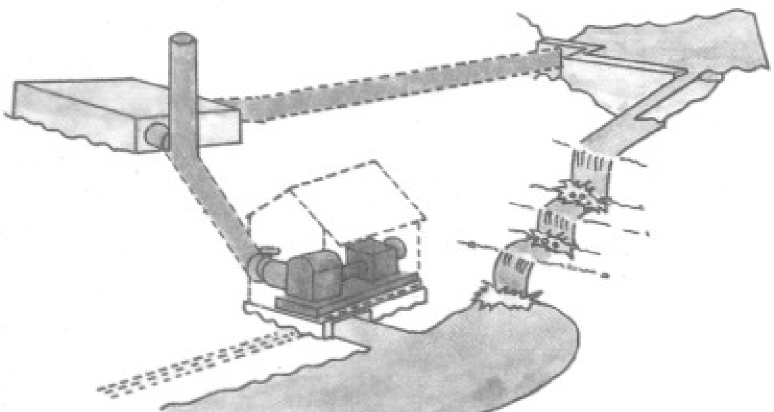


Open Channel Flow

1. Impulse — a. Pelton
   b. Turgo
   c. Cross Flow
2. Reaction —
   a. Francis
   b. Propeller with the following variations :
      i. Adjustable wicket gate with fixed runner blade – Propeller
      ii. Adjustable wicked gate and adjustable pitch runner blades — Kaplan
      iii. Fixed wicket gate with adjustable pitch runner blade-Semi Kaplan
      iv. Fixed wicket gate and fixed runner blade.

The turgo impulse wheel was specially designed for application in micro and mini hydroelectric stations with a specific speed intermediate between the pelton wheel and francis turbine. It is generally suitable for medium heads where higher rotational speeds coupled with the advantages of impulse wheel that is, higher part-load efficiencies are desirable. In this turbine, there is a higher axial thrust developed due to assymmetrical shape of the wheel buckets which is taken care of by an appropriately sized thrust bearing.

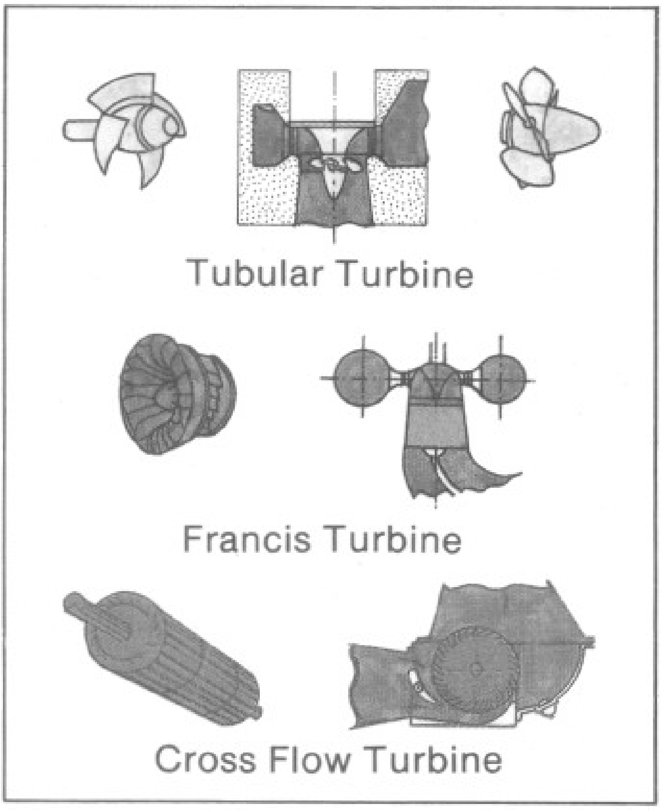
The cross flow turbine is approximately a ninty percent impulse and ten percent reaction turbine which is essentially suitable for micro and mini hydro applications due to its simple constructional features, higher part-load efficiencies which is almost flat over a very large portion of its operating range (from nearly 15 percent to full load), and self cleaning properties. As it is amenable to manufacture in very small workshops with normal fabrication facilities, it has formed extensive application in micro-hydro applications in developing countries. Its simple construction makes its maintenance easy even in remote areas.



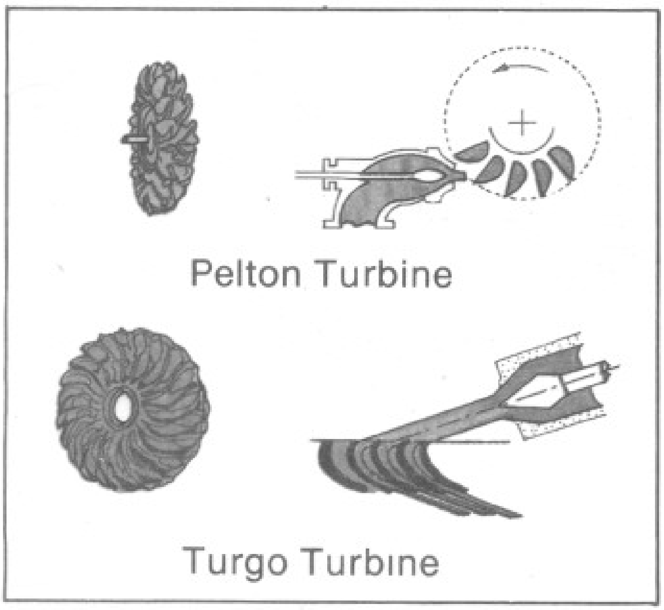
Conduit Flow

The Pelton, Francis and Propeller type turbines are essentially same whether used in small or large hydroelectric stations excepting for their axial setting.

Low Head Turbines



High head Turbines



The hydro turbine-generator axis arrangement in a hydropower station can be either vertical, horizontal or inclined. The vertical axis arrangement is adopted universally for the medium and large hydropower stations and the horizontal axis arrangement for the micro, mini and small hydropower stations. With emphasis on the development of small, mini and micro hydropower stations, inclined axis arrangement was developed and applied, though to a limited extent. The inclined axis arrangement was developed to reduce the cost of civil works by decrease in the horizontal longitudinal length of the power stations. However, this arrangement has not found favour with most of the manufacturers due to increased complexity in the design of the thrust bearing.

The low head installations have engaged the maximum attention of the designers for essentially two reasons, namely,

— multitude of low head sites, and
— head loss in the water passage constituting a significant proportion of the available head.

In order to reduce the head loss through the water passage within the turbine, the following variations in the turbine-generator configuration has evolved for the propeller type turbines:

— Tubular type with variations of S-type, A-type and Split-flow type
— Bulb type with variation of Pit-type
— Straflow type

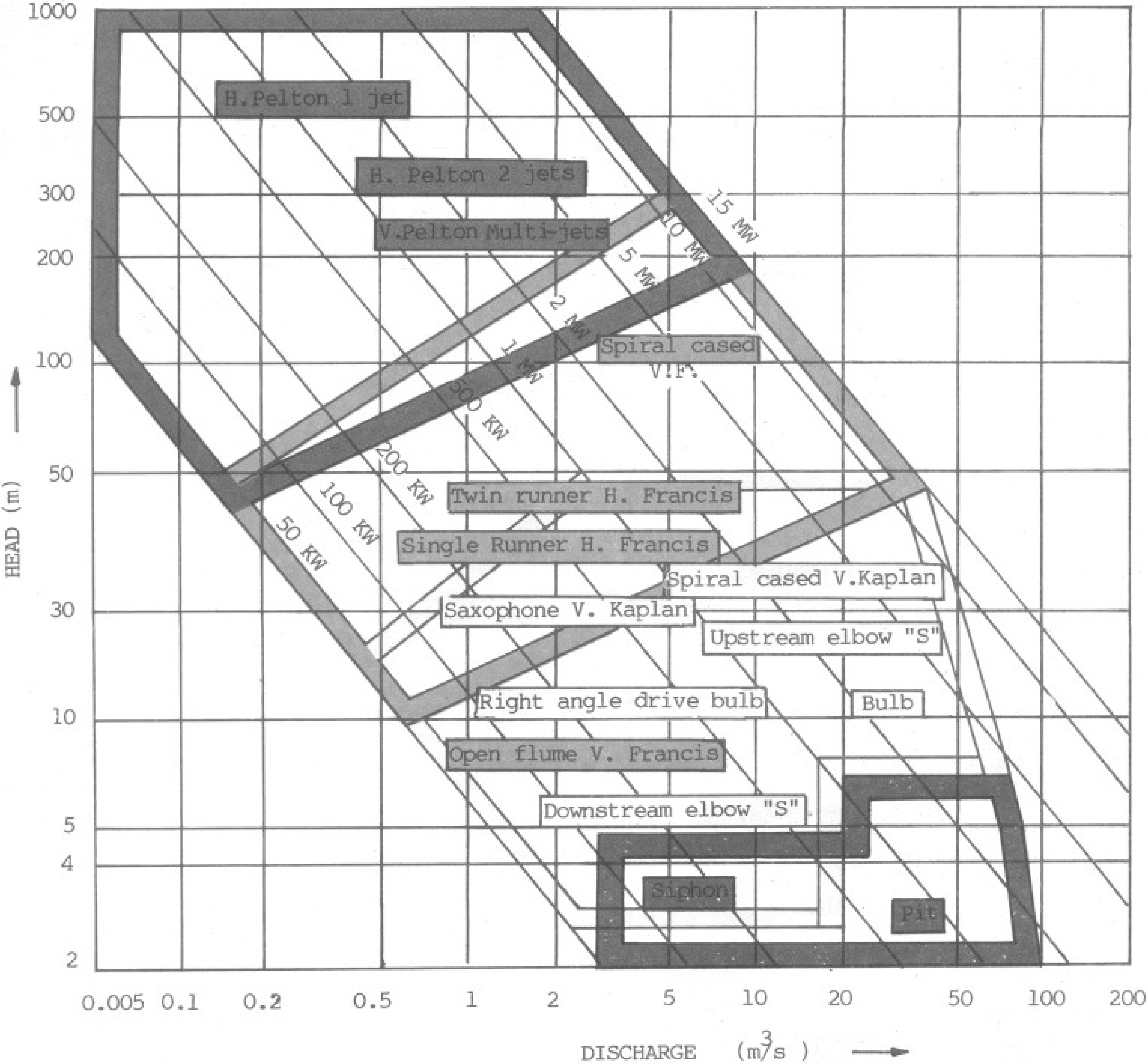
In the tubular type, the turbine is located within the water passage and the generator is placed outside it. S-type takes the name from the shape of the water path from the inlet valve to the draft tube exit. In the A-type, the turbine is coupled through a right angled-drive speed increaser to the electric generator which is mounted with its axis being vertical. In the split flow type, the generator axis and the turbine axis are parallel and are displaced in the vertical plane. To accommodate the drive arrangement, which normally consists of pulley and belt system, the flow passage is split into two and again join bak in front up the turbine's upstream face.

In the bulb type, the generator is enclosed alongwith the speed increaser within a nacelle located upstream of the turbine. The pit-type is a particular case of bulb-turbine layout with on open-flume setting. The bulb turbine arrangement has the disadvantages of low inertia of the rotating mass which is essential for the stability of operation of the generator with the electrical power system.

In the straflow (short version of "Straight flow") type, the inertia of the rotating mass is increased by providing the rotor poles on a ring mounted on the periphery of the runner blades. The stator of the generator is located outside the water passage, encircling the runner. This type of turbine-generator is also sometimes known as rim-generator.

The bulb-type and the straflow type have very high efficiencies, the flow-path being idealy straight (or axial) from inlet to exit through the turbine. However, the complex sealing arrangement required to prevent ingress of water into the generator, makes these types of generators not very much amenable to use in such environments where suitable skilled personnels are not available. Predictably, these type of turbine-generator arrangements are eminently suitable for higher outputs.

Application Chart for Hydro turbines
(Source : Dumont, France)



Selection of Hydro-Turbine

The selection of an appropriate type of turbine is based on the considerations of site conditions, namely, head and head variation, discharge and discharge-variation and load variation. The turbine which meets the performance requirements and with the maximum net annuitised benefits, is the most appropriate type. Each type of turbine has an operating range overwhich its performance is technically acceptable. Charts for turbine application have been developed by many of the manufacturers indicating the head and discharge ranges over which a particular type of turbine is more appropriate than others. Such a turbine application chart is shown in figure which can be used for selection of the type of the hydro-turbine.

For determination of the diametre of runner, all the manufacturers have developed charts showing the output characteristic of each standard runner diametre as a function of head and discharge. It may be borne in mind that the runner diametres have been standardised by each manufacturer and may vary from manufacturer to manufacturer. Similarly their performance characteristics may also vary as design considerations may be different. Therefore the selection of the appropriate turbine and runner diametre are based on the considerations of least cost of production of electrical energy at the particular site.

Generator

The generator is coupled to the turbine through speed increasing gears (or through belt-pulley drive for smaller units usually less than 100 kW and occasionally upto 200 kW capacity) in case of SHP applications. Speed-increaser increases the rotational speed of the generator, thereby reducing its size and consequently the cost.

The generators could be synchronous or asynchronous types. The synchronous types have their own excitation system whereas the asynchronous type (induction) have to depend on external sources like utility power supply system for providing the magnetisation power. Thus the synchronous types are more complicated, and costlier though more versatile in application. The induction generators operating under part load conditions have low power factor which may cause additional burden on the power system if not capacitively compensated. In short, induction generators are ideally suited for operation in parallel with the utility system and preferably at full load or near about it. However the generator capacity should be such that the utility system can deliver the magnetising power without any undue effect on it. The largest capacity of the induction generator so far installed anywhere is 5 MW.

The hydro-turbine driving induction generators also requires very simple controls for starting, loading and stopping, whereas an elaborate system including synchronisation facility is required when driving synchronous generators.

For isolated operation, synchronous generators are preferable, as for such conditions these outweigh the induction types on cost basis.

The excitation systems of the synchronous generators, as available are (a) Shaft mounted dc exciter type (b) Static type (c) brush less type. For SHP application brushless type is preferable due to its low maintenance requirements.

Conclusion

Small hydroelectric power plants have a definite role to play in the contemporary energy scenerio generally as a source for supplementing the electrical energy production and particularly in rural remote areas in meeting the energy requirements of isolated communities. However, their success depends on the ingenuity of the planner and the designer, and more importantly the conviction. Another dimension to the success is the participation and involvement of the beneficiaries of the project which is more relevant for the microhydroelectric schemes in the remote areas.

The major factor that influences the commercial success of SHP is the power marketing. It should be given due emphasis. This necessitates that SHP development activity to be more pragmatic, and relevant to the society needs, a programme based approach rather than a project oriented one. It can be more cogent, meaningful and self-sustaining, if it can form part of a multipronged development programme rather than an isolated activity.

Acknowledgement

The author is grateful to various reference books (listed elsewhere in this publication), papers, articles, drawings etc. which were referred to in the preparation of this article and to various experts in this field for stimulating discussions on the subject and their views.

Forthcoming Events

1.	5th International Conference on Small Hydro 1992	Delhi, India Nov. 2-6, 1992	Conference Secretariat (WP) Festival Hall, Petersfield Hamsphir GU31 4JW United Kingdom
2.	Water Power 1993	U.S.A.	American Society of Civil Engineers

ECONOMIC AND FINANCIAL ANALYSIS OF SMALL HYDRO PROJECTS

Arun Kumar and S.K. Singal

Any investment on project needs quantative evaluation in economic and financial terms to make decision judiciously for a financial institution. Small Hydro Power development project shall need such evaluation more rigrously as higher unit investment cost requires justification. Let us see the definitions of these analysis :

Economic Analysis : is a quantative evaluation of the economic feasibility of the project and gives a comparison between the benefits and costs of the project over the life time of the project.

Financial Analysis : is a quantative assessment of the ability of the project to repay the investment on a self liquidating basis. Hence a project to be financially feasible, the anticipated revenue receipts over the life time of the project should be more than the project disbursements.

In both analysis recurring annual costs and revenues are of primary concern. However, the other benefits such as upliftment of peoples living and education standard, value added commodity, enhancement in industrial and agriculture production due to electricity availability which do not yield revenue to the project may be considered in economic analysis not in financial analysis.

For a financial institution the economic evaluation of the project is aimed at evaluating for following objectives :

1. Determination of relative merits of different configuration of the project.
2. Determination of size & capacity ot the project.
3. Establish the ranking for developing sites.
4. Establish implementation priorities.

The evaluation can be done by adopting the following methodologies.

1) Net Present Value (NPV) method.
2) Internal Rate of Return (IRR) method.
3) Benefit Cost Ratio (BCR) method.

In this evaluation process the decision regarding the projects falls into two types.

a) Screening : with the objective to retain all those projects which fulfill the criteria for economic viability.
b) Banking : with the objective to fund all those projects which are ranked amongst the economically viable projects on the basis of the following criteria :
   (i) NPV basis : Project with highest NPV ranked highest.
   (ii) BCR basis : Highest BCR ranked highest.

Benefits : the benefits of the project can be either quantified monetary values or of non-monetary type. The benefits in monetary values are :

* Sale of energy of the project.
* Saving accruing in costs of fossil fuel.
* Saving accruing on energy losses in transmission.

Costs : The annual operating costs consists of following which will vary from plant to plant depending upon its size location and operation mode.

* Maintenance cost
* Replacement cost
* Interest
* Taxes
* Insurance

Procedure for Economic Evaluation

Step 1 — Decide if inflation effect is to be considered. If so, determine the rate of inflation.
Step 2 — Determine the economic life of the project.
Step 3 — Determine the unescalated costs each year.
Step 4 — Determine the unescalated benefits for the project for each year.
Step 5 — Escalate the cost and benefits by the rate decided in Step 1.
Step 6 — Determine discount rate.
Step 7 — Calculate the NPV, IRR or BCR as choosen.
Step 8 — Decide the economic viability of the project if minimum acceptable economic evaluation criteria is achieved.

Shri Arun Kumar and Shri S.K. Singal are Scientists at AHEC, University of Roorkee, Roorkee.

A CASE STUDY
Sarkari Mini Hydel Project
(2 x 750 kW)

Sarkari Mini Hydel Project site is located on Eastern Yamuna Canal at a distance of 14 km from Saharanpur District Headquarter in Uttar Pradesh.

Assumptions

1.	Operation cost	1% of total cost
2.	Maintenance cost	0.5% of civil works cost 2% of E & M works cost
3.	Annual depreciation charges	2% of total cost
4.	Interest rate	12%
5.	Selling price	Re. 1.00 per unit
6.	Life of project	35 years after commissioning
7.	Duration of project completion	3 years

Cost Estimates

1.	Cost of civil works	Rs. 140.00 lacs
2.	Cost of E & M works	Rs. 315.00 lacs
3.	Total capital cost	Rs. 455.00 lacs
4.	Nos. of units generated annually	Rs. 95.80 lacs

a. Benefit Cost Ratio

Annual Expenses	
Operation cost	Rs. 4.55 lacs
Maintenance cost	Rs. 7.00 lacs
Depreciation charges	Rs. 9.10 lacs
Interest charges	Rs. 54.60 lacs
Total annual expenses	Rs. 75.25 lacs
Annual revenue	Rs. 95.80 lacs

$$\text{Benefit cost ratio} = \frac{\text{Annual revenue}}{\text{Annual expenses}}$$

$$= \frac{95.80}{75.25} = 1.17$$

b. Net Present Value

Capital expenditure in I year	Rs. 55.00 lacs
Capital expenditure in II year	Rs. 180.00 lacs
Capital expenditure in III year	Rs. 220.00 lacs
Annual operation & maintenance cost	Rs. 11.55 lacs

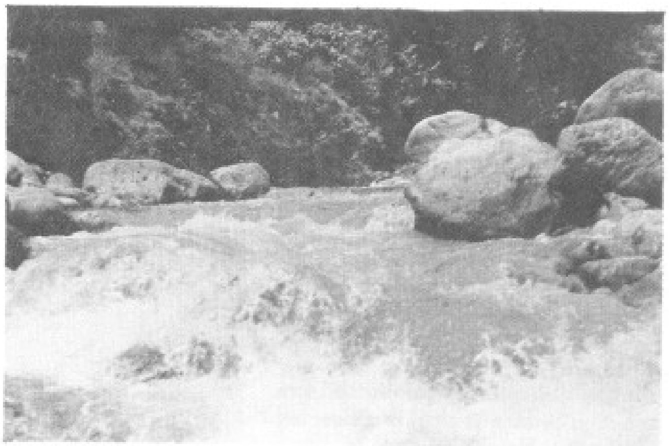
The net present value of investment and return are calculated at different discount rates and shown in Table I.

TABLE 1

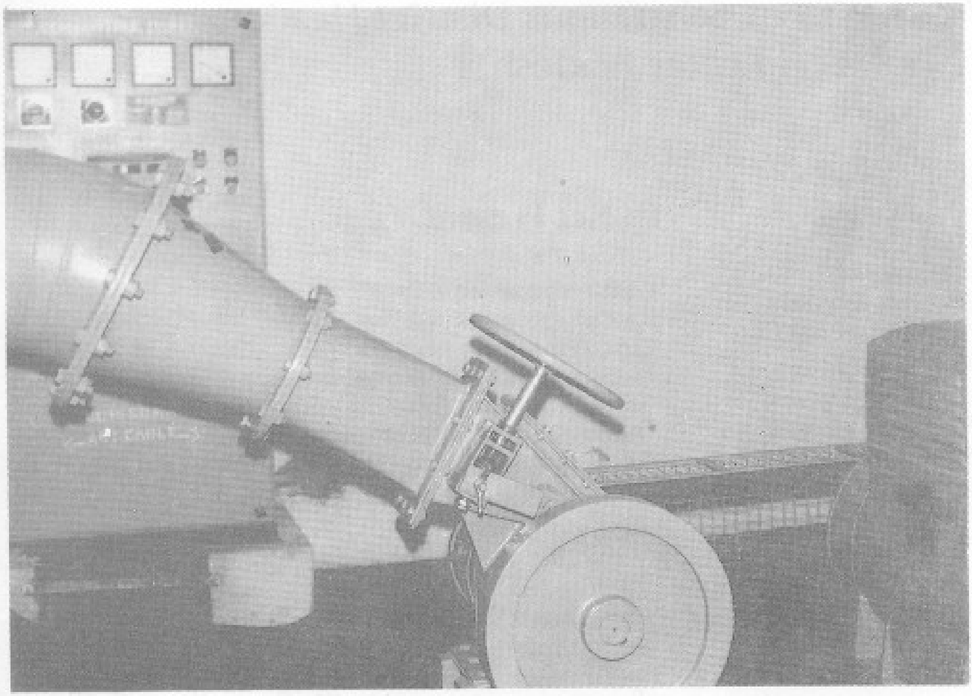
Discount rate (in percentage)	NPV of investment (in Rs. of lacs)	NPV of return (in Rs. of lacs)
8	499.29	956.69
12	463.84	603.25
16	426.79	440.49

c. Internal Rate of Return

As shown in Table-I the discount rate at which Net Present Value of two cash streams i.e. investment and return comes out equal is 16%. Hence Internal rate of return is 16%.



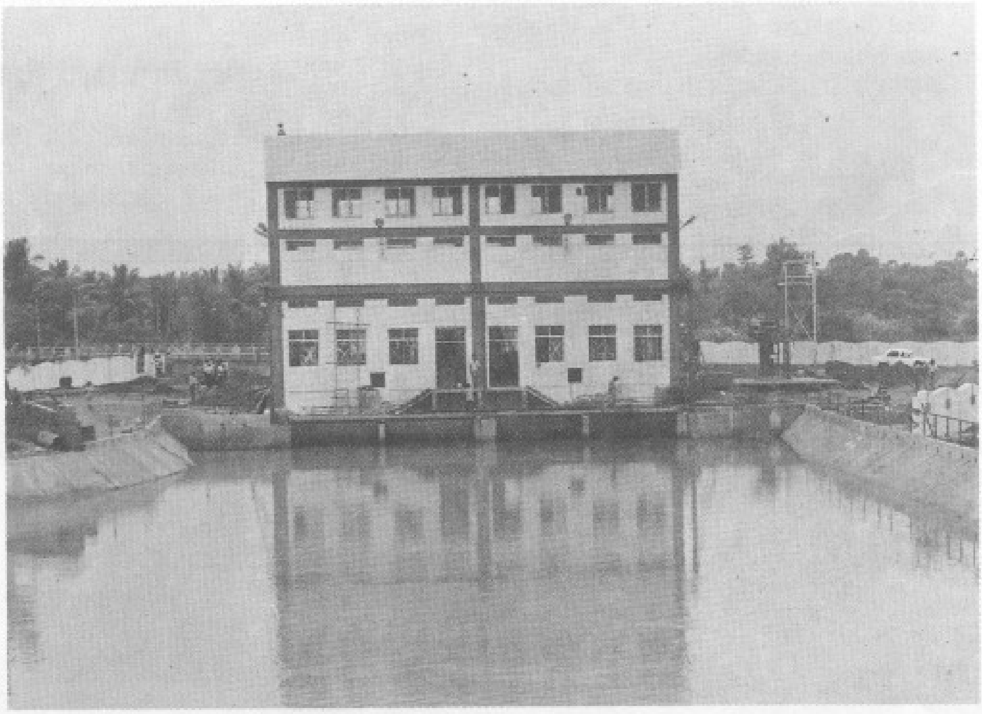
PROJECT PROFILES



POOKOT PROJECT— KERALA

The Pookot Project of capacity 1 x 10 kW is located at Pookot dairy farm and Sugandhagiri Cardamom estate, in Wynaad district of Kerala. The project was sponsored by DST-Govt. of India and Agency for Non-Conventional Energy for Rural Technology, Govt. of Kerala. Cross-flow type turbines designed by I.I. Sc. Bangalore and manufactured by Steel Industrials Kerala Ltd. have been used here.

CHETTIPETTA PROJECT —ANDHRA PRADESH



The Chettipetta Project is installed by APSEB at mile 6/0 on Eluru Main Canal at 2.74 m head in West Godavari District of Andhra Pradesh. It consisted of two vertical syphon turbines connected through speed increasors to induction generators of 500 kW capacity each and is for fully automatic operation. All the electromechanical equipments are supplied by M/s Triveni Engineering Works Ltd. New Delhi.

PROJECT PROFILES

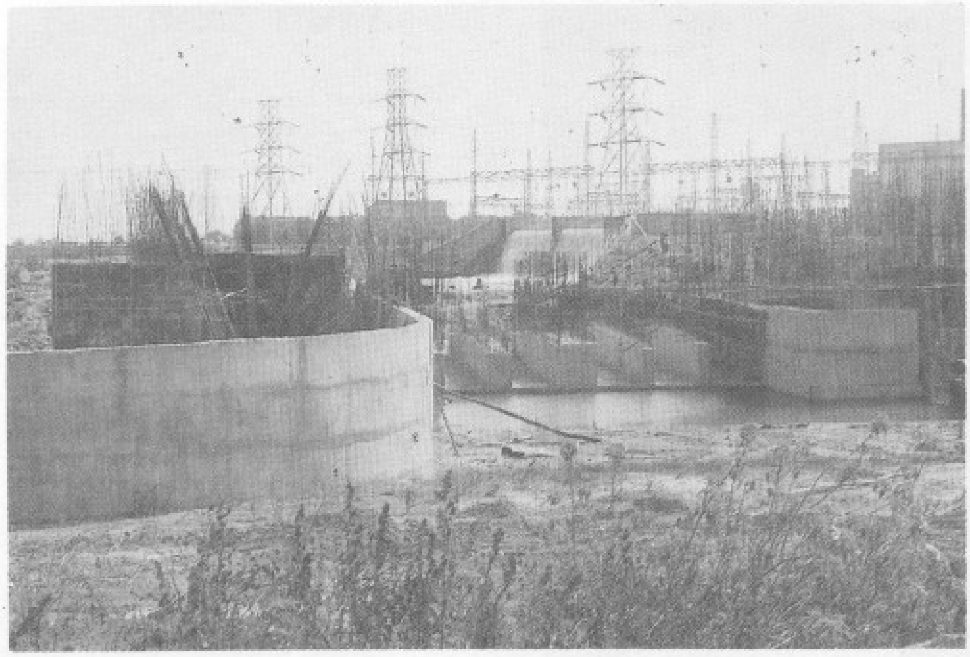


Photo Courtesy : MPEB/Jabalpur

KORBA PROJECT— MADHYA PRADESH

The Korba West Bank project is located in Bilaspur district of Madhya Pradesh at the down stream of seal pit of the return canal at 4.84 meter head. It utilises the cooling water release from the condenser of Korba West Bank thermal power station and the head available due to difference of the level between the exist level of the seal pit and the level of water in the return canal. The project consists of 1 unit of 850 kW and 1 unit of 1000 kW.

SATPURA RETURN CANAL PROJECT — Madhya Pradesh

The capacity of project is 2 x 500 kW. The project is constructed to utilise the drop of 3.09 m at the outfall of the return canal of existing Satpura thermal power station of MPEB at Village Sarni in Betul district.

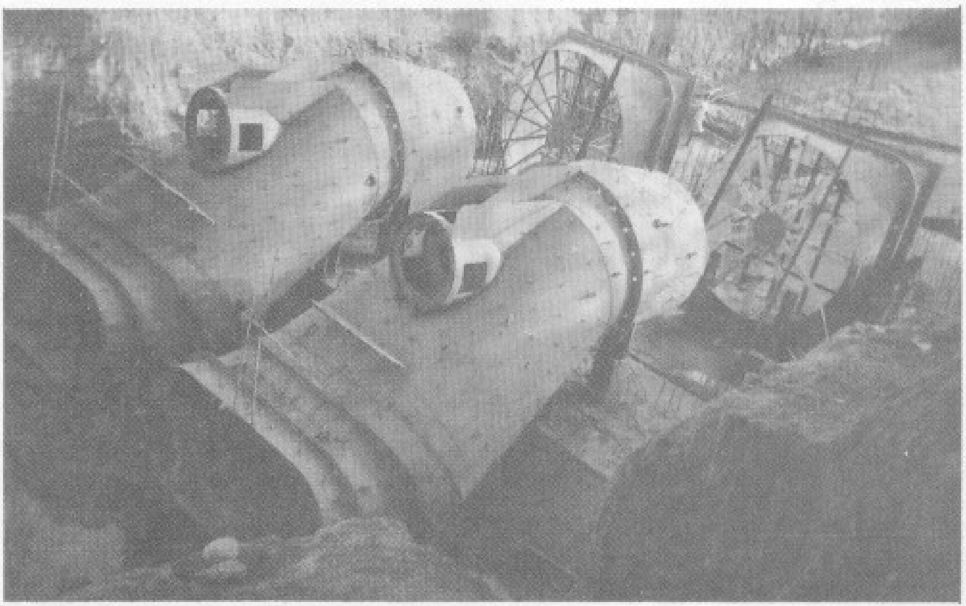


Photo Courtesy : MPEB/Jabalpur

PROJECT PROFILES

Photo Courtesy : TNEB/Madras

PYKARA PROJECT— TAMIL NADU

The Pykara Project is located in Nilgiris district of TamilNadu. The installed capacity of the power house is 1 x 2 MW.

SAHASHRADHARA PROJECT — U.P.

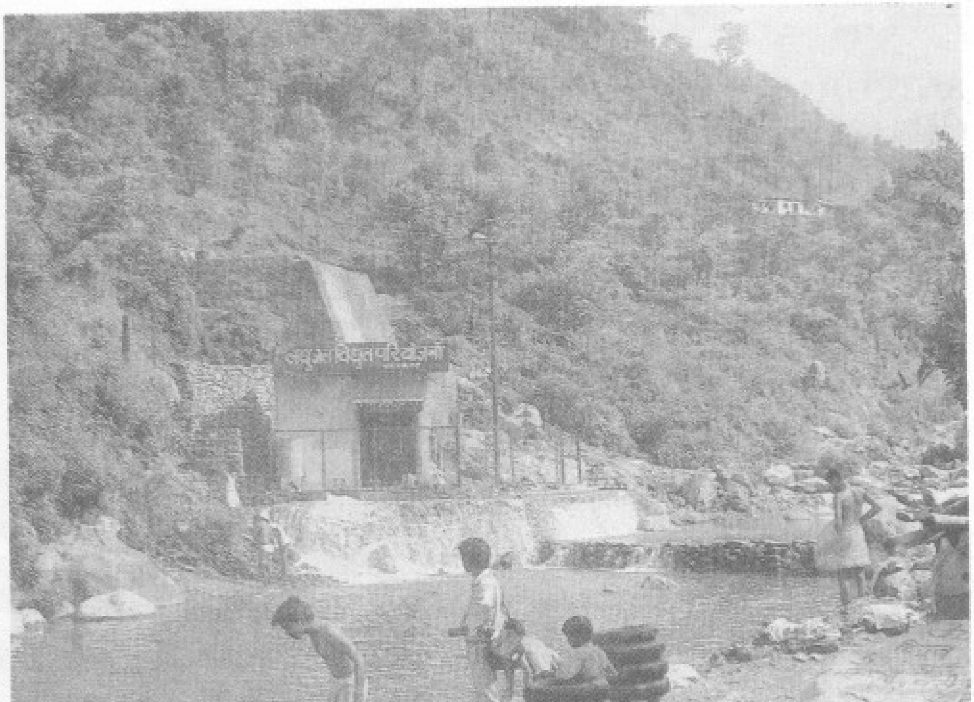


Photo Courtesy : AK/AHEC

It is located in Dehradun district of Uttar Pradesh. Its capacity is 1 x 10 kW on 5 m head. This project is installed by Non-conventional Energy Development Agency, Uttar Pradesh. The cross flow turbine, synchronous generator and Electronic load controllers, installed in this project, have all been developed indigenously.

PROJECT PROFILES

Photo Courtesy : AK/AHEC

BILKOT PROJECT— U.P.

Bilkot micro hydel project is located in Pauri Garhwal district of Uttar Pradesh. The available head is 20 meter. The installed capacity of power house is 1 x 50 kW. A 62.5 kVA synchronous generator has been coupled to a Francis turbine. The electronic controller has been designed, developed and installed by Alternate Hydro Energy Centre, University of Roorkee for voltage control and load management. The power house is being operated by NEDA, Lucknow U.P. since Jan. 1992.

KALMALA PROJECT— KARNATAKA

This project is installed by Karnataka Power Corporation Ltd. Bangalore. This scheme generates power at the fifth and sixth drops existing near Kalmala village (Raichur Taluk) on left bank canal of Tungabhadra Project. These two drops each of 3.8/m are located at 188th & 189th km of the canal. The irrigation releases in the canal vary from 3 cumecs to 7.4 cumecs for a period of about 309 days in a year. Total gross head available at these two drops is 7.62 m which utilised for power generation at a single power house located close to drop No. 6.

The above scheme has an approach channel, bypass weir, intake structure power house and tailrace channel with a horizontal tubular semi-kaplan type turbine with an installed capacity of 400 kW and total annual generation of 1.87 MU.

The unit was commissioned in January 1990 and is in operation since then.

Photo Courtesy : KPCL/Bangalore

GANEKAL PROJECT—KARNATAKA

This scheme contemplates power generation at the fourth drop, existing near Ganekal Village (Deodurg Taluk, Raichur District) on left bank canal of Tungabhadra project. This drop of 3.8 m is located at 182nd km of the canal. The irrigation releases in the canal vary from 2 cumecs to 14 cumecs for a period of about 309 days in a year. The gross head available at this drop is 3.80 m which is proposed to be utilised for power generation.

For the above scheme an approach channel, bypass weir, intake structure, power house and tail race channel have been constructed. Installation of a tubular semi-kaplan type turbine with an installed çapacity of 350 kW is in progress. This will yield an annual energy of 1.84 Mu.

Civil works of the scheme has been completed except for the second stage concreting in power house. Erection of service gate and hoist and the electrical machinery are being taken up.

KAKROI PROJECT—HARYANA

The Kakroi project, on the Western Yamuna Canal in Sonepat district of Haryana State is installed to demonstrate the economic feasibility of an ultra-low head hydro development and to study the working of different turbines. A head of 1.49 m has been developed to generate about 3 x 100 kW. The power house is located on a diversion channel on the left bank.

The following electromechanical equipment has been installed;

i. a 100 kW tubular turbine with an induction generator, supplied by Bharat Heavy Electricals Limited, India;
ii. a 100 kW propeller turbine (split flow with a synchronous generator) supplied by Voest Alpine, Austria;
iii. a 100 kW axial flow bulb turbine with synchronous generator, supplied by Essex Co., USA (under commissioning)

The project has been developed and designed by the Alternate Hydro Energy Centre, University of Roorkee. The project was funded by the department of Non-conventional Energy Sources, Government of India and Haryana State Electricity Board and was constructed by the Irrigation Department of Haryana State. Haryana State Electricity Board is operating the power house.

MANALI PROJECT— HIMACHAL PRADESH

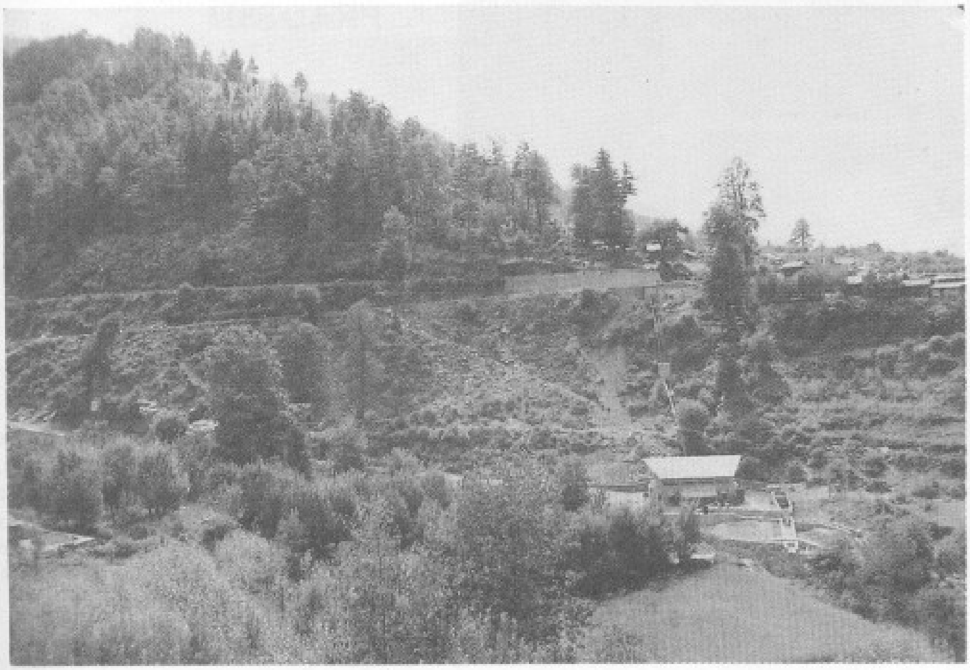


Photo Courtesy : AK/AHEC

The Manali Mini Hydro Station is located at Chhaki Nallah near Manali in Kullu district of Himachal Pradesh. The capacity of the power house is 2 x 100 kW, one synchronous generator of 100 kW and one Induction generator of 100 kW is installed. The available head is about 40 meter. The project is implemented with governer-less T.G. units with following special features.

a. Using commercially available centrifugal pumps as turbine.
b. Using induction generator.
c. Use of an electronic output load controller for replacing the conventional speed governing system involving input control and

This project is installed by Alternate Hydro Energy Centre, University of Roorkee, Roorkee (U.P.), HPSEB is operating the power house.

THUHI PROJECT— PUNJAB

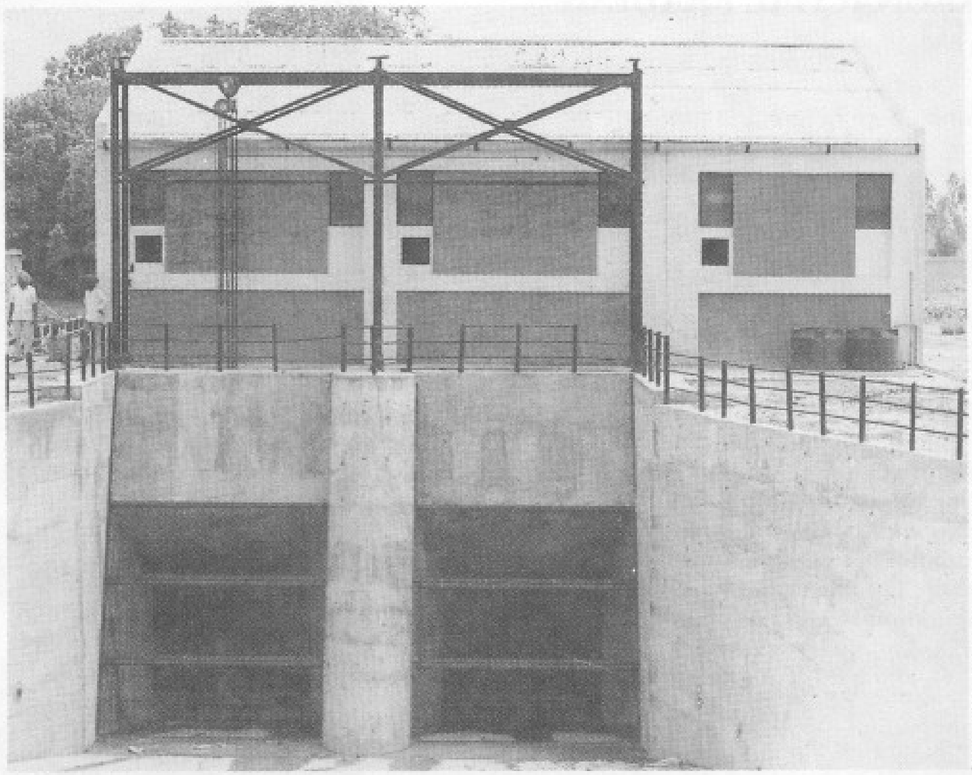


Photo Courtesy : PPGML/Chandigarh

The capacity of project is 2 x 400 kW. The project is canal based to utilise net head of 2.94m. Horizontal tubular type turbine with adjustable runner blades and adjustable wicket gate coupled with horizontal shaft synchronous generator is used for power generation. The project was commissioned in the year 1989.

CHARJU PROJECT— ARUNACHAL PRADESH

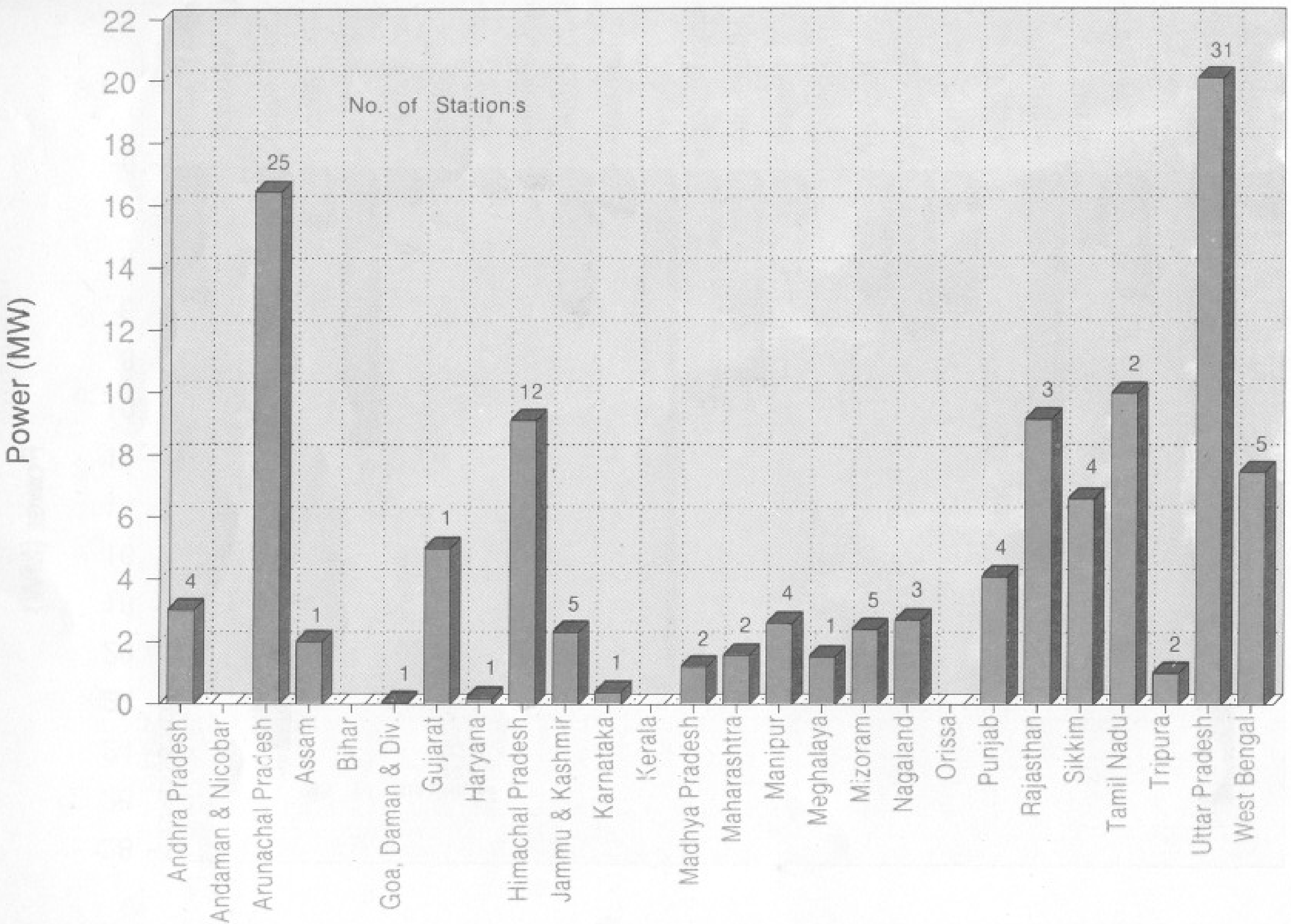
Photo Courtesy DDP, Itanagar

This project is located near Khela village on Khonsa - Changland road. The existing capacity of power plant is 2x200 kW and a unit of 200 kW is to be installed. Turgo Impulse (Horizontal) turbines coupled with Synchronous generator are used.

TIRATHJO PROJECT — ARUNACHAL PRADESH

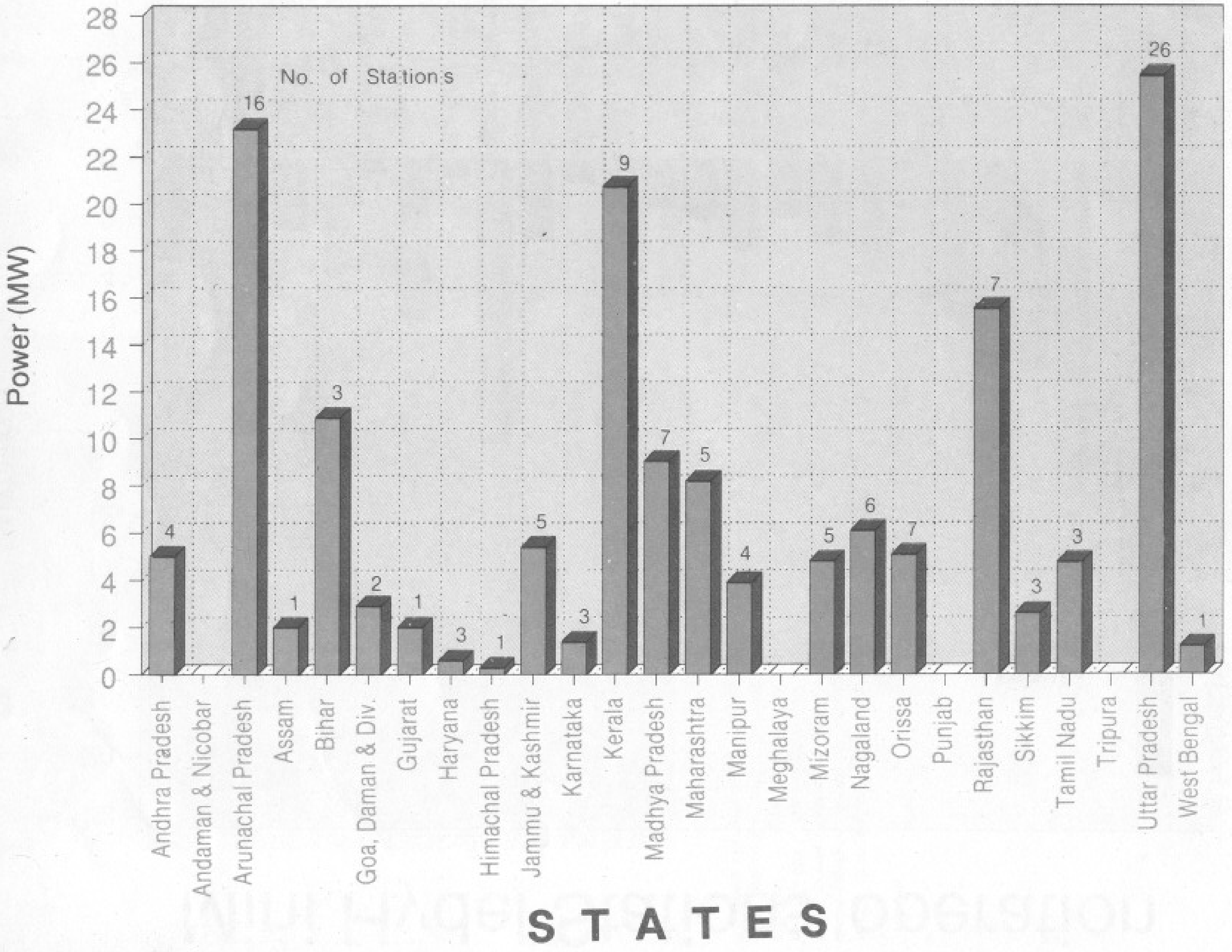
The project installed by P.W.D., Govt. of Arunachal Pradesh is located on Tirathjo River in District Tirap of Arunachal Pradesh. The installed capacity of project is 4 x 250 kW. Trench type diversion weir has been constructed. Horizontal Francis turbines are used to utilise 48 m head. The power house is in operation since 1977.

Mini Hydel Stations operation

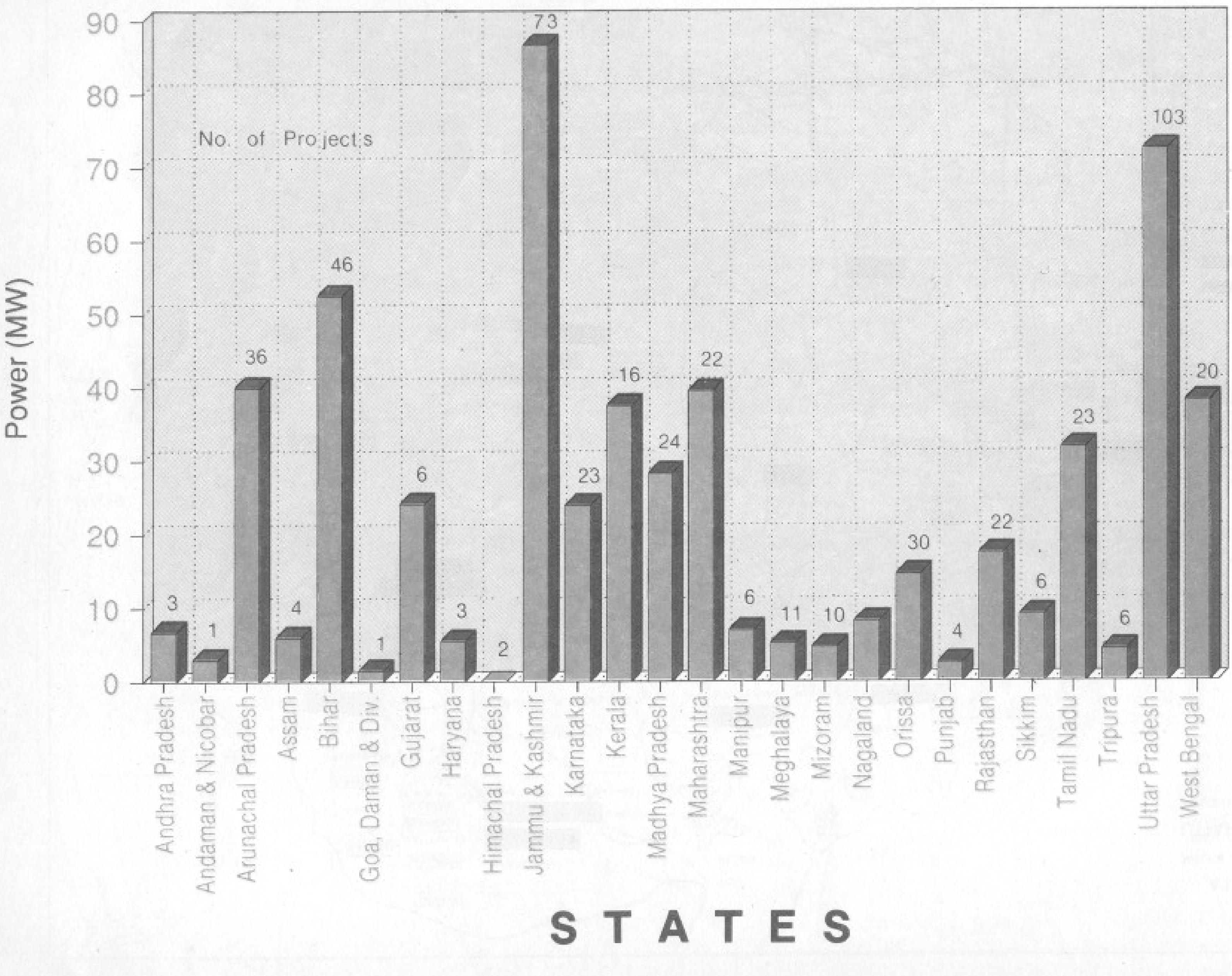


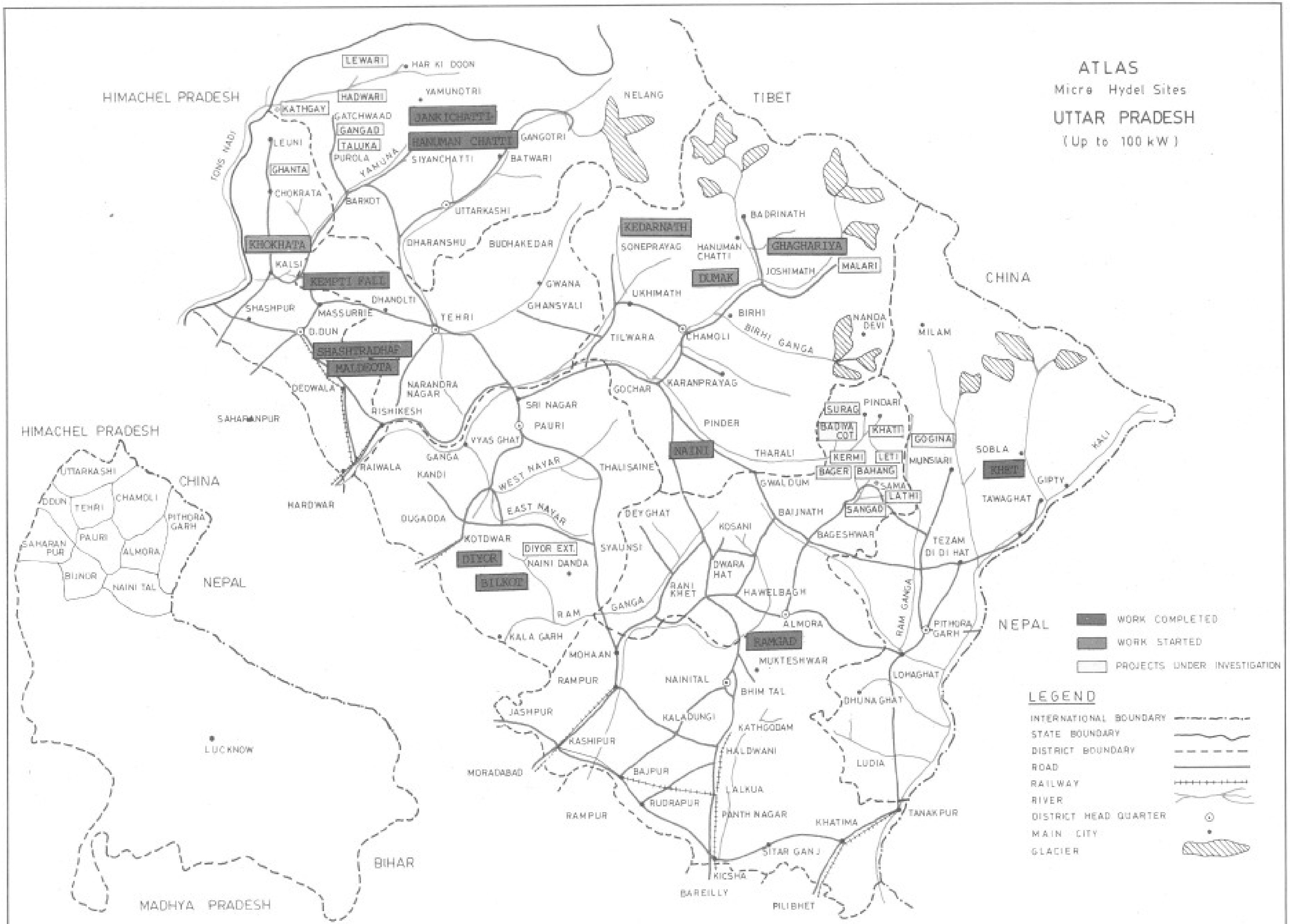
STATES

Mini Hydel Stations under construction

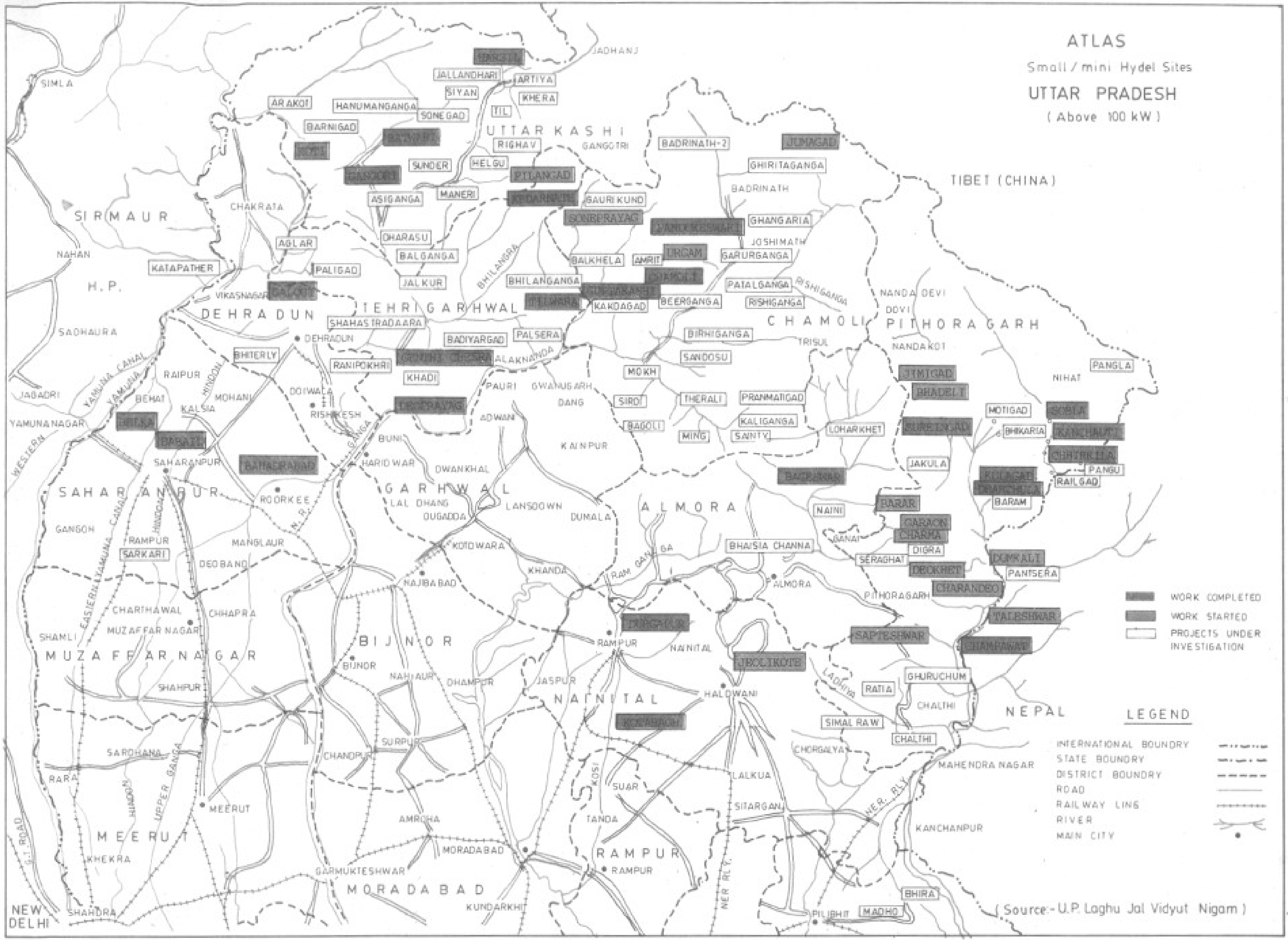


Mini Hydel Stations-future plan





Source :- Non-Conventional Energy Development Agency U.P.


ATLAS
Small / mini Hydel Sites
UTTAR PRADESH
(Above 100 kW)
TIBET (CHINA)
NEPAL
H.P.
SIRMAUR
UTTAR KASHI
TEHRI GARHWAL
DEHRADUN
CHAMOLI
PITHORA GARH
GARHWAL
ALMORA
NAINITAL
SAHARANPUR
MUZAFFARNAGAR
BIJNOR
MEERUT
MORADABAD
RAMPUR
SIMLA
NAHAN
SADHAURA
JAGADRI
YAMUNA NAGAR
NEW DELHI
JADHANJ
HARSIL
JALLANDHARI
ARTIYA
KHERA
SIYAN
TIL
ARAKOT
HANUMANGANGA
SONEGAD
BARNIGAD
RIGHAV
GANGOTRI
SUNDER
HELGU
PILANGAD
ASIGANGA
MANERI
KEDARNATH
GAURI KUND
SONPRAYAG
DHARASU
BALGANGA
JALKUR
AGLAR
PALIGAD
KATAPATHER
CHAKRATA
BHILANGANA
BALKHELA
AMRIT
URGAM
CHAMOLI
KAKDAGAD
BEERGANGA
BADRINATH-2
JUMAGAD
GHIRITAGANGA
BADRINATH
GHANGARIA
JOSHIMATH
GARURGANGA
PATALGANGA
RISHIGANGA
NANDA DEVI
NANDA KOT
TRISUL
SHAHASTRADAARA
BADIYARGAD
PALSERA
BHITERLY
RANIPOKHRI
KHADI
ALAKNANDA
PAURI
BIRHIGANGA
SANDOSU
MOKH
SIRDI
BAGOLI
THERALI
MING
PRANMATIGAD
KALIGANGA
SAINTY
LOHARKHET
PANGLA
NIHAT
MOTIGAD
BHIKARIA
JAKULA
RAILGAD
PANGU
BARAM
NAINI
DIGRA
SERAGHAT
PANTSERA
BHAISIA CHANNA
ALMORA
PITHORAGARH
RAIPUR
BEHAT
MOHANI
KALSIA
DOIWALA
RISHIKESH
HARIDWAR
BUNI
DWANKHAL
LAL DHANG
DUGADDA
LANSDOWN
DUMALA
ROORKEE
SAHARANPUR
GANGOH
RAMPUR
SARKARI
MANGLAUR
DEOBAND
KOTDWARA
NAJIBABAD
KHANDA
CHARTHAWAL
CHHAPRA
MUZAFFAR NAGAR
SHAMLI
BIJNOR
NAHTAUR
DHAMPUR
JASPUR
RAMPUR
NAINITAL
HALDWANI
RATIA
GHURUCHUM
CHALTHI
SIMAL RAW
CHORGALYA
MAHENDRA NAGAR
KANCHANPUR
SHAHPUR
SARDHANA
RARA
CHANDPUR
SURPUR
LALKUA
SUAR
SITARGANJ
TANDA
MEERUT
AMROHA
MORADABAD
GARMUKTESHWAR
KUNDARKHI
KHEKRA
SHAHDRA
PILIBHIT
MADHO
BHIRA
KOSI
WESTERN YAMUNA CANAL
EASTERN YAMUNA CANAL
UPPER GANGA
HINDON
G.T. ROAD
N.E.R. RLY.
WORK COMPLETED
WORK STARTED
PROJECTS UNDER INVESTIGATION
LEGEND
INTERNATIONAL BOUNDRY
STATE BOUNDRY
DISTRICT BOUNDRY
ROAD
RAILWAY LINE
RIVER
MAIN CITY
(Source :- U.P. Laghu Jal Vidyut Nigam)

ROLE OF IREDA IN PROMOTION OF SMALL HYDRO PROJECTS

V. Bakthavatsalam

The Indian Renewable Energy Development Agency Ltd. (IREDA) was established by the Govt. of India in March 1987 as a public sector undertaking under the administrative control of the then Department of Non-Conventional Energy Sources under the Companies Act, 1956 for the purpose of promoting and financing projects in the field of New and Renewable Sources of Energy (NRSE). The basic objective of IREDA is to commercialise technologies on a large scale which have become mature as a result of intensive indigenous R&D activities so as to generate/save power from non-conventional sources of energy.

2. During the four years of its existence, IREDA has financed a number of techno-economically viable projects pertaining to various areas of NRSE sector. The projects already financed by IREDA relate to generation of power from agro wastes; generation of power from wind energy; recovery of energy from industrial effluents; co-genration projects; manufacture of briquetes from agricultural residues; solar energy etc.

3. Based on the opportunity features of small hydro projects viz. availability of potential to the tune of 5000 MW, possibilities for supply of energy to rural remote and hilly areas of the country in a decentralised and environmentally benign manner, IREDA has identified it as one of the thrust areas for the 8th Five Year Plan with a focus on private sector participation.

4. The current financing policy of IREDA provides development of hydro projects upto small hydro capacity (maximum 15 MW) as per the Central Electricity Authority definition meeting the minimum viability criteria of DSCR 1.5 and Internal Rate of Return 12%. The main features of financing guidelines are as follows :

a)	Promoter's contribution	:	Minimum 25% of the project cost
b)	Moratorium period	:	Maximum three years
c)	Repayment period including moratorium	:	Maximum ten years
d)	Rate of Interest	:	12.5% gross per annum with rebate of 0.5% for prompt repayment
e)	Security	:	Bank Guarantee
f)	Monitoring charges	:	0.5% of the sanctioned loan amount or Rs. 1.00 lac whichever is less

5. IREDA has already financed 11 small hydro electric projects spread in four states of the country. These projects involved a total installed capacity of 23 MW and on implementation are estimated to generate 77.88 million units per annum. A shelf of projects consisting 21 number of small hydro proposals estimated to cost Rs. 5434.76 lacs and involving a total installed capacity of 21.95 MW are in the various stages of appraisal/evaluation.

6. Recently the World Bank has shown keen interest in extending a line of credit involving loan component to the tune of U.S. $ 70 million for the promotion of private sector participation in the small hydel development in the country. Public sector industrial undertakings wishing to generate their own power and wheel it to their work may also draw on these finances. The loan is likely to be finalised during the current financial year.

7. In order to foster development of this sector IREDA has initiated various steps which include :

a. Organising Awareness Programmes, Training Workshops, Entrepreneurship Development Programme (EDP) etc.
b. Getting the promotional policy introduced by the different states for the private sector participation viz. allocation of sites, introduction of energy wheeling/banking/buy back etc.
c. Getting the procedures for licencing, grant of various Govt. clearance, leasing of site etc. streamlined.
d. Streamlining of procurement procedures.

8. In the context the workshop on "Strategies for the development of Mini & Micro Hydel Projects" and "Scope of Consultancy Services for Mini and Micro Hydro Power Development on Irrigation Dam-Toes & Canal Drops" have been organised. The three southern States namely Karnataka, Tamil Nadu and Kerala have already introduced policy for private sector participation in their states including the power wheeling and banking. Other states viz. Andhra Pradesh, Madhya Pradesh etc. are in the process of getting the private participation policy introduced in their State on the similar line.

Shri V. Bakthavatsalam is Managing Director of Indian Renewable Energy Development Agency, New Delhi-110014.

NOTES

WORLD BANK LOAN FOR MINI HYDRO

Joint UNDP/World Bank Energy Sector Management Assistance Programme (ESMAP) conducted a preinvestment study recently regarding Mini Hydro Development on Irrigation Dams and Canal drops in India. For the benefit of our readers some important extracts from the report are given below. — Editor

Background

In India, there is the general perception that mini-hydro schemes are economically unattractive investments which must be assigned a lower priority relative to the large conventional hydro power systems. Over the past decade, the pace of India's large conventional hydro power program has slowed down because of: (i) the lack of financial resources in the states with the greatest hydropower potential; (ii) the recurring and drawn out disputes over water rights between states; and (iii) environmental and resettlement issues associated with large schemes; and (iv) the limited technical resources to proceed simultaneously with the preparation of several large schemes. Recognizing that the above impediments do not usually arise with mini-hydro schemes, the GOI is re-evaluating the scope for increasing the contribution of mini-hydro schemes to the power development goals of the Eighth Plan.

In recently completed review of the country's non-conventional energy program, ESMAP concluded that all the basic prerequisites for economically viable mini-hydropower generation exist at sites in India that are associated with irrigation water storage and distribution infrastructure (i.e., to harness the hydraulic energy created by discharges from irrigation dams and the flow of water across diversion weirs and canal drops). Compared to river based schemes, the cost of developing irrigation based mini-hydro schemes should be considerably lower because most of the civil works have already been constructed.

Despite the initial assessment by ESMAP, there still are doubts within the GOI about the economic viability of irrigation based mini-hydro schemes. These doubts persist because the average costs of developing pilot schemes in several states has exceeded Rs. 30,000 per kW installed in 1988 prices. Following the transfer of responsibility of mini-hydro schemes (upto 3 MW capacity) from the Department of Power (DOP) to the DNES, a multi-agency Sub-Committee on Mini-Hydropower was convened to formulate a strategy to improve the cost-effectiveness of mini-hydro programmes in general, and to review proposals for the Eight Five-Year Plan (1990-95). In parallel with the work of the Sub-Committee, the GOI through DNES requested ESMAP to assist further in critically evaluating proposals for new irrigation based mini-hydro schemes in several states, and if warranted by the findings, to address comprehensively the pre-investment requirements for a multi-scheme investment program for consideration by international and/or domestic financial institutions.

Objectives

The principal objective of this study was to apply techno-economic criteria to improve the design and economic viability of irrigation based mini-hydro schemes, and to identify and prepare a medium term investment program to develop a series of irrigation based mini-hydro schemes in the southern region of India. Accordingly, the study covered previously identified and investigated sites in the States of Andhra Pradesh, Karnataka, Kerala, and Tamil Nadu which have similar topography and irrigation regimes. At the request of the DNES, the scope of the study was expanded to include twelve prospective sites in the State of Punjab, all of which are earmarked for development under the mini-hydro component of the ongoing World Bank/IDA financed Punjab Irrigation and Drainage Project.

Standardization of Designs

To improve upon the original designs, considerable attention was given to identifying practical measures to minimize capital costs. For turbine-generator units, this was achieved by developing a set of standardized specifications according to available heads and discharges. As a result, a set of eight standardized specifications based on runner diameters were developed for the turbine requirments of all fifty-three schemes, ranging in diameter from 2800 mm to 1000 mm (i.e., for fixed blade tubular turbines). Similarly, a set of eight standardized capacities were specified for the induction (asynchronous) generator; the minimum capacity was 350 kW and the maximum was 3500 kW. All redundant equipment and instruments that had previously been incorporated into the electrical protection and switching arrangements were eliminated. Standardized single line diagrams and electrical protection schemes were developed to cater to the requirements of all the fifty-three schemes. To minimize the costs of civil works, alternative layouts and designs of the main civil structures were re-defined and evaluated according to three criteria: (i) structural modifications to the existing irrigation facilities were reduced to a minimum; (ii) layouts of civil structures and electrical switching systems were streamlined to facilitate construction, so that schemes would be implemented within two irrigation seasons; and (iii) layouts were specified so as not to cause any permanent loss of productive agricultural land. To the extent possible for each category of mini-hydro scheme, a set of standard designs were developed for main civil structures, particularly the power house structures, and the water intake and conveyance structures.

Proposed Mini Hydro Demonstration Program

Subject to the detailed preparation and appraisal of the proposed project, it is expected that the World Bank would provide technical assistance to address the following requirements for effective implementation of the schemes:

Notes

(a) Strengthening the capacity of IREDA to administer the funding facility in a manner that would accelerate the development of economically and financially viable mini-hydro schemes based on design principles and approach presented in the report. If feasible, a separate revolving fund would also be established at IREDA for pre-investment work needed to sustain the pipeline of viable mini-hydro projects;

(b) Conducting in-service training programmes under DNES/IREDA sponsorship to develop the capability of professional personnel (i.e., from SEBs, private sector, etc.) involved in planning and executing irrigation based mini-hydro schemes, especially the investigation, design, construction, operation, and maintenance of grid-tied schemes;

(c) Strengthening the capacity of DNES to promote and support a nationwide effort to improve planning and policy formulation for mini-hydro development, and to accelerate the investigation and preparation of prefeasibility studies for prospective mini-hydro schemes associated with existing and planned irrigation dams and canal systems in all states.

(d) Strengthening the capacity of the SEBs to implement the mini-hydro programs, especially on technical matters such as identifying, investigating, and preparing preliminary designs for mini-hydro prospects, and on project management involving the application to implement the schemes (e.g., supervising procurement and construction work etc.).

*Following the **availability** of ESMAP report (Blue cover report No. 139A/91 in 3 Volumes available from IREDA/DNES free of charge for the potential developer), DNES got prepared the standard type designs and standard technical specifications for International Competitive Bidding in consultation with its consultant Alternate Hydro Energy Centre and participating SEBs. These designs were audited by World Bank in Nov. 1991 and revised draft has been again sent to World Bank for its adoption.*

World Bank in its latest aide memoire clearly indicated that loans will be available to private companies developers for these mini hydel schemes. The prerequisites for the final appraisal have been completed in the following forms.

(i) Prepared Standard Type Design covering all types of turbines and hydraulic layout in the low head range of irrigation system.

(ii) Prepared Standard Tender Specification Documents for International Competitive Bidding to establish a rate of contract for fixing up the prices of electromechanical equipments to achieve economy of scales.

(iii) Organised workshop of the awareness amongst the organizations.

(iv) Issuing the necessary guidelines for the State Govt. inviting private companies to develop the mini-hydel schemes.

World Bank is expected to prepare final appraisal sometimes in 1992. The loan is expected upto the tune of 70 million US$ and for about 110 MW.

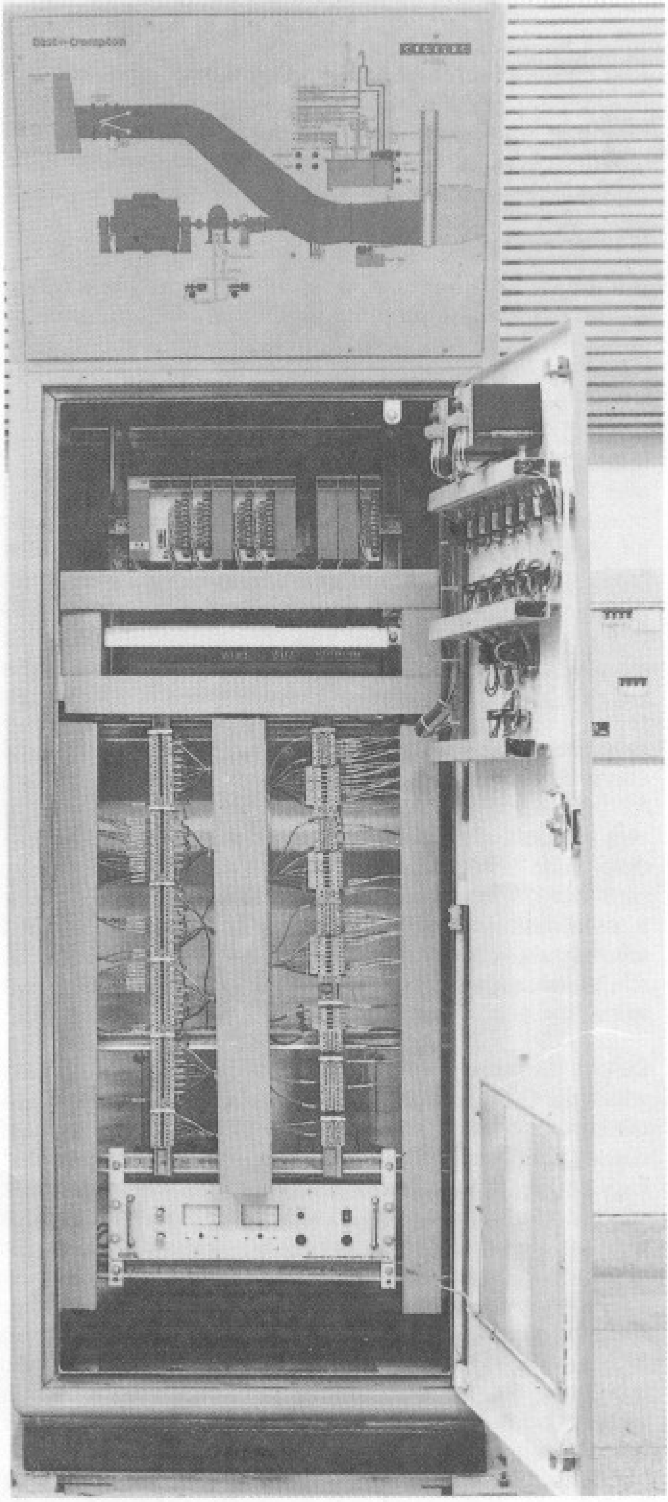


Photo Courtesy : CEG ELEC/NOIDA

Typical Automation Controls for Kerala Project

SMALL HYDRO TO IMPROVE GLOBAL ENVIRONMENT

The Global Environment Facility (GEF) Fund has approved $ 12.52 million for optimising development of small hydel resources in India as part of its portfolio for improving the World's environment. It is a matter of great pride that this Project is the only one so far accepted from India for inclusion in this portfolio as also the only one in the World in the sector of small Hydro.

2. It may be recalled that the GEF, established in November, 1991, is a three year $ 1.5 billion fund providing grants and low interest loans to developing countries, which will help implement projects for relieving pressures on global ecosystems. The Fund is a cooperative venture among some 40 National Governments, World Bank, UNEP and UNDP and has the following 4 areas of concern :

1) Reduction in emission of greenhouse gases;
2) Preservation of biological diversity;
3) Arresting the pollution of international waters; and
4) Preservation of the ozone layer.

3. For the first tranche, the Fund approved some 50 environmental projects costing over $ 200 million. These include proposals to preserve tropical forests in Congo, protect biodiversity in Eastern Africa, South Pacific and Poland, arrest marine pollution in China and strengthen national conservation units in Brazil. There are three projects from China in this list with an outlay of $ 42 million in all, but none from India. Since India's contribution to the GEF turst fund is SDR 4 million, it was a matter of concern that no project from India could so far be included in the GEF portfolio. The hilly hydro proposals from India, although small is, therefore, a hopeful beginning for further cooperation between India and the GEF.

For the benefit of our readers, we are giving below some important extracts from the Project Document submitted by the DNES and approved by the GEF authorities for further development. In case there are any suggestions/ comments for improvement, they would be most welcome.

— Editor

A. Project Justification

1. Problem to be addressed : the present situation

No electricity in remote hilly villages, or electricity only for lighting through carbon emitting diesel generators for 4-6 hours every evening. This is so because no grid extension is planned for hamlets and populations that do not fall under the category of a "Census village". Grid extension is typically $5000/ km or more. There is often a senseless attempt to extend grid lines regardless of cost, possibly for want of a better solution.

Wherever hydel projects exist, they have not always shown sensitivity to the environment. Costs are often high. There is a general lack of standardised designs for turbines, generators and civil works. Multiplicity of designs and sizes of turbines have led to absence of economies of scale in manufacture and failure to incorporate latest technology. Scaling down design and construction parameters of large hydro, for adoption for small hydro, have resulted in many redundancies.

Cooking and heating needs are mostly met through fuelwood resulting in deforestation, carbon emissions and deleterious consequences for the health of the womenfolk. Alternative options of LPG or coal supply, wherever attempted, have proved to be expensive, unreliable and, therefore, unsustainable in the long run. There is a general non-availability of low cost, low wattage electric cooking and heating devices in absence of market, R&D inputs and lack of interest by the power utilities. Necessary consumer equipment is just not available with the adaptations, as required, for rural uses.

There are no master plans for undertaking a more scientific exploitation of local hydel resources. This is due to lack of training and resources required for such compehensive exercises.

There is also a general lack of testing facilities for small hydro power equipments such as turbines, generators and controls, within moderate costs. Field acceptance tests are almost never conducted as each test costs more than Rs. 3 million. Performance charts of small equipments are practically not available. This is further compounded by a general absence of model solutions to follow or model projects to copy and for want of any macro policy in this area. Activities are, therefore, still scattered without reference to any models.

No systematic attention has been given to the potential of upgrading some 200,000 water mills operating in India. This is because model designs and other inputs in training and fabrication are lacking. Inspite of all governmental and NGO efforts, only 200 or so such water mills have so far been upgraded.

Finally, there is a total lack of Human Resource Development as State Electricity Boards give low priority to small hydro. Training courses of long and short term durations in small hydro have just started. The result is that the total installed capacity in small Hydro in India (upto 3 MW) hardly touches 80 MW.

2. Expected end of project situation

The following situation is expected as a result of the project:

(i) A master plan for small hydel development up to 3 MW unit capacities in the entire Himalayan and sub-Himalayan region from the State of Jammu & Kashmir to Arunachal Pradesh.

(ii) A set of proven standard designs, sizes and methodology for small hydel technology in hilly areas.

(iii) Improved laboratory, technical and training facilities in AHEC, Roorkee and two other regional institutions, one in the North West and another in the North-East, identified during the project.

(iv) Several demonstration hydel projects in different parts of the country to enable standardisation of technology for several situations such as: altitudes from 12000 ft. to 2000 ft.; temperatures from-40°C to + 40° C, rainfall from 10 mm to 3000 mm, heads from 30 mt. to 1000 mt. encountered with the development of small hydro projects in hilly regions.

(v) Recommendations about the suitability of the low wattage, storage, cooking and heating devices that are already available commercially in the Indian market or abroad, with improved and lower cost modified designs, if possible, and finally,

(vi) An environmentally enlightened and technologically up-to-data project admiñistration authority at least in the pilot project areas, trying to harness, on the basis of the master plan made available to them, every kw of economically viable hydel potential.

B. Project Strategy and Implementation Arrangements

1. Project Strategy

The strategy of achieving drastic cost reductions would be by optimising selection and standardisation of equipment, building reliable stand alone operation capability and training involved personnel and communities. The aim would be to prove that popular perceptions about small hydro electric projects being somewhat expensive in terms of higher initial costs, higher managerial and administrative costs and relatively low utilisation are not always correct. In fact, they can, with requisite scientific and technical inputs, very easily compete with and, actually, outperform all other known conventional or non-conventional options of providing electricity to the same remote and hilly site with distinct environmental benefits. The inputs required in this exercise would be : a thorough scrutiny of existing project proposals so as to achieve optimisation of resource exploitation; standardisation of equipments used, and bulk placing of orders so as to achieve significant economies of scale. Indigenous manufacturing capabilities very much exist for end-use appliances as well as turbines, generators (synchronous as well as asynchronous) and control equipments covering practically all ranges. About 10 manufacturers for turbines (with foreign collaborations with Cos. such as Voith, Voest Alpine, Kossler, Boving, Neyrpic, Esac) and 5 for generators (except one, all in the private sector) can make the equipment in standard packages with reasonably robust designs but can not reduce costs for want of sufficient orders and lack of cost-effective and area-specific system designs.

2. Implementation Arrangements

a. The central unit in New Delhi will plan coordinate and guide the project in collaboration with UNDP/World Bank, project authorities, consultants, manufacturers, institutions and NGOs. Plans for further extension of the project to other areas, after its completion, will also be formulated by this Central Unit.

b. Institutions will handle the training & testing components.

c. State Government/Project authorities will help in data collection for master plans and execute the pilot projects.

d. Consultants will make master plans for the projects area, identify requirements of training and equipments, formulate load development strategies and help in general trouble-shooting.

3. Alternative Implementation Arrangements

a) The alternative strategy in vogue at present, lets project authorities/State Govts. extend grid lines to these hilly areas as well as install local hydel projects, with neither the benefit of any overall master plan nor the latest scientific, technological and environmental inputs. Hence, a comprehensive change in strategy.

b) Talking of alternative options of meeting the fuelwood needs of such ecologically fragile areas, use of LPG, kerosene or coal has been often suggested. These are, however, found feasible only in areas that are on roadheads. Use of these fuels in any case will not help in reducing carbon emissions or global warming. Afforestation in the long term could perhaps be the cheapest and the most comprehensive way of reducing or actually, absorbing carbon emissions. However, the mean annual increment of wood in a **natural** forest (**not** short rotation energy plantations that can yield more but which cannot be recommended in natural forest areas) in India is only around 2 tonnes per hectare. In that case, since each kw of small hydro installed capacity, (from the calculations at following paras can save 94.2 tonnes of fuelwood, this would amount to 47.1 hectares of natural forest area conserved, over the plant's normal life of 30 years. Taking the average cost per hectare of fresh afforestation to be US$1500 per kW, the cost of fuelwood replacement by afforestation of 47.1 hectares ($ 18840) thus works out to be almost 12.5 times more expensive. Of course, these figures are only indicative and are not meant to belittle the importance of afforestation; that has to be supported regardless of costs. The project, if anything, would only strengthen such efforts by reducing, to the extent possible, the biotic influences that affect adversely the survival rates in such efforts.

C. Special considerations

Special consideration application to this project would be :

i) Mitigating the drudgery of poor people specially women and children in rural/tribal areas, in collecting wood; improving their health (cooking on wood has been calculated in certain situations to be equivalent to smoking as many as 24 packets of cigarettes/day) by giving them a smoke-free, reliable and faster alternative for cooking; making available hot water for improving sanitary conditions and; making better use of man power (in fact "women/children power") which is spent in collecting the fuel wood. (Surveys have, for example, indicated that a typical household in Mandi in Himachal Pradesh requires 500 kgs. of fuelwood per month for cooking and heating, for which women travel 6 kms/day and spend 3.7 hrs/day on an average. It has been further estimated that the time spent in fuelwood collection follows an equation namely Y = 21.75 + 2.6 X where Y is the quantity of fuelwood collected in kgs. and X is the time spent in hours. This drudgery increases during monsoons, get complicated when forest guards act tough and becomes expensive when cash is required to purchase this fuel. Alleviating this situation could allow women to pursue some other activities, many of which can be income generating).

The project will help prepare, therefore, a complete implementation package identifying and specifying all hardware as well as software elements.

ii) The biomass so gathered (and pilfered) in the form of logs, twigs etc. does not generally have a price in areas where forests are closer. In semi-urban areas such as block or district headquarters as well as areas where forests are about 10 kms. away, people have to buy at least 60% of their requirement of fuelwood in the form of logs from Government or private depots. In any case, the unfettered use of biomass does have a negative impact in terms of carbon emissions that this project intends to tackle by trying to provide a much more attractive alternative. Involvement of NGOs and village communities in execution, operation and maintenance would be another special consideration.

iii) The project is backed with a shelf of projects of 150 MW of exploitable capacity in India and is, therefore, eminently replicable in the national context. The project's experience will be invaluable in the international context also as the Himalayas directly touch Pakistan, China, Nepal and Bhutan. The lessons of hilly hydro in any case can be applied to any similar region in the world.

iv) The project should lead directly to reduction in deforestation trends in the hilly regions of India. These regions are now experiencing major deforestation and land erosion problems as well as threats to their enormous bio-diversity which result directly from demands for fuelwood. The emission-reduction technology is technically proven and with GEF support would lead to potential benefits for the global environment.

(a) Benefits due to replacement of thermal power

It is estimated that taking the existing Capacity Utilisation Factor (CUF) of small hilly hydro at 0.30 and life as 30 years, the annual carbon saving potential of a typical hilly hydro should be 0.84 tonnes per year per kW, which would translate to 25.23 tonnes per kW for the entire life of the system. The calculations are :

CUF x 8760 x 0.32 kgs. per kW per annum;

where CUF = capacity utilisation factor assumed to be 0.30 in case of small hydro but should, inspite of the seasonal variations in flow, increase to at least 0.60 when the objective of our proposal of allowing people to cook and heat also from the energy from the small hydro is realised.

8760 is the number of total hours available in a year; 0.32 kgs. is the amount of carbon emitted while generating an average kWh of electricity (considering typical thermal plants in India based on such factors as the type of coal used, its ash content etc. and the thermal hydel mix in the country)

The pilot projects proposed would themselves lead to the installation of around 5000 kW capacity in about 20 projects. They should, according to this formula, save at least 4,200 tonnes yearly at 30% CUF, which should hopefully at 60% CUF, with the measures suggested, increase to 8400 tonnes yearly and more, specially if the grid reaches these places.

Since India has a realisable potential of about 3000 MW in hilly small hydro, this sector can be believed to thus represent an enormous potential of reducing carbon emissions by about 2.5 million tonnes annually even at a CUF of 30%.

(b) Benefits due to replacement of fuelwood

Calculations for these are :

$$\text{1 kW electrical installed capacity} = \frac{\text{CUF} \times 8760 \times 860 \times 0.7}{4200 \times 0.12}$$

$$= 3.14 \text{ tonnes} \quad \text{wood / year}$$

where CUF is 0.30 for small hilly hydro;
8760 is the number of hours in a year;
860 is the energy in kilo cal./kwh of electricity used;
0.70 is the efficiency factor of a typical electric heater/cooker;
4200 is the kilo cal. energy/kg. of fuelwood, and
0.12 is the thermal efficiency of a typical wood stove.

This means that the 5000 kW installed capacity in Pilot Project would lead to a saving of 15700 tonnes of fuelwood annually and 3000 MW of realisable potential to 9.42 M. tonnes/annum! Taking carbon @45% for the woody biomass, this would translate to 7065 tonnes of carbon emission avoidance in the Pilot project areas. This being somewhat similar to the figures discussed earlier at prepage confirms the significant potential of this sector in reducing carbon emissions globally.

v) The project may also impact upon the reduction in pollution of waterbodies by reducing migration to urban areas, when enhanced availability of energy in the target regions leads to enhanced employment opportunities. Taking the Advisory Board on Energy's (Government of India) calculations for planning the energy requirements of an Indian by 2004/5 AD for cooking at 620 K.cal. of useful heat/capita/day, heating at 30 K.cal/capita/day and lighting at 30 K.cal/capita/day, each kW of installed capacity of small hydro, even at a CUF of 30%, should meet the energy requirements of 9.11 persons/year. This is 5000 kW would translate to 45,550 persons and for 3000 MW to 27.3 Millions beneficiaries! This would obviously be no mean potential for reducing urban migration.

vi) The project is innovative as it involves undertaking measures in scientifically graded steps and in well selected and fairly representative geographical areas of the hills. It, also for the first time in India, suggests rational use of electrical energy in such ecologically fragile areas for cooking, heating and year round greenhouse functioning purposes and seeks to provide devices and model solutions to make these ideas economically and socially vaible.

vii) The project is of sufficient maturity as it intends to build upon **indigenous industrial capability** as well as almost two centuries of practical experience in handling projects from lowly watermills for grinding wheat to sophisticated projects exploiting an ultra-low head of only 1.5 meters near Delhi!

viii) The project is part of a major thrust area of the Department of Non-Conventional Energy Sources, Government of India for renewable energy development and for environmentally benign development of hydel sources. The Indian Ministry of Environment and Forests too looks upon these small projects, which do not involve any pondage of water or felling or submergence of trees or relocation of people, very favourably.

ix) In the context of the general energy shortage prevailing in India as well as the large dedposits of coal that India has, the project does not have priority in financial terms when compared to the investments already planned and committed for coal-based or nuclear power stations or even large dam based hydro stations. Without GEF funding emphasising the superior global environmental advantages of the current proposal, therefore, the project may not have a very high priority in India's development portfolio.

D. Immediate objective(s), output and activities

Immediate Objective 1

To develop a **master plan** for the optimum utilisation of small hydro resources of the Himalayan & sub-Himalayan regions.

Success Criteria

— the indicative master plan, including a long-term comprehensive development plan and investment strategy, will have been produced by month 10 of the project.

— the final master plan, incorporating the latest data and feasibility studies for high priority schemes, will have been completed by month 16.

— the master plan will have :

— assured available data, plans, development modules regarding commissioned, on-going, abandoned and planned schemes.

— assured alternative resource development schemes;

— formulated, analyzed and ranked potential projects based on national and regional objectives, technical & economic feasibility, socio-economic & environmental impact, initial and recurrent costs, and operation and maintenance complexity for at least three model administrative/water shed areas; e.g. 9000 ft. and above category (low rain fall area), 5000-9000 ft. category (medium rain fall area) and balance 5000 ft category (high rain fall area) e.g. Ladakh/Lahaul Spiti, Almora-Pithoragarh, Arunachal/Meghalaya respectively.

Immediate Objective 2

To install demonstration projects.

Success Criteria

When upto 20 demonstration projects are completed, low wattage cooking, heating and other load development devices are in use in at least 25% households in the project areas and when at least 500 watermills are upgraded.

Immediate Objective 3

To upgrade the capabilities of the DNES and selected project authorities to prepare integrated small hydro development plans and to determine optimal investment promotion policies, regulations, strategies, programmes and implementation arrangements in project areas.

Success Criteria

At least 20 planners will have successfully completed a series of practical training seminars on the fundamentals of integrated small hydro development planning and would have come out with recommendations for changes in policies, strategies and programmes that are perceived to be improvements by the Govt.

DNES and three other project authorities would have upgraded their facilities to the level that they can handle similar projects in future all by themselves.

Immediate Objective 4

To improve laboratory, technical and training capabilities of Alternate Hydro Energy Centre (AHEC), Roorkee and possibly two other regional institutions, one each in the North-Western and North-Eastern regions of India; which will be identified, after establishing the needs of the sector, during the course of the project. The objective is to enable them to provide testing, training, applied research, consultancy and information services to serve the Indian small hydro industry and utilities.

Success Criteria

By the end of the project:

* the AHEC will be able to offer annually a number of certificate or diploma courses of durations one to 12 weeks covering all aspects of small hydro development. Each course will be able to accommodate 20 in-service trainees.
* the other two centres will be able to offer annually two refresher courses on issues pertinent to the regions they are located in.
* The three centres will have model test and design facilities in mechanical, hydraulic and electronic workshops.
* The three centres will have a comprehensive collection of books, journals, reports, manuals, films, working models, computer hardware and software to take care of the applied research and training needs of the small hydro sector in India.
* The three centres together will be able to carry out applied research—at least 1 study per centre annually that responds to industry/utility needs. Research methodology shall be at the standard of professional market research.
* the AHEC will be able to provide problem solving consultancy services and uptodate, useful information in response to needs expressed by the Small Hydro industry and Utilities.

News Flash

Development of Rubber Sheet Inflating/ Deflating DAM

Untapped hydro power resources are often located in mountainous regions. Therefore a need exists toi develop a new type of water intake system requiring less maintenance than systems composed of concrete dams and gates.

Two Japanese firms have accordingly developed rubber dams capable of discharging silt deposition by flushing due to the automatic inflation and deflation of a bag like structure.

The bag structure is comprised of multiple inter woven layers of chloroprene rubber and nylon, which have excellant friction and weather resistance properties — inflation and deflation are controlled automatically.

Study on Alternative to Hydraulic Steel Pipes

To reduce the cost of development of small and intermediate size penstock it is necessary to develop alternatives to the steel pipes in use today.

There is development of a fibreglass reinforced plastic mortar pipe (FRPM pipe) which is lightweight, rustproof, easily installed and does not require painting .The FRPM pipe is composed of glass fibre and plastic mortar. The pipe joint features a seal of styrene-butadiene rubber.

Indian Standard on Small, Mini & Micro Hydro Power Stations

Bureau of Indian Standards has brought out IS 12800 (Part 3)—1991 : Guidelines for Selection of Hydraulic Turbine, Preliminary Dimensing and Layout of Surface Hydroelectric Power Houses Part 3 : Small, Mini & Micro Hydroelectric Power Houses. For copies, readers can contact B I S, Manak Bhawan, 9 Bahadur Shah Zafar Marg, New Delhi-110002.

Small Hydro Projects Taken up by State Govts. with MoNES assistance

S.No.	NAME OF PROJECTS	STATE	UNIT SIZE kW	TOTAL CAPACITY kW	OUTLAY Rs lacs	MoNES SHARE Rs lacs	COMMISSIONING SCHEDULE	PROJECT STATUS
1.	SRIRAM SAGAR	ANDHRA PRADESH	500	1000	225.00	110.00	31/9/92	WORK IN PROGRESS
2.	SRIRAM SAGAR	ANDHRA PRADESH	500	1000	225.00	110.00	31/9/92	— do —
3.	SRIRAM SAGAR	ANDHRA PRADESH	500	1000	225.00	110.00	28/2/93	— do —
4.	CHETTI PETTA	ANDHRA PRADESH	500	1000	276.90	69.00		UNDER OPERATION
5.	MUKTO (TWANG DISTT)	ARUNACHAL	1500	3000	540.00	270.00		SANCTIONED IN MARCH 92
6.	KITPI (TWANG DISTT)	ARUNACHAL	1500	3000	540.00	270.00		—do—
7.	SIDDIP (EAST SIANG)	ARUNACHAL	1000	3000	580.00	290.00		—do—
8.	SIPPIT (EAST SIANG)	ARUNACHAL	1000	2000	460.00	230.00		—do—
9.	LIROMOBA (WEST SIANG)	ARUNACHAL	1000	2000	460.00	230.00		—do—
10.	KAKROI	HARYANA	100	300	141.00	119.00		TWO UNITS UNDER OPERATION
11.	JUBBAL	H.P.	150	150	30.64	30.64		UNDER OPERATION
12.	MANALI	H.P.	100	200	57.56	57.56		UNDEDR OPERATION
13.	SATPURA	M.P.	500	1000	247.50	118.80	31/3/93	CIVIL WORK UNDER PROGRESS/E&M EQUP. AT SITE
14.	CHARGAON JATALAPUR	M.P.	800	800	262.98	1.15*	31/3/93	CIVIL WORKS IN PROGRESS
15.	CHAMBAL	M.P.	600	1800	668.27	26.10*	31/3/93	CIVIL WORKS FOR PH COMP/DIVERSION WORKS IN PROGRESS
16.	BHIM GARH	M.P.	1200	2400	559.95	2.06*	31/3/93	CIVIL WORKS UNDER PROGRESS/E&M EQIP. INSPECTED
17.	KORBA	M.P.	800	800	236.88	—*	Oct. 92	CIVIL WORKS UNDER PROGRESS/E&M EQUIPMENT RECIEVED
18.	TILWARA	M.P.	250	250	106.31	—*	31/3/93	CIVIL WORKS UNDER PROGRESS
19.	BARBORIA	ORISSA	325	650	193.00	96.58	31/3/93	CIVIL WORKS INITIATED/EQUP AT SITE
20.	KENDUPATANA	ORISSA	250	500	180.00	90.00	31/10/92	—do—
21.	ANDHARI BANGI	ORISSA	325	325	77.18	19.30	31/4/93	SANCTIONED IN MARCH '92
22.	HARBHANGI	ORISSA	1000	1000	366.10	91.53	30/6/93	—do—
23.	POTTERU STAGE I	ORISSA	3000	3000	407.09	101.77	31/12/93	—do—
24.	POTTERU STAGE II	ORISSA	3000	3000	420.09	105.22	28/2/94	—do—
25.	BIRIBATI	ORISSA	325	650	180.00	45.00	31/12/92	—do—
26.	BADNALA	ORISSA	325	650	140.30	35.06	31/12/92	—do—
27.	KARMI	U.P.	50	50	22.00	11.00	31/10/93	SANCTIONED IN MARCH '92
28.	BAGAR	U.P.	50	50	22.50	11.25	31/10/93	—do—
29.	LATHI	U.P.	50	100	40.00	20.00	31/10/93	—do—
30.	SANGAD	U.P.	50	50	21.20	10.60	31/10/93	—do—
31.	BAHADRABAD	U.P.	125	250	63.47	33.47		RE-TENEDERS WILL BE INVITED
32.	BILKOT	U.P.	50	50	40.00	15.83		UNDER OPERATION
33.	KHET	U.P.	50	100	49.48	21.00		—do—
34.	NAINI	U.P.	50	50	39.96	13.52		—do—
	Total			35,175	8105.36	2765.44		

* These figures depict interest subsidy @ 7% released by MoNES for loans financed by IREDA.

Manufacturers of Small Hydropower Equipments

MANUFACTURER	HEAD Range (m)	TYPE OF TURBINE	TYPE OF GENERATOR	RATING (kW)	SCOPE OF SUPPLY
Beacon Neyrpic Ltd. 39, Industrial Estate (North) Ambattur Madras-600098 Phone: 655391, 651541 Telex: 041-22071 Fax: (044) 456223 Gram: CROMBEST	2 — 6 6 — 30 10 — 200 100 — 1000	Siphon Kaplan Francis Pelton	N/A	N/A	Turbine
Bharat Heavy Electricals Ltd. Piplani, Bhopal-462022 Phone: 546100, 540200 Telex: 0705264, 265 Fax: (0755) 540425 Gram: BHARATELEC	3 — 16 150 — 500 4 16 — 25 45 — 180	S type tubular V Pelton Bulb V Kaplan H Francis	Induction Synchronous	upto 3000 & Above	Turbine, Generator, Gear Box, Control Panels
Boving Fouress (P) Ltd. Plot No. 7, KIADB Industrial Area, P.B. 11, Hoskote Bangalore-562114 Phone: 263/455 Telex: 0845-5086 Fax: (0812) 395176 Gram: FOURESSCOP	upto 30 upto 30 20 — 300 Above 200	Full Kaplan Semi Kaplan Francis Pelton	Induction Synchronous	1000 Above 1000	T.G. Unit, Complete E+M equipments for turnkey execution
Crompton Greeves 1, Dr. V.B. Gandhi Marg, Bombay-400023		—	N/A	N/A	Generators
Cegelac India Ltd. A-21-24, Sector-16 Electronic Nagar Noida-201 301 Phone: 89-20385, 89-20425 Telex: 03171118 HOPE-IN Fax: (011) 8920405		—	—	—	Automation of S.H. Plants
Flovel Pvt. Ltd. A-219, Okhla Industrial Area, Phase-I, New Delhi-110020 Phone: 6816036, 6813587 Telex: 031-75100 FLOV-IN Gram: FLOVIN	2 — 20 3 — 10 15 — 300 90 — 400	Tubular/Pit Francis Open Flume Francis Pelton	—	—	Turbine, Gearbox
Jyoti Ltd. Industrial Area, P.O. Chemical Industries Vadodra-390003 Phone: 320041, 321038 Telex: 0175-214 JN IN Fax: (0265) 320766 Gram: PROJYOTI	2 — 25 2.5 — 30 45 — 180 50 — 200 100 — 400	Tubular Kaplan Francis Turgo-impulse Pelton	Induction Synchronus	upto 50 upto 3000 & above	Turbine, Generator, Control Panel, BF valve

N/A — Information not available (—) — Not manufactured

Manufacturers of Small Hydropower Equipments

MANUFACTURER	HEAD Range (m)	TYPE OF TURBINE	TYPE OF GENERATOR	RATING (kW)	SCOPE OF SUPPLY
Kirloskar Elec Co. Ltd. III Floor, Kundan House 16, Nehru Place, New Delhi-110019 Phone: 6436576 Telex: 031-63180 KEC-IN Gram: RAVIUDAYA		—	Induction Synchronous	upto 100 upto 1500	Generator, Control Panel
Larsen & Toubro Ltd. 1B, Park Plaza, 71, Park Street Calcutta-700016 Phone: 293251, 295568 Telex: 4821, 5306 Fax: (033) 295534 Gram: UTMAPLANT	upto 10 3 — 10 5 — 25 26 — 200 200 — 400	Pier type Francis open flume S — Turbines Francis (spiral casing) Pelton double jet	N/A	N/A	Turbine
NGEF LTD. P. Box No. 3876 Old Madras Road By appanahalli, Bangalore-560 038 Telex: 0845-2210/8057 Gram: ENGEF		—	Induction Synchronous	upto 300 55 to 1600	Generators
Punjab Power Generating Machines Ltd. SCO 108-109, Sector 8-C Chandigarh-160018 Phone: 29025, 42782 Telex: 395-484 PPJM IN Fax: 0172-32826 Gram: PUNPOWER	3 — 25 5 — 200 100 — 400	Tubular Francis Pelton	Induction Synchronus	upto 3000	Turbine Generator, Gear Box, Complete E+M works for turnkey execution
Steel Industrials Kerala Ltd. Silk Nagar, Athani P.O. Mulamgunnathukavu Thrissur (Kerala)-680771 Phone: (048795) 335, 380 Telex: 0887-258 SILK-IN Fax: (0487) 40511-PCO Gram: SILKATHANI	1 — 30 10 — 300 80 & above (up to 100 kW demo units)	Kaplan Francis Pelton Cross-flow	Induction Synchronus	upto 1000 upto 3000 & above	Turbine, Generator, Gear Box, Control Panels and turnkey execution
The Triveni Engg. Works Ltd. D-196, Okhla Industrial Area, Phase-I, New Delhi-110020 Phone: 6811878 Telex: 031-75154 PAE-IN Fax: (011) 6812280, 3310117 Gram: TEWPEDCO	1.8 — 5 5 — 8 10 — 130 5 — 15	Kaplan with Syphon intake Bulb Francis Pressurised Vertical Kaplan	Induction Synchronus	50 — 1500 200 — 3000	Turbine, Generator Gear Box, Control Panels and turnekey execution.

N/A — Information not available (—) — Not manufactured

DETAILS OF PROJECT

1. EASTERN GANDAK CANAL H.E.P.
2. TRIVENI LINK CANAL H.E.P.
3. EASTERN GANDAK COMBINING FALLS BETWEEN R.D. 43.00 AND 65.50
4. BY COMBINING BETWEEN RD 79.00 AND 890
5. BY COMBINING FALL BETWEEN RD 240.50 AND 247.30
6. FALL AT RD 311.5
7. RAIPUR H.E.P.
8. SIWAN BRANCH CANAL AT OFF TAKE FROM SARAN CANAL AT RD 900 SONE CANAL SYSTEM
9. DUDHAR
10. ARANG
11. JAINAGARA
12. SIRKHINDA
13. AMAITHI
14. RAMPUR
15. NATWAR
16. GUNSAI
17. CHUROITI
18. SIKRAUL
19. BHAKAWA
20. PARARAHA
21. DHAWANI
22. DHELA BAG
23. NASARIGANJ
24. PAHARAWAN
25. SAWARI
26. HARPUR
27. CHAURI
28. DILLIA
29. PAWNA
30. SAKHANA LOCK
31. DEHRA
32. TEJPURA
33. SIPHA
34. AGNOOR
35. BELSAR
36. BALIDAD
37. ARWAL
38. MAHABALIPUR
39. KADHAWAN H.E.P.
40. SONE WESTERN H.E. PROJECT
41. SONE EASTERN CANAL H.E.P.
42. UPPER SAKARI SCHEME
43. TILAIYA DHADHAR H.E. PROJECT
44. BAGODAR H.E.P.
45. BARNAR RESERVOIR L.B.C. H.E.P.
46. R.B. CANAL H.E.P.
47. HARKATTAJORE H.E. PROJECT
48. JHAJHWA H.E.P.
49. SENAKATAN H.E.P.
50. LOHA TAWBA H.E.P.

DETAILS OF PROJECT

51. KANHAR H.E.P.
52. NORTH KOEL H.E.P.
53. RIGHT CANAL H.E.P.
54. RIGHT CANAL H.E.P.
55. BURHAGHAGH
56. PARAS H.E.P.
57. KANS H.E.P.
58. PARAS H.E.P.
59. TENU BOKARO CANAL H.E.P.
60. SANKH STAGE I
61. SANKH STAGE II
62. SANKH STAGE III
63. SANKH STAGE IV
64. SANKH STAGE V
65. NORTH KARO H.E.P.
66. SOUTH KARO H.E.P.
67. HIRANI H.E.P.
68. CHANDIL DAM H.E.P.
69. KITANALA H.E.P.
70. KHARKAI DAM TOE RIVER BED
71. K. DAM L.B. H.E.P.
72. K. DAM R.B. H.E.P.
73. GALUDIH BARRAGE
74. DIMNA SAT NALA H.E.P. SUBERNAREHNA
75. LEFT CANAL
76. LEFT CANAL
77. LEFT CANAL
78. MUHANE H.E.P.

Source:- Bihar State Hydroelectric Power Corp. Ltd)

SUGGESTED READINGS

Journals :

1.	International Water Power & Dam Construction	Monthly	Quadrant House, The Quadrant, Sutton, Surrey, SM2 5 AS, U.K.
2.	Hydro Review	Monthly	HCI Publication, 410 Archibald St., Kansas city, MO64111-9899, USA
3.	Irrigation & Power Journal	Bi-monthly	Central Board of Irrgation & Power, Malchha Marg, Chanakya Puri, New Delhi-21
4.	American Society of Civil Engrs. 1) Energy Division 2) Water resources planning 3) Hydraulics Division	Monthly	American Society of Civil Engineers, United Engg. Centre, 345 East 47th Street, New York, NY 10017-2398
5.	Indian Journal of Power and River Valley Projects	Monthly	Books & Journals Pvt. Ltd. 6/2 Madan Street, Calcutta-700072
6.	'Hydro Plus' (in French with Abstract (in English)	Monthly	Magazine International de l'Eau 13, Pue St-Florentin 75008 Paris
7.	Small hydro power' News, newsletter	Quaterly	Hangzhou Regional Centre (Asia Pacific) for Small Hydro Power, P.O. Box 1206, Hangzhou, China
8.	Hydronet	Tri-annually	Reinhold Metzler, Stephan Blatlmann, Str 11, D7743 Furtwagen, Germany

Conference-Proceedings

1.	"International Conference on Small Hydro"	Every 2 yrs. since 1984	Organised by "International Water Power & Dam Construction", Surrey, U.K.
2.	"Water Power"	Every 2 yrs.	Organised by "American Society of Civil Engineers" and US Bureau of Reclaimation, USA
3.	National Seminar on Small Hydro	—	Organised by "Central Board of Irrigation & Power" New Delhi Jan 1983.

Books/Reference Reports

(i)	"Micro Hydro Power Source Book	J.R. Inversin	NRECA, USA 1986.
(ii)	"Small Mini Hydro Power Structures	Fritz	McGraw Hills
(iii)	"Handbook on Hydro Electric Engg."	P.S. Nigam	Nem Chand & Bros., Roorkee
(iv)	"Hydro Power Engg. Hand Book"	Gulliver and Arndt	McGraw Hills
(v)	Hydro Electric Engg. Practice (3 vols)	J. Guthrie Brown	CBS Publishers & Distributors Delhi
(vi)	Water Power Development Vol. 1 — Low Head Power Plants	Emil Mosoyni	Hungarian Academy of Science Akademiai Kiado, Budapest
(vii)	IS 12800 : (Part 3)—1991 Guidelines for Selection of Hydraulic Turbine, Preliminary Dimensioning and Layout of Surface Hydro Electric Power houses Part 3 : Small, Mini & Micro Hydroelectric Power Houses.		Bureau of Indian Standard Manak Bhawan, 9 Bahadur Shah Zafar Marg, New Delhi-110002
(viii)	Small Hydro Standardisation (Publication No. 175)		Central Board of Irrigation and Power, New Delhi-110016
(ix)	Micro Hydropower Information Package		SKAT Tigerberg Str 2, CH-9000 St. Gallen, Switzerland
(x)	Micro Hydropower Handbook (2 Vols)	McKinney	U.S. Deptt. of Energy (Jan 1983)
(xi)	Small & Micro Hydro-electric Power Plants, Technology & Feasibility	Noyes R	—
(xii)	Simplified Methodology for Economic Screening of Potential Low Head, Small Capacity Hydroelectric sites		Todor Engg., USA (Jan 1980)
(xiii)	Feasibility Studies for Small Scale Hydropower Additions — A Guide Manual		US Army Corps of Engineers (July 1979)
(xiv)	Hydropower Cost Estimating Manual		US Army Corps of Engineers (June 1979)
(xv)	Reconnaissance Evaluation of Small Low Head Hydroelectric Installations		U.S. Deptt. of Interior (1979)
(xvi)	Hydropower Engg.	Warnick C.C.	Prentice Hall/Vol (1984)
(xvii)	Hydropower : The Design Use and Function of Hydromechanical Hydraulic and Electrical Equipment	Raabe J.	VCI Varlag Dussldorf (1985)
(xviii)	Guidelines for Development of Small Hydro-electric Schemes		Central Electricity Authority, Govt. of India (1982)
(xix)	Hydroelectric Handbook	Creager & Justin	John Wiley & Sones Inc.

State Nodal Agencies Implementing Small Hydro Projects

ANDAMAN & NICOBAR ISLANDS

Chief Engineer
PWD
A & N Admn. Portblair
Phone : 21215
Gram : PRINGENGO

Superintending Engineer
Elect. Deptt.
A & N Admn. Portblair
Tel. : 21365

ANDHRA PRADESH

Principal Secy. (Energy & Environment)
Govt. of Andhra Pradesh
Hyderabad
Tel. : 235452

Chief Engr. (Projects)
APSEB, Vidyut Soudha
Hyderabad-500049
Tel. : 223528
Telex : 0425-631 APEB-IN
Fax : (0842) 33317
Gram : APSE BOARD

ARUNACHAL PRADESH

Commissioner Power
Deptt. of Power
Govt. of Arunachal Pradesh
Itanagar

Chief Engineer
Deptt. of Power
Govt. of A.P.
Itanagar-791111
Tel. : 2536
Gram : CHIEFPOWER

Chief Engineer
Rural Works Deptt.
P.B. 108
Govt. of A.P.
Itanagar-791111
Tel. : 2525
Gram : RURALWORKS

ASSAM

Secretary
Deptt. of Power
Narengi
Guwahati
Tel. : 61402

Member (Generation)
ASEB, Paltan Bazar
Guwahati-781001
Tel. : 40880

BIHAR

Secretary
Department of Energy
Govt. of Bihar
Patna-800001
Tel. : 225412

Director (Tech.)
BSHEP Corporation
2nd Floor, Sone Bhawan
Birchand Patel Marg
Patna-80001
Tel. : 224069
Gram : Hydel
Fax : (0612) 220651

GOA

Secretary (Power)
Govt. of Goa
Panji-403101

C.E. (Electrical)
Electricity Deptt.
Vidyut Bhawan, 3rd Floor
Panji-403101

GUJARAT

Deputy Secretary (Power)
4th Floor, Block No. 5
New Sachivalaya
Gandhi Nagar
Tel. : 20343

Chief Engr. (Civil)
GEB, Vidyut Bhawan
Race Course
Vadodara-390007
Tel. : 328784
Gram : GUJELBOARD
Telex : VIYUTBRD-2647
Fax : 0265-324018

HARYANA

Commissioner & Secy.
Govt. of Haryana, Chandigarh

Chief Engr. (Hydel)
HSEB, Govindpuri
Yamuna Nagar
Tel. : 25658

HIMACHAL PRADESH

Secretary (Power)
HP Secretariat, Shimla
Tel. : 77176

Chief Engr. (Plg.)
HPSEB, Vidyut Bhawan
Shimla-171004
Tel. : 5007

J & K

Commissioner & Secy.
Power Development Deptt.
Govt. of J & K
Srinagar/Jammu
Tel. : 30301/46206

M.D.
Power Dev. Corp.
Raj Bagh, Near Convent School, Srinagar-190001

KARNATAKA

Commissioner & Secy.
Deptt. of Energy
M.S. Building
Bangalore-560001
Tel. : 262373

C.E. (P & RES)
Karnataka Power Corporation Ltd.
116/2, 1st Floor, Trade Centre
Race Course Road
Bangalore-560001
Tel. : 268431
Gram : MYPOWER
Telex : 0845-2687 MYPC
Fax : (0812) 262144

KERALA

Commissioner & Secy
Power Deptt.
Govt. of Kerala
Trivandrum
Tel. : 67495

Chief Engineer (Civil)
(Planning & R)
Kerala SEB
Vidyuthi Bhawanam
Trivandrum-695004
Tel. : 78834
Gram : ELEBOARD
Telex : 435-361 KSEB IN
Fax : (0471) 78246

MADHYA PRADESH

Officer on Spl. Duty
Energy Deptt.
Govt. of Madhya Pradesh
Bhopal
Tel. : 546010

C.E. (Civil) S & I
MPEB
P.B. 34 Rampur
Jabalpur-482008
Tel. : 311104-11 Ext. 2892
Gram : ELECBOARD
Telex : 0765-209, 267 MPEB-IN

○ State Government ● Implementing Agency

State Nodal Agencies Implementing Small Hydro Projects

MAHARASHTRA

Secretary
4th Floor Room No. 401
Mantralaya, Bombay-400032
Tel. : 2026767

C.E. (Hydro Project)
Irrigation Deptt.
Hongkong Bank Building
4th Floor M.G. Road
Fort, Bombay-400023

MANIPUR

Commissioner (Power)
Govt. of Manipur, Imphal
Manipur

C.E. (Power)
Electricity Deptt.
Hydro Electric Investigation
Circle, Govt. of Manipur
Imphal-795001
Tel. : 20050

C.E. (NEC Projects)
Irrigation & Flood Control
Deptt., Govt. of Manipur
Khuyathong, Imphal-795001
Tel. : 20824

MEGHALAYA

Secretary (Power)
Govt. of Meghalaya
Shillong

C.E.
MSEB
Upper Lachumiere
Shillong-793001
Tel. : 23406

MIZORAM

Secretary (Power)
Govt. of Mizoram, Aizwal
Mizoram
Tel. : 3371

Chief Engineer (P)
Electrical Deptt. Mizoram
Aizwal-796001
Tel. : 2848

NAGALAND

Addl. Secretary
Deptt. of Power
Govt. of Nagaland, Kohima

S.E.
Deptt. of Power
Govt. of Nagaland, Kohima

ORISSA

Chief Engineer (Plg. & Dev.)
OSEB Room No. 10
Tech. Wing, Saheed Nagar
Bhubaneshwar-751007
Tel. : 50687

MD
Orissa Power Generation
Corp. Ltd.
Alok Bharti Complex
6th Floor Shaheed Nagar
Bhubaneshwar-751007
Tel. : 55782, 57528
Gram : OPIGICI
Telex : 0675-358 OPGC-IN

PUNJAB

Secretary (I & P)
Govt. of Punjab
Chandigarh

Engr.-in-Chief/M & MHP
PSEB
F-1 Shakti Vihar
Patiala-147002
Tel. : 73634
Telex : 0394-203 PSEB IN

RAJASTHAN

Dy. Secretary
Govt. Sectt. Energy Deptt.
Bhagwan Das Road, Jaipur
Tel. : 520866

Chief Engineer (Mini Hydel)
RSEB, Old Power House
Jaipur-302006
Tel. : 65392
Gram : MINIHYDEL

SIKKIM

Secretary (Power)
Govt. of Sikkim, Gangtok
Tel. : 22244

Add. Chief Engineer
Power Deptt.
Govt. of Sikkim
Gangtok-737101
Tel. : 22927
Telex : 0264-202

TAMILNADU

Commissioner & Secy. (PWD)
Govt. of Tamil Nadu
Fort, St. George
Secretariat, Madras
Tel. : 561622

Chief Engineer (Planning)
TNEB, 800, Anna Salai
Madras-600002
Tel. : 831208
Telex : 041-7261 TNEB

TRIPURA

Secretary (Power)
Govt. of Tripura
Govt. Secretariat, Agartala

C.E. (Electrical)
Deptt. of Power
Agartala

UTTAR PRADESH

Secretary (Power)
Govt. of U.P.
Lucknow-226001

MD
UPLJV Nigam Ltd.
12th Floor, Vikash Deep
22 Station Road
Lucknow-226019
Tel. : 243819, 246904

S.E. (Micro Hydel)
NEDA
B-46 Mahanagar Extension
Lucknow-226006
Tel. : 73975
Gram : NEDA
Telex : 0535-245, NEDA IN
Fax : 0522-245 455

WEST BENGAL

Secretary (Power)
K.S. Roy Road
GOWB, Calcutta

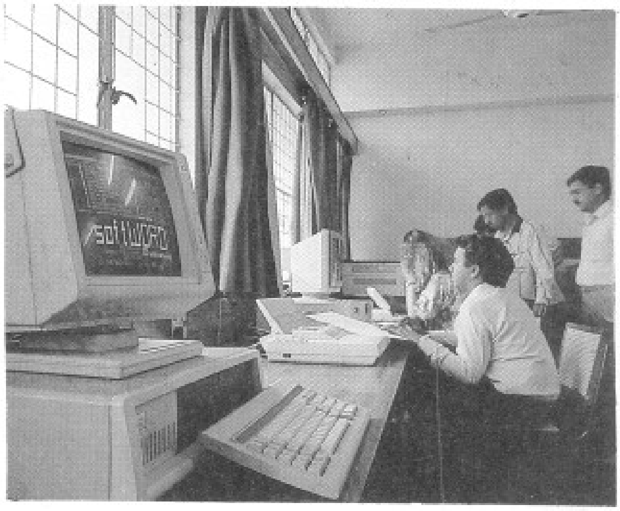
C.E. (Hydel)
WBSEB
Vidyut Bhavan
Salt Lake
City
Calcutta-700091
Tel. : 373006

○ State Government ● Implementing Agency

ALTERNATE HYDRO ENERGY CENTRE
UNIVERSITY OF ROORKEE, ROORKEE

Established in the Year 1982, it has:

* Developed cost-effective and efficient small hydro power systems and integrated power generation systems
* Set up three Natioinal Demonstration projects at:
  —Jubbal (1x100+2x25 kW) high head
  —Manali (2x100 kW) medium head
  —Kakroi (3x100 kW) ultra low head
* Served on national committees as member
  —Technical Advisory Committee of DNES
  —Hydro Electric Power House Structures Sectional Committee RVD 15.4. Prepared the first draft and finalised version of Indian Standard no. 12800 (Part 3): 1991 on small, mini & micro hydro electric power houses.
  —Working group for preparing 8th Plan draft proposal on mini hydel.
* Made several notable achievements for small hydro systems and bio mass energy eg.:
  —Use of governorless turbines
  —Development of electronic controller
  —Application of pump as turbine
  —Development of bio-mass gasifier
  —Operation of diesel engines wholly on producer gas
  —Replacement of cattle dung by agricultural waste in bio-gas plants.
* Aided research & development, through:
  —Pilot testing of bio-mass gasifiers
  —Development of hydraulic air compressor



  —Study & design of pump as turbine
  —Development of velocity head turbine
  —Establishment of rural energy complex village
  —Improved gharats/water mills
  —Cross flow turbines
* Served as technical consultant to the various central/state agencies on:
  —Preparation of Standard type designs and technical specifications for ICB on proposed World Bank Aid Small Hydro Projects
  —Preparation of detailed project reports for small hydro power stations
  —Solar thermal power stations
  —Bio-gas & bio-mass systems
  —Planning, design and erection of small hydro stations
  —Improved gharats
  —Cross flow turbines
  —Integrated energy systems
* Conducted short term training programmes on Small Hydro and Renewable Sources of Energy.
* Established data bank on small hydro at AHEC
* State bank chair in appropriate energy technology of rural development
* Centre for Hydro Energy set up at AHEC by MHRD
* Establishing Management Information System (MIS) on mini hydel between MoNES & AHEC
* Providing technical inputs on small hydro to state & national Organizations.
* Environmental Impact Assessment of Hydro Projects
* Environmental Energy auditing of mills, factories.