MINI HYDRO POWER

Proposed Eighth Plan Implementation Programme

Vol. 1

सत्यमेव जयते

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MINISTRY OF ENERGY
DEPARTMENT OF NON CONVENTIONAL ENERGY SOURCES
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FOREWORD

In India the development of small hydro and other renewable sources with rather modest potential of each is taking place in a somewhat peculiar environment. Electricity generation and distribution network is facing problems of insufficient peaking capability, very high T & D losses and insufficient scope for load management. The above problems are typical of a system with heavy reliance on large, centralised projects. When combined with the cost and time overruns of specially large hydro projects, acute prower shortage of as much as 20,000 MW is likely to be faced at the end of Eighth Plan. It is being felt strongly that unless the system distortions viz. thermal-hydel mix, insufficient dispersed generation are removed, sanctioning of additional capacity can be counter productive. Small hydro with an estimated* potential of 5000 MW, with its dispersed nature and short gestation period deserves greater attention, than has been the case so far. Integeration of other renewable sources viz. solar, wind, agricultural and human waste is being attempted world over to design environmentally clean electricity generation and distribution networks.

Footnote

* Small hydro potential estimated as a percentage of the total large hydro potential is likely to be a gross under estimation

In an anxiety to serve about 2/3rd of India's population spread in more than 5 lakh villages, the present electricity generation and distribution system has been stretched beyond its capacity. Load shedding of 10-12 hours in the rural areas is a reality. Small hydro sources located on canal falls, directly feeding into the distribution network, because of their dispersed nature, are ideally suited to augment the electricity network, at the rural end. Substantial cost reduction would be possible if new canals are designed with the twin objective of irrigation and power generation.

When integrated with other renewable sources such as biomass, solar, wind etc., there is a distinct possibility of designing self contained, decentralised systems for rural areas, to further relieve the National Grid. Reduction in Transmission and Distribution losses, as a square of the small hydro installed capacity would be a bonus.

It may not be out of context to mention that a similar exercise is possible by recycling of waste to relieve the National Grid of stretching into semi-urban areas.

The development of small hydro potential in the hills, however, has a different role. Far away from the electricity network in inaccessible locations, requiring small amounts of power, with accelerated erosion of fuel yield from forests.

hardships are increasing. In such areas, it would be necessary to lay local low voltage grids, to integrate all possible small hydro sites in the area, to even out short term fluctuations in the demand and supply. There may still be a need to augment the network with a conventional source, such as diesel, to meet the peak demands.

In the past, the CEA was the sole authority for technical and financial scrutiny and approval of all power projects, including micro/mini/small hydel projects proposed by SEBs. Small hydros, by their very nature, are dispersed projects. Thus a very large number of sites yield comparatively less by way of megawatts of installed capacity. Big projects attracted more time, more personnel, more capital and more attention. Not enough attention has thus been paid to the development of an indigenous manufacturing infrastructure, upgradation of technology and even cost-effective designs of micro/mini hydel projects. With the result that performance never looked up and interest generally waned.

Further more, the inordinately long time taken to clear projects proposed by SEBs led to rapid dimunition of interest amongst the latter, particularly as no Central funding was available as an incentive. A move towards decentralization viz., the decision that mini hydel projects with capital cost less than Rs. 5 crores need not be referred to CEA, did not yield the desired results largely because the SEBs themselves, in the absence of any Central financial incentive and operating within the same big project bias, could not dedicate themselves successfully to the implementation of mini/micro/small hydel concept and implementation there of.

The DNES has been, over the last 20 months, interacting closely with a number of SEBs to ascertain why SEBs are reticent about undertaking such projects. Some of the reasons often stated before are :-

i) higher capital cost, on per MW installed basis;

ii) relatively low PLF and high managerial and administrative costs on per KW installed basis;

iii) the dispersed nature of the projects requiring a very large number of personnel to prepare even the feasibility reports and DPRs, again for relatively low gains in terms of MWs yielded.

It would be seen, from a closer scrutiny of these arguments that the same large project bias underlies these stated reasons. It has further been compounded by the prementioned factors of inadequate attention to improving technologies, designs and outputs of both the projects in general and the equipment in particular.

Thus, there is every reason to ensure that a clear break is made from this regressive situation. The design and implementation practices that prevail in respect of large hydros, are dimetrically opposite and have to be discarded in regard to planning micro/mii/small hydels. For example, every large hydro is a "unique" project linked with a storage system. Whereas for the small/mini/micro hydros which are essentially "Run of the River" uniqueness has to be eschewed to provide standardisation and economy of scale, in production and maintenance. This is vital if gererating costs are to be reduced to acceptable levels.

The DNES and its AHEC located at Roorkee University have in a short span of time, been able to gain fairly deep insight into the whole range of activities connected with the micro/mini/small hydro projects. DNES has been able to gear up the R&D activity, to provide greater direction and ensure postive and quicker results. The functioning of AHEC has been reorganised sectorally and activity has been stepped up. Further, experts from France, Sweden, US, China, UK and the EEC have interacted closely with scientists and technical personnel from DNES/AHEC in order to get a hold on improvements/upgradation of technologies of design and equipment. Demonstration schemes have been revitalised and projects at Jubbal (150 KW) with high head (80 m); Manali (200 KW) with medium head (40m) and Kakroi (300 KW) with ultra-low head (1.8 m) have been set up.

Significant results in cost-reduction are being achieved. For instance, using the guidelines issued by CEA, the Karnataka Govt. is executing projects at an exorbitantly high cost, ranging from Rs. 49000/KW to Rs. 85000/KW installed. At such prices, the whole mini hydel activity is likely to be slow. Focussing on innovative designs of civil structures, new and high efficiency designs of equipment and improving concepts such as multiple orders on identical sites to facilitate volume production of identical equipment. Using this strategy, turnkey contractors have expressed willingness to instal high performance turbines on a turukey basis at Rs. 25000/KW installed at canal falls of about 3 M head. For higher heads and flows, the costs would be lower.

Similarly, DNES, in consultation with experts and machine manufacturers, is looking at recurring costs, such as manpower and maintenance requirements, in an attempt to minimise these without detriment to high yield operations. Automation and microporcessor controls that are robust in construction are being discussed with well-known international designers and manufacturers. In relation to the relatively small budgetary allocation available, the results achieved so far have been significant.

It must be appreciated that like all other renewable energy sources, mini/micro hydels should not really be considered as 'stand alone' systems. Thus, there is every reason to regard these as part of the renewable energy scene, rather than clubbing these with large hydros as independent 'stand alone' power sources. They can be best handled as other decentralised renewable energy systems such as wind solar biomass etc. Infact the mini & micro hydels can often be handled as integrated systems along with local biomass, wind & solar sources. Thus, from the stage of investigation, through equipment selection, standardisation, operation and upto maintenance, etc., small hydros require a special developmental outlook, special training of operators and dedication to the cause of making these cost-effective and reliable. DNES is already well-ahead on this path and will be successful in its endeavours having recently been given the responsibility for micro/mini hydel schemes upto 3 MW.

Commodore Narinder Singh
Adviser, DNES

EXECUTIVE SUMMARY

1. DNES constituted a subgroup on micro/mini hydel vide letter No.1/18/88-PLG (Refer Vol II for details). The first meeting of the group was held on 13.01.1989 at New Delhi followed by another meeting on 27.01.1989 at Roorkee. Subsequently regional meeting of the sub - group were held at Gauhati (8.2.89), Hyderabad (10.2.89) and Bombay (23.2.89). The enclosed report is the outcome of the deliberations held at these places. The Subgroup had the benefits of advice from Cdr. Narinder Singh, Adviser, DNES.

2. It is well recognised that the exploitation of conventional sources of energy viz. large hydro, coal and oil in thermal power plant and nuclear energy is fraught with grave risks to environment, and an irritrievable erosion to the life supporting capability of earth has already set in . The energy plans for so called "development" in the developed countries include measures to improve existing energy generation systems, energy conservation and the use of non-conventional renewable energy sources. There is a distinct trend to discourage installation of additional capacity with conventional sources . Not many pressing reasons have come to light to deviate from the above scheme of development in India.

3. It has also been recognised world over that pronounced variability with time and the dispersed nature of the renewable resources are the main

factors which demand a special design effort. It is virtually impossible to design economically viable stand alone energy system with a single resource. This is precisely the reason that community biogas plants, small hydro units for remote hilly areas,wind turbine operated pumps for irrigation, solar powered street lights with battery back up are not finding greater acceptance not withstanding considerable efforts in the form of money, manpower and R&D work. Based on a critical evaluation of the existing programmes and a global literature survey, a fresh R & D programme as a fore runner of the extension work in renewable energy area has every chance of succes.

4. In the case of mini-micro hydro generating systems, the Alternate Hydro Energy Centre has gained a deeper insight into their investigation, design, execution and monitoring activities based on the literature survey and the experience gained on National Demonstration Projects, followed by analysis of the results. It is the peculiar nature of the resource, which demands a complete break from the design practices of large hydro projects. Any guidelines issued for the construction of mini- micro hydel projects should have enough flexibility to implement cost saving measure. As any major repair of the plant during its operation can be a financial catastrophe, strict quality control during the construction stage becomes manadatory by encouraging local participation. The Alternate Hydro Energy Centre is compiling a Technical Document as a guideline for implementation of small hydro programme.

5. It is firmly established that the cost reduction strategy of using

" governorless turbines", generally followed during the Seventh Plan has to be discarded. The mini/micro hydel units can be made economically viable, only by operating them in the "maximum energy generation'' mode. In fact it may be appropriate to set cost standards in terms of unit generation cost. In the light of above observation, small hydro units would find application in the following three distinctly different environments:-

(i) In the electrified areas to augment the sub-transmission and distribution network.

(ii) In the remote areas , particularly in the hilly regions where local low voltage grid can be envisaged as a long term measure . Initially, the local grid may be working in the isolated mode, if it is far away from electrified area.

(iii) Multi-purpose gharats to serve the localised energy needs , which includes lighting,the rice hulling, oil extraction etc.

6. Small hydro units because of their small size can be connected to a large system only at the sub-transmission or distribution level. The widespread connection of small hydro units in the above manner, which would be converting single source feeder into multi-source feeders, and the associated

problems of integration with a large network, need careful examination at the feasibility stage itself.

The "grid operation" of small hydro units relieves them of the requirment of load - frequency control, thereby simplifying turbine governor. There is also a possibility to use Induction Generators in this arrangement.

7. Small hydro units connected to local grids operating in isolated mode, would need either a storage device, or a "schedulable" generation source connected on the same grid to meet the peak power demands. In addition some units, totalling at least 25% of the total grid capacity may have to be on load-frequency control duty. While planning Local Utility Grids, the possibility of electricity generation from renewable sources may also be explored.

8. There is a distinct scope in the remote rural and hilly areas for multi-purpose power units, largely made with local material and local expertise to satisfy a variety of energy needs of a locality.

9. Considering the fact that the availability of grid supply would be crucial for the economic viability of small hydro projects, the co-ordinating agency would be required to bring

necessary legislation, on urgent basis, on the pattern of PRRPa Act of 1979 in U.S.A., for speedy grant of power generation licences to the state agencies and private enterpreneurs, and also for quick transfer of land.

10. Unlike China, whose small hydro programme is 36 years old, in India, the small hydro manufacturing base has remained weak under the shadow of the more attractive large hydro and thermal sector. In addition, the trend world over on Small Hydro Fluid Machinery is for exhaustive R & D on improved and new designs of machines.

Unless there is an active participation from the manufacturers in the Research & Development and technology transfer programmes, with institutions like AHEC, which are having both the academic and field experience, low cost and efficient machines would not become available for the Small Hydro programme.

11. Special nature of small hydro project design, completely different in character from large project design, is by itself a very strong reason that Design Methodologies have to be developed specially suited for small hydro projects. Standardisation of design wherever possible will be very helpful and Computer Aided Design of Small hydro project is a must.

It must be mentioned that Seventh Plan DNES policy of sanctioning National Demonstration Projects to AHEC, located in an academic environment has paid rich dividends.The UGC has also approved the running of a post graduate programme on renewable sources of energy in AHEC to be funded by DNES.

12. The state agencies may have to review the small hydro implementation strategy in view of the necessity to meet target schedules on a very large number of sites coupled with the fact that the consulting agencies are in general preparing voluminous project reports (DPR's) for small hydro projects at substantial cost. It may be worthwhile involving Regional Engineering Colleges,Universities and Diploma polytechnics having computer facilities for analysis and collection of data for project report preparation. Students and voluntary agencies could be used for data collection. In fact, some of the R&D projects based on operational data collected on running projects could also be assigned to Regional Engineering Colleges, and the funds for the same provided in specific project proposals.

13. In China, training and involvement of local people was an integral part of the small hydro programme, which resulted in substantial saving of the operation and maintenance cost of the project. In the absence of alternative power supply, local people had a stake in trouble free operation of the plant.

In India, the small hydro development is taking place, in a different environment, where after the commissioning, there does exist a definite possibility of neglect of the project. It may ultimately be in the interest of the co-ordinating agency to encourage/enforce local participation. The co-ordinating agency may also be required to bring necessary legislation for this purpose.

14. Recognising the fact that an altogether different strategy is required fo planning, design and execution of Small hydro systems (including mini and micro) and to undertake much needed R&D activity in this field a strong training programme for a selected number of serving engineers of state implementing agencies be arranged at the post-graduate and doctoral levels. In addition, some 2-4 weeks short duration state-of-art courses be also arranged for higher level executives.

15. It is very necessary to organise comprehensive information systems. This can be achieved by dissemination of information on R&D efforts and extension works through organisation of seminars symposia and workshops. Also it is necessary to collect , store and retrieve information regarding power potential of Small hydro systems (including mini and micro) and on feedback obtained from projects already executed in this field. It is proposed to have a National Data Bank of Small Hydro Power (including mini and micro) which shall be linked up with the computer system of DNES.

16. The rapid development of small hydro system is an urgent necessity which requires a major effort in R & D, evolving special design methodologies and erection and commissioning techniques . The effort

required is gigantic but not impossible and calls for setting up of a Regional UNDP centre to promote all aspects of Small Hydro System (including Mini and Micro). AHEC with its rich experience in R & D, design, erection and commissioning of a number of National Demonstration Projects can provide an ideal setting for such a centre.

MINI HYDRO POWER EIGHTH PLAN IMPLEMENTATION PROGRAMME

FOREWORD

EXECUTIVE SUMMARY

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Supplementary material

1. Proposed Technology Development Plan for Mini Hydel

- Science Advisory Council to the Prime Minister highlights in a Document (An Approach to a Perspective Plan for 2001 A.D : Role of Science and Technology) that when critical targets had to be met, a missionary zeal through the identification of National Technology Mission can provide renewed impetus. In such situations the conventional planning, dependent on economic exercises and allocation of funds derived from it would not suffice.

- Realising that 30% of the Seventh Plan outlay was earmarked for Energy, and that the usage of Science and Technology in the energy sector has been rather unsatisfactory in the past, Energy has been identified as one of the key areas for National Technology Mission approach.

- Science Advisory Council has also shown serious concern over the continued intensification of resource use, which has led to a depletion of renewable resources. In this regard the harmful effects of large hydro [1] and thermal projects on soil, forests, and rivers must be considered. In the opinion of Science Advisory Council, the cost of environmental degradation accompanying the intensification of resource use has been largely borne by the weaker sections of the society, while the benefits have accrued to those already better off.

- Concerned with the resource crunch for the Eighth Plan the Government is already paying urgent attention on Energy conservation measures. Interestingly energy demand of 2005 A.D can be met only with improvements of 8% in PLF, 30% in appliance efficiency and 10% reduction in T&D losses. A structural change in the energy sector, from dependence on large projects to small projects would help in achieving the above objectives [2]. In this regard mini hydel, co-generation in sugar industry using bagasse and wind power generation have been identified by World Bank already as bankable options.

- Specifically, the Mini Hydel Technology Development Plan would have the following objectives:-

(i) A National Plan of integrating environmentally clean renewable sources of energy, with the existing networks.

(ii) Develop necessary human resource preferably from existing agencies, through specialised training to orient them for execution of projects which are small yet large in number.

(iii) Arrange local participation, so that the systems receive their care, necessary for optimum performance. Overall system performance in terms of PLF, energy conservation etc. will depend upon this vital link.

(iv) National R&D hook up involving colleges and Universities at the regional and national level, in close collaboration with manufacturers and entrepreneurs.

Ref :-

1. "Dams the principal cause of droughts and devastating floods" by V.K. Bansal, V.P. Kapur, paper accepted by 6th World Congress on Water Resources, Canada, June, 1988.
2. "Towards an ecologically safe Energy policy" by V.K. Bansal, V.P. Kapur, paper presented.

FINANCIAL REQUIREMENT

- The enclosed documents contain data regarding mini hydel projects prepared on the basis of the following documents :
  - i. Document of Rural Electrification Corporation
  - ii. Specific information received from various states collected by AHEC scientists.
- State agencies are requested to update the information contained in the document and send it to the Director, Alternate Hydro Energy Centre, University of Roorkee, Roorkee - 247667.
- Projects have been classified under the following four heads:
  - i. Operational
  - ii. Under construction
  - iii. DPR is ready
  - iv. Other prospective sites

  Besides above, the following additional criteria have been used for identification of sites.

  - i. Project capacity < 3 MW
  - ii. Head > 2.5 m
  - iii. Projects in the electrified area, which shall be generally on the canal falls (Head range 3-7m)
  - iv. Projects in the remote areas, in the hills (head range generally > 7m)

- On projects, where cost estimates were not available, the following average values have been used to estimate costs :

Capacity	Sites on canal falls Cost Rs./kw	Sites in the hills Cost Rs./kw
< 100 kw	35,000	30,000
< 500 Kw	30,000	25,000
< 1 MW	25,000	20,000
< 3 MW	20,000	15,000

- Sites yielding 822.3 MW at a cost of Rs. 1715 crores have been identified for Eighth Plan programme (Refer List 'A'). Details of specific sites have been included in Vol. III of the document.

- Sites on canal falls yielding 148 MW at a cost of Rs. 333 crores can be taken up immediately for construction (Refer List 'B')

Financial requirement of the Mini-Hydel programme

Item	Rs (in crores)
1. Generation of 822.3 MW on sites identified on All India basis (state wise allocation in List 'A', Tentative list of identified sites in Vol. III)	1715=00
2. Gharat improvement programme	35=00
3. Research and Development (Plan of AHEC in collaboration with Regional Engineering Colleges and equipment manufacturers)	15=00
4. Training and manpower development for the Mini-Hydel programme	2=00
5. Design methodologies which includes design standardisation and setting up computer-aided design facility at various SEB'S	2=00
6. Information system which includes setting up of a data bank, organising seminars, symbosias and publications	5=00
	1774=00

A. Summary of the Mini hydel potential for the Eight Plan

S.No. State/UT's	Eight Plan programme				Likely to be completed by 1990			
	DPR not ready		DPR ready		Sites under construction		Sites operational	
	A		B		C		D	
	Capacity MW	Cost (Rs.in crores)	Capacity MW	Cost (Rs. in crores)	Capacity MW	Cost (Rs.in crores)	Capacity MW	Cost (Rs.in crores)
1. Andhra Pradesh	30.3	71.8	12.6	28.3				
2. Andman & Nicobar	3.0	4.5						
3. Arunachal	40.3	76.0	-	-	6.8	14.4	14.1	27.8
4. Assam	9.6	15.6	6.0	7.8				
5. Bihar	25.1	64.7	1.0	0.3				
6. Goa, Daman & Div.	1.5	2.3						
7. Gujrat	8.3	25.3	18.51	46.0	2.0	6.6		
8. Haryana	-	-	24.1	52.3	0.4	1.3		
9. Himachal Pradesh	8.3	12.4	0.5	1.3				
10. Jammu & Kashmir	63.0	103.9	23.7	62.3	7.6	28.8		
11. Karnataka	6.9	17.6	17.0	32.0	24.1	63.1		
12. Kerala	112.0	247.5	9.7	25.2	10.0	3.2		
13. MadhyaPradesh	27.5	60.3	9.7	21.8	3.8	9.6		

14. Maharastra	61.0	142.1						
15. Manipur	7.00	13.0						
16. Meghalaya	5.2	13.8		-				
17. Mizoram	1.5	11.1						
18. Nagaland	0.5	1.0	7.8	18.0	0.8	2.3	2.5	5.8
19. Orissa	14.6	29.9	0.01	0.3	-	-	0.04	0.8
20. Punjab	41.9	124.2	29.3	60.9				
21. Rajasthan	0.8	2.0	8.6	21.7	1.0	3.3		
							4	
22. Sikkim	9.1	17.0						
23. Tamil Nadu	77.4	125.5	7.9	10.3	4.8	9.9		
24. Tripura	4.4	10.1						
25. Uttar Pradesh	99.0	208.6	4.4	11.6	16.7	35.7	8.6	20.9
22. West Bengal	38.2	70.5						
	718.2	1511.4	183.21	404.5	81.8	162.0	25.24	55.3
	662.9	1362.1	159.1	352.8	72.2	162.0	25.24	55.3

Abstract	MW	Cost (crores)
1. DPR's not ready	718.2	1511.4
2. DPR's ready	183.21	404.5
For Eight Plan	822.3 MW	1714.9 crores
3. Sites under construction	81.8	162.0
4. Sites operational	25.24	55.3
Upto Seventh Plan	97.44 MW	217.3 Crores

FIRST PRIORITY SITES ON CANAL FALLS FOR WHICH DETAILED PROJECT REPORTS ARE READY

S.No.	Location	Capacity MW	Cost (Rs. in crores)	No. of sites
1.	2.	3.	4.	5.
1.	Andhra Pradesh	40.6	96.3	8
2.	Assam	-	-	-
3.	Bihar	1.0	2.5	1
4.	Gujrat	15.0	38.5	13
5.	Haryana	24.0	52.3	20
6.	Himachal Pradesh	-	-	-
7.	Jammu & Kashmir	-	-	-
8.	Karnataka	17.0	32.0	8
9.	Kerala	9.7	25.2	6
10.	Madhya Pradesh	9.7	21.8	12
11.	Maharastra	-	-	-
12.	Manipur	-	-	-
13.	Meghalaya	-	-	-
14.	Nagaland	-	-	-
15.	Orissa	0.01	0.03	1
16.	Punjab	29.3	60.9	21
17.	Rajasthan			
18.	Sikkim	-	-	-
19.	Tamil Nadu	2.4	3.4	2

20.	Tripura	-	-	-
21.	Uttar Pradesh	-	-	-
22.	West Bengal	-	-	-
23.	Andhra Pradesh	-	-	-
24.	Arunachal Pradesh	-	-	-
25.	Goa,Daman & Diu	-	-	-
26.	Mizoram	-	-	-
		148.7 MW	33.2 Crores	92 sites

3. Strategies for Programme Implementation

Realising, that short gestation period can be the trump card of mini hydel programme, and significant cost reduction can be achieved by grouping exploitation of similar sites on all India basis, the implementation strategy may have the following special features :-

The exercise of identifying potential sites on all India basis, under taken now for the preparation of 8th plan document, may be carried further to collect hydrological data on each site. In each state the activity can be co-ordinated by SEB, with the technical help of DNES, AHEC combine. The work on the first set of sites on all India basis may be over by May, 90.

- AHEC may take steps to computerise the design process of mini hydel plants. This work may also be over by May, 90. In this process active help of experienced SEB engineers can also be taken, by involving them in post graduate and doctoral programmes.

- The first set of orders for the mini hydel programme could be placed in the beginning of 1991, which gives about 21 months for the equipment manufactures to obtain state-of -art technology, and assimilate it.

DNES, AHEC combine may also have to initiate steps to widen the manufacturing base so that turn-key contracts can be offered with much more confidence and competition.

- AHEC in collaboration with voluntary agencies may run training programme in the localities where first set of mini hydel plants are going to be set up to involve local people in the mini hydel programme. Latter, the training programmes could be run by state agencies in collaboration with voluntary agencies.

4. TRAINING & MAN POWER DEVELOPMENT

- Small hydro design practices are in a evolutionary stage. because of their new role in the present day Energy Scenario. The training programme will be of the academic nature, at the doctoral and post graduate level, for the serving engineers of state agencies.

- Short term training programme of 2-4 weeks duration, run through Continuing Education Department will focus on continuous updating of design practices, prevalent in states.

- Workshop on "Improvement of Gharats" held at Kotdwar in Sept.87, in one of its recommendation suggested organising of 1-2 month workshops in the hills for actual fabrication of multi-purpose gharats, as a self help programme.

- UNESCO working group meeting held in May, 1983 at Colombo, Sri Lanka recommended establishment of a Master's programme in Small Hydro field at AHEC.

- Screening Committee of the Post-Graduate Board of UGC in the meeting on 28.8.86 approved a Post Graduate programme on Alternate Hydro Energy Systems to be run by AHEC and suggested financial assistance for the same from DNES.

- Alternate Hydro Energy Centre has been recognised as an Academic Department of the University to conduct Doctoral programmes., since Sept. 1985.

- Under the New Education Policy, it has been recommended that the user agencies should fund related educational programmes. The educational programmes, in this particular case, are going to directly benefit the extension work of the co-ordinating agency. Hence the Co-ordinating agency of the Small Hydro Power programme, should be provided funds for the same.

5. R & D AND TECHNOLOGY UPDATE

Governors for Mini hydel units

Majority of the mini hydel units connected to the grid do not have to carry out load frequency control. Use of induction generator on stable grids further eliminates the need to include synchronising facility of the governor. Governors for ultra-low-head turbines have to content with non-linearities and sluggishness in certain regions, which makes it impossible to manage the situation with fixed contoured three dimenstional cams. Availability of low cost microprocessors has virtually revolutionised the whole field. There is immense scope for technology transfer and in-house R & D in close collaboration with equipment manufacturers.

Interfacing problems of mini hydel systems

In the design of protection panels, insufficient attention has been paid to simplify the schemes. Besides, the present protection schmes are designed for one-way power flow from the utility power plant to the customer - but not for the phase co-ordinated distribution network required to handle two way power flow. Use of microprocesors can result in considerable simplification and cost reduction and better man-machine interface.

Stand alone mini-hydel systems

In rural areas the power supply availability is sometimes as low as 10 hours in a day or less. Mini-hydel systems feeding into the grid, would therefore, remain unutilised, unless they have the capabilities of operating in the stand-alone mode. Biogas and diesel based engines, can be integrated with mini hydel systems for isolated operation of mini hydel plants. Recent experiments on mutiple feed biogas plants have shown encouraging results. The research area needs investigation and setting up of some National Demonstration Projects in collaboration with Energy Development Agencies of states.

Improved materials for civil design

In recent years experiments have been conducted for improving the static and dynamic properties of concrete by the addition of steel fibres. With the technical expertise of Roorkee University in Civil Engineering design, further experiments in the above areas can lead to significatnt cost reduction of mini hydel plants.

Summary of the proposed "Gharat Improvement programme in the Eighth Plan" by Dr. A.P. Joshi, HESCO, Kotdwar

i. In the hills, Gharats can meet a variety of energy needs of the people such as electricity for lighting, rice hulling, stone grinding, oil expelling etc., and lead to saving of diesel.

ii. Presently there are approximately 7000 gharats in the U.P.Hills alone, producing on an average 2 KW of energy with an efficiency of 15-17% only.

iii. In Nepal, a German group FAKT has developed Multi-Purpose-Power-Unit(MPPU) essentially with local material and expertise which can be used as a complete set : turbine, mill and power take off, and is compatible with the traditional civil design. Another Swiss Group SKAT has developed Cross-flow-turbines efficiency 60-70% again with local material and expertise, for power generation from Gharat programme. More than 450 locally built units have been installed with financial support from Agriculture Development Bank of Nepal.

iv. There are about 75 active voluntary agencies in the U.P. Hills. In September 1987 HESCO had organised a workshop on "Gharat Improvement" for the benefit of voluntary agencies. HESCO can co-ordinate the voluntary agencies in this parogramme.

v. One of the significant recommendation of the above workshop was organising of 2-4 weeks training programme in the Hills, on an actual gharat site, for the benefit of voluntary agencies, to help them set up improved gharats in their region. Setting up of a small workshop to be latter used for maintenance of "Improved Gharats" could be an integeral part of the above training programme. AHEC can organise such workshop in collaboration with HESCO.

6. CRUCIAL ROLE OF DNES THE CO-ORDINATING AGENCY

- SMALL HYDRO AS DISTINCT FROM LARGE HYDRO

The small size, pronounced variability of the source with time, and the dispersed nature of the resource demand a clear break from the design and implementation practices of large hydros, which are by nature just the opposite of large hydro. While large hydros are required to supply firm power, small hydros have the design and operational objective of "maximum energy generation".

- SIMILARITY OF SMALL HYDRO WITH OTHER RENEWABLE SOURCES

Although the power generation activity began with small hydro generation, in their new incarnation small hydro sources fulfil an entirely new role. Hence they are being clubbed with other renewable sources of energy viz. solar, wind, biomass etc., due to the similarity in their nature and role. All over the world small capacity units, based on the above resources, take advantage of the grid to exploit the resource to its maximum.

- SPECIAL NATURE OF SMALL HYDRO DESIGN

Realising the special nature of small hydro design, the Amercian Society of Mechanical Engineering (ASME) alongwith the Hydraulics Division of American Society of Civil Engineers (ASCE), since 1980, had brought out a number of special issues titled "Small Hydro Power Fluid Machinery" dealing with the investigation, equipment selection, standardisation, and operation and maintenance aspects of small hydro.

- SPECIAL EXPERTISE AND NICHE OF ALTERNATE HYDRO ENERGY CENTRE IN MINI/MICRO HYDRO DEVELOPMENT

The Alternate Hydro Energy Centre (AHEC) has gained a deeper insight into the entire gamut of activities connected with small hydro based on the execution of three National Demonstration Projects, followed by an exhaustive literature survey. The Centre has also analysed the guidelines issued by Central Electricity Authority for othe implementation of mini/micro hydel plants (Details in Vol II). The centre is of the firm opinion that any guidelines issued,without gaining direct experience on the execution of small hydro projects, can even retard the growth of small hydro projects in the Eighth plan. Similarly the document titled "Small hydro stations-standardisation-Publication no.175" brought out by the Central Board of Irrigation and Power - its various schedules on technical and commercial aspects need considerable simplification, and the manufacturing capabilities need updating for it to be meaningful during the Eighth Plan. Specifically, AHEC will have the following revised objectives during the Eighth-Plan.

(i) Workout, in close co-ordination with DNES, Eighth Plan prgramme of small hydro development for each State. Sites of the same type on All India basis shall be clubbed together to gain cost reduction advantage.

(ii) Computerisation of the small hydro designs for uniformity, and fc catering to a very large number of sites.

(iii) Training of designers from various state electricity boards, to leave sufficient scope for individual excellence in offering innovative designs. Guidelines tend to discourage innovative designs.

(iv) Execute R&D programmes, drawn on the experience of project executed in the Seventh Plan. Some R&D projects may also be drawn on the basis of monitoring of projects, to be executed in the Eighth Plan.

5. ROLE OF CO-ORDINATING AGENCY

A very large number of sites, yielding little by way of megawatts, an under developed manufacturing infrastructure, and the compulsion to induct personnels from large hydro and other power establishments into an alien area, makes it a very challenging task for the co-ordinating agency.
The large project bias of the state agencies charged with the actual implementation of the programme has to be removed, through special training programmes. Research and Development activity has to be decentralised in various Universities and engineering colleges, to closely co-ordinate with manufacturers in the region.

Realisation that the magnitude of maintenance problem can be enormous, participation by local agencies or private contractors has to be arranged, right from the investigation stage of the project.

Obviously the problems of mini/micro hydel development, as mentioned above, are entirely different in character. It is certain that a successful mini/micro hydel programme, in the Indian context, needs much more than mere issue of certain documents as guidelines or standardisation of machinery or scrutinising reports on the lines of small hydro.

Fortunately, the Department of Non-Conventional Energy Sources, through its various state agencies and extension services has conducted similar prgramme for other renewable sources quite successfully. While evaluating the mini/micro hydel programme of the DNES and AHEC in the Seventh Plan the following factors may also be kept in mind :

(i) "Large hydro bias" of the personnels executing the programme, has been largely responsible for cost escalation time over runs and choice of inefficient machines.

(ii) DNES had only Rs.5 crores allocated in the Seventh Plan for the small hydro work, which was too little to attract investment from the states in an area, which is still not attractive because of higher installation cost, when compared with large hydro projects.

(iii) The capacity limit of 3MW, and an artifical division of small hydro projects as mini, micro and small was too restrictive, and left only uneconomical projects in the kitty of DNES. In fact the entire 12MW range of small hydro (Investment < 20 crores) comes under the financial powers of Secretary, DNES. Basically, all projects, distinct from large hydro projects, and of capacity less than 12MW should be under the power of a single co-ordinating agency.

6A. PROPOSED AND RECOMMENDED OUTLAYS ANNUAL PLAN 1989-90

DEPARTMENT OF NON-CONVENTIONAL ENERGY SOURCES

Rs. in Crores

S.No.	Sector/Programme	Seventh Plan Allocation	1988-89 Outlay	Proposed Outlay 1989-90	Recommended Outlay 1989-90
1.	Family Size Biogas Plants	177.00	53.38	85.00	57.50
2.	CBP/IBP (WRRRS)	17.00	3.00	7.00	4.00
3.	R&D in Biogas	6.00	1.00	1.00	1.00
4.	National Programme on improved chullah	40.00	10.00	20.00	12.00
5.	Solar thermal energy	32.00	7.00	13.32	9.00
6.	Solar Photovoltaic	27.00	9.50	22.60	9.50
7.	Wind energy	20.00	5.50	10.00	6.00
8.	Rural renewable energy system	0.50	0.25	1.00	0.25
9.	Biogas & DAP	30.00	6.00	15.00	6.00
10.	Energy from urban agricultural wastes	14.00	2.25	11.20	1.15
11.	Alternate fuel/BP vehicles	5.00	0.50	0.75	0.50
12.	Magneto Hydro Dynamics	10.00	1.25	2.5	0.50
13.	Geothermal energy	2.85	0.10	1.00	0.25
14.	Chemical sources of energy	4.00	0.40	0.75	0.50

15.	Ocean energy	3.00	0.05	0.10	0.05
16.	Hydrogen energy	5.00	0.40	0.75	0.50
17.	Micro hydel energy	5.00	1.00	9.00	2.05
18.	IREDA	10.00	2.50	3.36	3.25
19.	Regional offices /monitoring cells	0.65	0.40	0.80	0.50
20.	Information and public education	3.00	0.30	0.70	0.40
21.	Seminar/Conferences	-	0.01	0.12	0.10
22.	International	0.35	0.02	-	-
	Total	412.35	105.00	205.95	115.00

6B. DNES PLAN FOR HARNESSING RENEWABLE ENERGY POTENTIAL DURING 7th, 8th AND 9th PLANS

S.N.	Source	1985-90	90-95	95-2000	Total
1.	Power from biomass	100 MW	1200 MW	4700 MW	6000 MW
2.	Power from Wind	140 MW	1000 MW	3860 MW	5000 MW
3.	Power from Solar system	60 MW	440 MW	1500 MW	2000 MW
4.	Sewage sludge	5 MW	15 MW	30 MW	50 MW
5.	Power from small hydro	200 MW	600 MW	1200 MW	2000 MW
6.	Photovoltaic pumps	1.5 MW	4.5 MW	30 MW	35 MW
6.	Wind pumps	5 MW	15 MW	30 MW	50 MW
7.	Energy from Municipal Solid Waste	16 MW	48 MW	96 MW	160 MW
	TOTAL				15295 MW

6C. DETAILS OF THE SEVENTH PLAN ALLOCATION OF DNES OF MINI/MICRO HYDEL PROGRAMME

		MONEY RELEASED (Rs. in lacs)
1.	A.H.E.C.	76.58
2.	Jubbal	27.87
3.	Manali	54.60
4.	Kakroi	110.00
5.	Ralla	25.00
6.	Bahadarabad	15.00
7.	Gholia	15.00
8.	Sahoke	15.00
9.	Kendrapara	15.00
10.	Orissa	15.00
11.	Chargaon	15.00
12.	Site efficiency measuring instrument	3.00
13.	Pilot testing of Biomass Gasifier	1.50
	Grand Total	388.55

7. ENERGY SCENARIO

A. MINI HYDEL AS AN ENERGY OPTION FOR INDIA.

In India the GDP elasticity for the commercial energy (electricity,coal, oil) in the last 20 years has been 1.62. This means that if a growth rate of 5% has to be achieved for the Eighth Plan, the commercial energy consumption will have to grow at 8.10% compound per annum. This means that one has to plan for the energy demand becoming double every 9 years. With about 30% of the Plan outlay required for energy, it is becoming increasingly difficult to mobilise resources for the targetted growth of Eighth Plan. Anticipataed serious unemployment problems, as a result of reduced growth rate is also a concern of the planners.

Performance of large multi-purpose hydro projects, undertaken since independence, leaves much to be desired. Out of 246 projects, 181 have remained incomplete. As a result thermal generation share has declined, and is likely to be 29% at the end of Seventh Plan. Poor plant load factor (PLF) of thermal plants is mainly because sufficient peaking capability is not available from the hydel sector. It must be mentioned that even 1% improvement in the PLF of thermal plants saves investment required to generate 500MW. Mini hydel power with its short gestation period can be quickly harnessed to correct the imbalance. Improvement of PLF , as a result of contributing to the peak demand would be a bonus.

Another disturbing feature of the Electricity distribution network is the high transmission and distribution losses, which is probably the highest in the world. Here again mini hydel plants with the involvement of only 11 KV lines, immediately save at least 9% of losses of the EHV circuits. In fact, the dispersed nature of mini hydrl potential turns out to be a boon in disguise.

There is an urgent need to work out the correct potential of mini hydel power, by identifying all possible sites on All India basis. The earlier estimate of 5000MW of small hydro power, worked out as a percentage of the large hydro potential, is likely to be misleading.

7B. **"Towards an ecologically safe energy policy"**

- Wherever energy performs work, heat is generated, leading to calefaction of air and water. Hence the present trend of energy demand doubling every 14 years can not continue for long.
- Taking cue from "mature" natural eco-system which have diversity and have web like structure, one may have to discard large and centralised power system.
- No living specie can survive for long without recycling the waste, and waste is inevitable in any resource process. Energy generation from recycling of waste, may mean some life style adjustments.

- Energy intensive agriculture with fertilisers, mechanised forming etc. is unsuitable for developing countries. Even in the advanced countries the trend is towards organic forming.
- Ecologically unsafe large hydro and thermal projects may have to be discarded sooner or later.
- Chinese approach of training construction workers on the job, with the help of engineering graduate students, led to involvement of local people in the small hydro programme, which is absolutely essential for a "web like" energy system.
- Future energy demands can be met with greater stress on non

commercial energy sources, which are fuel wood, dung cake, vegetable waste and animal power.

References:

1."Towards an ecologically safe energy policy" Paper by V.P. Kapur, V.K. Bansal, presented at the U.G.C Sponsored National seminar at the University of Jodhpur, Feb. 26-28.1987.

TECHNICAL PAPER

SPECIALISTS OR ENGINEERS

BASED ON THE CONTRIBUTION TO THE CLOSING CEREMONY OF THE INTERNATIONAL SYMPOSIUM ON HYDRAULICS FOR HIGH DAMS IN BEIJINDG, CHINA, NOVEMBER 1988

As hydraulicians, most if not all of us started out originally as civil, mechanical or electrical engineers responsible for deriving optimal, least-cost solutions without losing sight of the overall systems involved. Due to the past and current trends in research, however, almost all of us have gone through a silent transformation towards specialists in an increasing number of ever more narrowly defined subjects. Are we content with this course of events, and do we want it to continue ?

Consider, as an example, our involvement with large dams. Two of our main goals here are (1) to supply farmland and cities with water and (2) to make available more energy. The common solution of the engineering specialists have been (1) to store and pump water and (2) to produce energy with the aid of dams and power stations. By taking a broader view of the systems involved, could we not possibly find alternative solutions which would achieve the same goals more economically and more ecologically sustainable ? What if we strived, first, to reduce water losses and energy losses in our systems ?

From a Nepalese engineer who headed a group of experts charged with investigating the water-supply system of Kathmandu. I know that the estimated water loss in that area is about 70 percent! But exorbitantly high water losses are by no means restricted to developing countries. They are also known to exist in cities such as Boston. Even a modest reduction of these losses would provide extra water supply at minimum expenditure within a short time, while increased water storage and pumping would only increase operating costs of an inefficient system, apart from aggravating the debt crisis due to the large sums of investment necessary in that case.

Similarly startling results with respect to energy have been obtained by four internationally known experts (Lovins et al., 1981), even though they used assumptions deliberately biased in the direction least favourable to their conclusion. Figure 1 shows potential energy-efficiency improvements in the F.R.Germany achievable by present technologies for the residential and commercial sectors in two categories : the "2030" case, involving measures readily deployed over a period of 50 years, and the "present technical limit", involving replacement of the entire existing stock. Similar diagrams were deduced for the industrial and the transport sectors. All measures together would reduce Germany's energy needs by 69 % ("2030") to 79% ("Present techn. limit"). In addition, according to this study, the total improved from 0.73 in 1973 to 0.87 in 2030, e.g., by combining production of heat and electricity. In other words, deployment of cost-effective technologies could quintuple West German energy efficiency!

The authors also extended their case study to show that it is simply not true that increased prosperity and global equity requires ever-increasing amounts of energy. Available new technologies can provide increased energy services more cheaply by wringing more work out of available energy sources, thus making technical progress possible that could never be achieved by the conventional strategy of merely building up energy production. It is not energy perse that we require, but rather the services that energy gives us, such as comfort, light, mobility, and smeltering. It is more sensible therefore to view the problem as one consisting in how to provide the amount, type, and source of energy that will do each desired task in the most economic way. The great advantage of developing countries in this respect is that they can develop their energy-using infrastructure efficiently right from the begining, avoiding costly "retrofits".

Viewed in this light, the tasks for which energy is presently required in an industrial country such as the FRG are ; 75% for heat (23% of which is needed at temperatures below 100°C), 18% for portable liquid fuels to run vehicles, and only 7% for electricity! In no industrial country can additional electricity be used cost-effectively at present, because the electricity-specific needs are already met by present capacity. What is required in addition to increased efficiency (Fig.1) is the harnessing of such renewable energy sources as passive and active solar heating; passive solar cooling; solar process heat; conversion of farm and forestry wastes to alcohols and pyrolysates (oils made by heating wooden matter with little air); small-scale hydroelectric power; windpower; and in some instances solar cells.

In all countries so far studied, Lovins et al.(1981) have found that the fastest and cheapest way to replace imported oil are, first, energy-efficiency improvements and, second, renewable-energy plants. Investments in such slow and costly measures as new conventional power stations, slow down oil replacement by diverting resources from more effective measures. Their study shows, moreover, that the combined global use of efficiency improvements and renewable sources can supply a highly prosperous world with doubled population in a way which, surprisingly, reduces to almost zero the global rate of burning fossil fuels, thus holding the CO_2 level in 2030 to within 10% of its present value! I surely do not have to stress the significance of such an accomplishment, in view of the problems confronting us in connection with the CO_2 "greenhouse effect". Of major concern in all industrialized countries with long sea coasts, at present, is the problem of how they can best protect themselves against a possibsle future rise in sea level brought about by climatic changes due to excessive CO_2 releases.

It turns out that we have again two paths for a solution. The one that immediately comes to mind to the specialist in us has to do with costly measures including dams and a variety of hydraulic structures. An alternative, obviously, would consist in the realization of the just-discussed least-cost energy strategy on a global scale, since this strategy holds a good chance to avoid the disastrous greenhouse effect altogether. What I wish to stress here is that this alternative solution with its great advantages both environmentally and economically entails enormous challenges for all engineers.

I consider it our responsibility as engineers to inform ourselves comprehensively about this alternative path - e.g., by inviting experts like Amory B.Lovins*) for mutual discussions -

and to pursue and propagate this path when we find that it is feasible.

*) Amory B. Lovins, M.A., D.Sc.h.c., educated at Harvard and Oxford, is a physicist working on energy and resource policy in more than 15 countries. He has published over ten books and many technical papers and has been a consultant to a wide range of governments and international and private organizations. He was recently bestowed with the Right-Livelihood award (Alternative Nobel Prize). Lovins is Director of Research of the Rocky Mountain Institute in Old Snowmass, Colorado, 81654, USA.

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Lovins, A.B., Lovins, L.H., Krause, F., Bach, W. (1981: Least-Cost Energy/Solving the CO_2 Problem. Brick House Publication Co., Andover, Mass., USA.

8. CRITICAL RE-EVOLUATION OF LARGE MULTI-PURPOSE HYDRO AND THERMAL PROJECT

A. EXCERPTS FROM A REPORT

1. Useful life of the project comes out 62 years as against 100 years calculated by project authorities.
2. Total annual energy available for sale on the bus bars should be found by deducting the transmission and distribution losses, which are at least 20% .
3. Interest rate should be at laest 12% , as against 8% shown in the project report.
4. Compensation for houses, land, crop, solatium etc. should be much higher than estimated by project authorities.
5. In addition to the above factors the benefit cost ratio should be worked out in the following manner:

(1) Suppose that the project is under construction for "n" years, and the cost stream is C_1 , C_2 ,- - - - - C_n , then the compounded value of cost stream is :

$$C = \sum_{t=1}^{n} C_t \ (1+i)^{n-t}$$

where "i" is the interest rate.

(2) Let "m" be the useful life of the project, and the benefit stream is B_1 , B_2 , - - - - B_m , then the present value of benefit stream is :

$$B = \sum_{t=1}^{m} B_t / (1+i)^t$$

(3) Similarly the present value of the operating expenses stream $R_1, R_2, - - - - R_m$ would be :

$$R = \sum_{t=1}^{m} R_t/(1+i)^t$$

(4) Benefit cost ratio = B/C+R

6. Benefits & costs of a multi-purpose project compared:

	Claim of Project authorities	Revised calculations
i. Energy generated annually on 90% availability basis	3029 million KWH	2423 million KWH
ii. Cost of power	35 paise	73 paise
iii. Revenue return with sale rate of 48 paise at bus bar.	11.52%	6.89%
iv. Benefit cost ratio for agriculture.	3.5:1	1.28:1
v. Benefit cost ratio of the whole project.	not calculated	0.56:1

7. World Watch Institute, Washington has stated that " the most mature alternative" for the Third World is small hydro power, which can be commissioned quickly, have low interest costs and marginal foreign exchange requirements, besides being environmentally safe.

8. Comparision of the original multi-purpose project with an alternative run-of-river scheme

		Multi-purpose project	Run-of-river scheme
i.	Capital cost for power component.	Rs.1264 crore	Rs.442 crore
ii.	Installed capacity	1000 MW	309 MW
iii.	Annual energy generation on 90% availability (unit - KWH)	2910 million	1521 million
iv.	Unit generation cost	73 paise	28 paise

8B. ENVIRONMENTAL IMPACTS OF MULTIPURPOSE HYDRO PROJECTS

Big dams on a river kill the river itself. In a recent international publication (1) a theory has been presented which states that dams are the cause of drought and devastating floods, and rapidly eroding power gains due to deteriorating ground water conditions are marginal.

The increasing incidence of drought and floods affecting larger and larger areas is a clear proof of the deteriorating 'health' of not only the river system but of the connected ground water system also. The above should be treatyed as a well connected drainage system, from the Himalayas to the seas taking centuries to stabilise and to operate as a perpetuating system, capable of withstanding reasonable vagaries of nature entirely on its own. In the normal course, rivers charge the aquifers, when in spate, and when the rivers recede, the aquifers charge back into river to maintain the flow. Through the above process the river and the ground water system is also kept ready to receive the next flood. Damming the river section and diverting the water through a canal system, chokes the natural drainage system due to inadequate flow, and due to its very absence in the fresh areas the problems of water logging and salinity appear.

The net result is that the situation becomes contrasty. A disconnected drainage system is both the cause of drought and devastating floods. Recently when rivers in Bihar were in floods the adjoining states U.P. and M.P. were reeling under severe drought, and immediately after, the reports of floods have started arriving from U.P.

It is also a myth that the presence of water is a sufficient condition for successful irrigation. The plants throw salts into the soil, a process known as 'guttation', and the salts must be removed to rejuvenate the soil. A critically placed ground water table in a well connected system, modulating through charging and discharging, is an ideal irrigation system, called a successful irrigation system.

Exploiting of ground water on a large scale is bound to lower the ground water table with consequent additional power to retrieve the water from greater and greater depths, till the time it becomes non available. The damming completely offsets the claimed benefit of power. In short, it is a complete paradox that the dams are meant for flood control, irrigation and power.

Reference :

1. "Dams, the principle cause of devastating floods and droughts" by V.P. Kapur, V.K. Bansal; Paper accepted for 6th World Congress on Water Resources, Canada, June 88.

9. STAND ALONE MODE OF ELECTRICITY GENERATION

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1. In rural areas the power supply availability is sometimes as low as 10 hours in a day, or even less. Therefore, small hydro systems installed in such areas to augment the grid network would remain unutilised unless they have the capability of Isolated operation. Biogas and diesel I.C. Engines can be integrated with the small hydro systems to operate the plant in 'Load following mode'.

2. The Department of Non-conventional Energy Sources and the State nodal agencies have established a number of rural energy complexes in rural areas with clear objectives to demonstrate technological innovation in the field of renewable energy and to create awareness amongst people about possible benefits and advantages associated with renewable technolgoies compared to the use of conventional energy systems.

3. One of the major component of the complexes is Community type Biogas Plants of about 60-85 cu.m. capacity which are presently facing gobar shortages and so incapable of providing gas for cooking and other purposes. While using plants for meeting domestic cooking energy needs, there are lots of

maintenance problems with both the distribution lines as well as cooking units, perhaps because of the condensation of water in lines leading to blockage of the gas passages.

4. It is also vital that all the energy systems installed in such energy complexes are working individually and in isolation and so system capacities are not fully utilised. The integrated system approach provides solution to all the problems associated with the use of energy systems in isolation. Depending upon the avaialability, one, two or more sources can be integrated for providing energy on a continuous basis.

The solar hot water systems which are installed at these complexes would also be used for preheating the water in winter for slurry making to improve the gas generation.

5. The agricultural and forest residues can be used for supplementing the gobar supplies in the community type biogas plants at the energy complexes which will result in a reliable supply of biogas. The research and development work pertaining to this aspect has been carried out in India and abroad and the results are highly encouraging.

6. The energy complexes have all the systems as mentioned. Therefore, Research and Development work pertaining to this

aspect would be carried out at such a energy complex estalished near Roorkee at village Brahampur.

7. The extension work for this strategy would require the preparation of realistic regional plans regarding the availabiltiy of agricultural and forest residues and their characterisation in conjunction with the planning of small hydro plants and subsequently the biogas plants installed at the energy complexes would be integrated with small hydro plants.