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SMALL HYDROPOWER DEVELOPMENT

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1 SMALL HYDRO DEVELOPMENT BACKGROUND

India has a century old history of hydropower and the beginning was from small hydro. The first hydro power plant was of 130 kW set up in Darjeeling during 1897, marked the development of hydropower in the country. With the advancement of technology, and increasing requirement of electricity, the thrust of electricity generation was shifted to large size hydro and thermal power stations. However, in the last 10-15 years there was a renewed interest in the development of small hydro power projects due to its benefits particularly concerning environment and ability to produce power in remote areas. Small hydro projects are economically viable and have a relatively short gestation period. The major constraints associated with large hydro projects are usually not encountered in small hydro projects. PM initiative 50,000 MW Hydropower development has further accelerated its growth.

2 DEFINITION OF SMALL HYDROPOWER

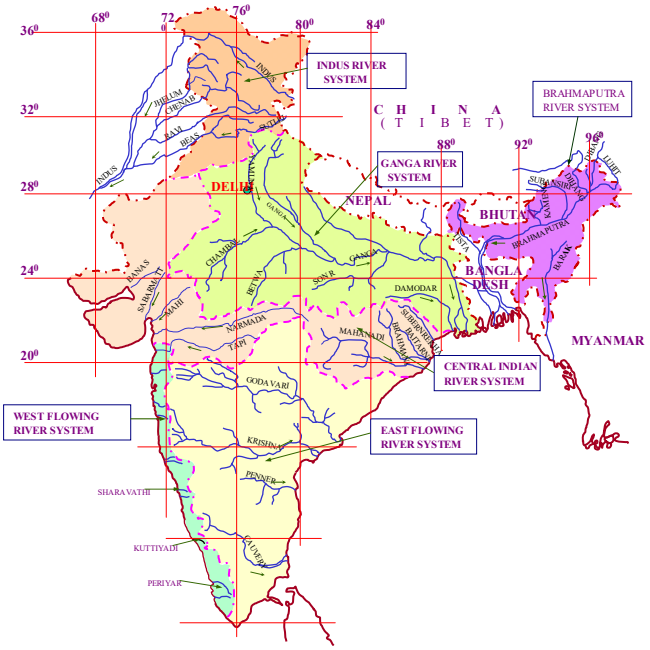
There is a general tendency all over the world to define Small Hydro by Power output. Different countries follow different norms, the upper limit ranges between 5 to 50 MW. CEA in its publication (1982) defines small hydropower only up to 15000 kW station capacities. However, with the transfer of mandate for hydropower now with Ministry of Non-Conventional Energy Sources up to 25,000 kW, small hydropower is taken up to 25,000 kW in India. However, now the distinction between these four categories has been done away with and hydropower projects with station capacity up to and including 25 MW are defined as small hydropower projects.

3. OVERALL HYDROPOWER POTENTIAL AND ITS DEVELOPMENT

For the purpose of hydro-electric potential India has been divided into six river basins, namely the Indus basin, Ganga basin, Brahmaputra basin, Central Indian river system, west flowing river system and east flowing river system.

The Central Electricity Authority (CEA) has identified hydropower potential in the country and has identified 845 sites. Out of these 845 schemes, 288 hydro schemes, with an aggregate installed capacity of 42,000 MW, are at present either under operating being implementated or have been cleared by CEA. The balance schemes include about 164 schemes, development of which has been transferred to the Ministry of New and Renewable Energy having the mandate of developing sites with an installed capacity of 25 MW or less.

MAJOR RIVER SYSTEMS OF INDIA



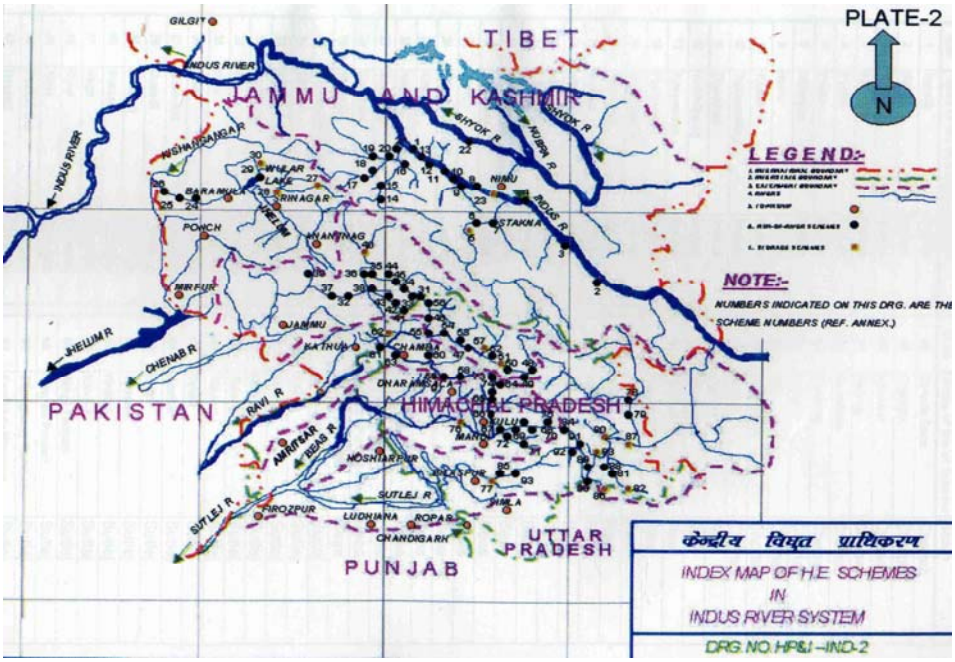
Total installed capacity of such schemes is about 2300 MW. Thus, about 400 schemes having a total installed capacity of about 1,00,000 MW, have been categorized, and their status is as given in the following table 1.

Table 1: STATUS of Hydropower Site Development

Status of Schemes	Number of Schemes	Installed Capacity (MW)
Schemes Identified	845	1,48,700
Under Operation	224	24,636
Under Construction	50	13,756
CEA Cleared	14	3608
Less than 25 MW	164	2,300
Balance Schemes (Approx)	400	1,02,300
	Say	1,00,000

3.1 Indus Basin – (J&K)

The Great Indus basin draining areas in the states of J&K, Himachal Pradesh and Punjab is one of the major basins of the country. The Great Indus basin comprises six major rivers namely Indus, Jhelum, Chenab, Sutlej, Ravi and Beas. Rising in Tibet at an elevation +5182m behind the mountains of Great Himalayas, Indus River traverses a total of about 2880 CMS. of which about 1114 CMS lies in India. The total area intercepted by these 6 major rivers is about 11.6 lakh sq. Kms. out of which more than 1.7 lakh sq. Kms. lies in the Indian territory.



SOURCE: CEA RANKING STUDY - INDUS BASIN - VOLUME – II, OCTOBER 2001

3.2 Hydropower potential in J&K

3.2.1 Hydro Power Potential

The hydro potential in the state of J&K as estimated is given in Table 2.

Table 2: Hydropower potential in J&K

Sl. No.	Name of the Basin	Hydro Potential	
		Identified (MW)	Developed (MW)
1.	Jehlum	3560	732.60
2.	Chenab	10360	724.50
3.	Indus	2060	8.55
4.	Ravi	220	9.00
	Total	16200	1474.65

3.2.2 Installed Capacity

The present installation on these basins is given in Table 3.

Table 3: Installed Capacity

State sector			
Sl. No.	Name of Project	Installed capacity (MW)	Year of commissioning
STATE SECTOR			
A.	**Jehlum River Basin**		
1.	Ganderbal	15.00	1955 – 56
2.	Upper Sindh	22.60	1973 – 74
3.	Lower Jehlum	105.00	1978 – 79
4.	Karnah	2.11	1990 – 91
5.	Upper Sindh – II	105.00	2002 – 03
6.	Pahalgam	3.00	2005

	Sub total	**252.00**	
B	**Chenab Basin**		
1.	Rajouri	0.70	1960
2.	Chenani – I	23.30	1971 – 72
3.	Chenani – II	2.00	1995 – 96
4.	Chenani – III	7.50	2001 – 02
5.	Baderwah	1.00	2005
	Sub total	**34.50**	
C	**Ravi Basin**		
1	Sewa – III	9.00	2002 – 03
	Sub total	**9.00**	
D	**Indus Basin**		
1	Stakna	4.00	1988
2	Hunder	0.40	1994 – 95
3.	Sumoor	0.10	1994 – 95
4.	Bazgoo	0.30	1994 – 95
5.	Iqbal Bridge	3.75	1995 – 96
	Sub total	**8.55**	
Total		**304.65**	
CENTRAL SECTOR			
1.	Salal HEP	690.00	345 MW in 1997 345 MW in 1994
2.	Uri – I	480.00	1997 – 98
	Total	1170.00	
Grand Total		**1474.65**	

3.2.3 Under Development

The development by different sectors is given in Table 4.

Table 4: Hydropower under development in J&K

A. State Sector		
S. No.	Name of the scheme	Capacity (MW)
1	Sawalkote stage I & II	1200
2.	Baghilhar – II	450
3.	Parnal	37.50
4.	New Ganderbal	93
5.	Kirthai	240
6.	Lower Kalnai	50
	Total	**2070.50**
B. Central Sector		
S. No.	Name of the scheme	Capacity (MW)
1.	Kishanganga	330
2.	Uri – II	240
3.	Burser	1020
4.	Pakal Dul	1000
5.	Sewa – II	120
6	Chutak	44

7.	Nimoo Bazgoo	45
	Total	**2799**

C. Private Sector				
S. No.	Name of the Project	Name of source stream / tributary	District	Estimated Capacity (MW)
1.	Aharbal	Vishow	Anantnag	15.0
2.	Kahmil	Kahmil	Kupwara	3.75
3	Hirpora	Rambiara	Pulwama	9.0
4.	Niagadh	Naigadh	Doda	6.0
5.	Athwatoo	Madumati	Baramulla	7.5
6.	Ranjala Dunnadi	Upeer Kalnai	Doda	7.0
7.	Tangmarg	Ferozpora	Baramulla	6.0
8.	Mandi	Mandi	Poonch	4.0
9	Boniyar	Hapatkhai	Baramulla	3.0
10.	Brenwar	Doodganga	Budgam	2.0
11.	Drung	Ujh	Kathua	2.0
12.	Thanda Pani	Thanda pani Tawi	Rajouri	2.0

An initiative to develop 50,000 MW of hydropower has been launched by Govt of India for entire country as PM initiative. Under this initiative 162 schemes have been identified at of which 142 hydro electric schemes (51311 MW) are being surveyed and investigated and their DPR is being prepared. Such PFR for the state of J&K the given in table 5.

Table 5: Hydropower Schemes for PFR are ready in J&K

Sl No	**Scheme**	**Installed Capacity Total (MW)**	**Head (m)**	**Annual Energy (GMh)**
1	Barinium	240	117.77	1170.34
2	Bichlari	35	462.60	148.29
3	Dumkhar	45	27.80	219.18
4	Kanyunche	45	28.76	223.02
5	Karkit	30	26.90	153.11
6	Kawar	320	74.00	1426.56
7	Khalsi	60	33.00	272.60
8	Kiru	430	105.33	1935.77
9	Ratle	560	92.33	2483.37
10	Shamnot	370	56.33	1650.19
11	Shuas	230	115.70	1117.87
12	Takmaching	30	18.53	145.52
13	Ujh	280	143.33	456.06
	Total	**2675**		

The survey and investigations for a large number of hydropower schemes is being undertaken by different central PSUs and state governments. 142 HE Schemes (51311 MW) are under Survey & Investigation and preparation ofr DPR. These schemes comprise of 46 Nos. (14150 MW) under 50,000 MW initiative and 96 schemes (37161 MW), other than

50,000 MW initiative. The summary of schemes under S&I highlighting few potential state is given in Table 6:

Table 6: Summary of HE Schemes under Survey & Investigations in some potential states

Region	State	From 50,000 MW initiative		Other than 50,000 MW		Total	
		No	MW	No	MW	No	MW
Jammu & Kashmir		3	1250	8	3125	11	4375
Himachal Pradesh		5	1701	9	1681	14	3382
Uttarakhand		23	3049	14	1561	37	4610
Sikkim		4	835	9	1388	13	2223
Arunachal Pradesh		7	6960	10	20835	17	27795
Total All India		46	14150	96	37161	142	51311

For development of the entire potential, survey and investigation activities of all identified projects would need to be completed by the end of the twelfth plan i.e. by 2016-17. Completion of survey and investigation activities would involve an expenditure of over Rs. 5000 crore and completion of projects would require more than Rs. 5, 00,000 crore (1 crore = 10 million) at today's prices

The Government of India plans to develop the remaining potential in coming years in table 7.

Table 7: GOI Plan for Hydropower Development

Plan	Hydropower addition MW during plans, starting with 10th successive plan	Total hydropower developed at the end of each plan MW
10th Plan 2002-07	8854	35115
11th Plan 2007-12	18000	53115
12th Plan 2012-17	30000	83115
13th Plan 2017-22	31000	114116
14th Plan 2022-27	35885	150000

4. GUIDELINES FOR DEVELOPMENT OF HYDRO ELECTRIC PROJECT SITE

The Electricity Act 2003 and Policy made there under encourages private sector to participate in generation of power generation, transmission and distribution. While thermal generation has been completely delicensed, hydro projects presently required clearances with respect to optimal utilization of water and interstate and public safety issues. Competitive bidding for purchase of power has to be initiated by a distribution licensee. The developer has to be pre-qualified. The states are required to do the exercise of prequalification. The selection of successful developer from the prequalified developers should be on the basis of tariff based bidding. The competing bidders must be required to post a bid bond (suggested figure is in the vicinity of Rs. 5-10 lac/ MW) and a performance bond (suggested figure is Rs. 10-20 lacs/MW). Failure to take up the project within a pre-specified time after the award should lead to a call on the bid bond and award to the next qualified bidder. The performance

bond should be linked to achieving specific milestones in a predefined time frame and subject to call in case of non-performance as per the PERT schedule.

The hydropower projects generally cause displacement of families and this requires relief and rehabilitation (R&R) to be provided to the affected families. The developer has the responsibility to provide relief to and rehabilitation of the project effected families. The government of India has laid down a policy on R&R, a copy of which is given as Annexure 4.5. The estimated expenditure must be included in the budget of the project. Relief and rehabilitation casts a burden on the State Government also. The States are, therefore, assisted by giving incentives such as 12% free power for mitigation of the distress among people.

The Ministry of Power has notified on 18th April 2006 the following limits above which hydroelectric projects must be submitted to the CEA for its concurrence:

(i) Rs. 25000 Crore, provided that-

a) The scheme is included in the National Electricity Plan as notified by the Authority under sub-section (4) of Section 3 of the Act and the scheme conforms to the capacity and type (run-of-river/storage) as mentioned in the NEP; and

b) The site for setting up the hydro generating station has been allocated through the transparent process of bidding in accordance with the guidelines issued by the Central Government under Section 63 of the Act.

(ii) Rs. 500 crore for any other scheme not covered by clauses (i) : (a) and (b) above.

The ministry has also through tariff policy of January 6, 2006 and subsequent clarification dated March 28, 2006, indicated Jan 6th, 2006 as the cutoff date beyond which all project proposals other than those by public sector entities must be awarded through tariff based competitive bidding.

The CEA has also guidelines for formulation of detailed project reports for hydro electric schemes, there acceptance and examination for concurrence. These are annexed.

To ensure that development of hydro projects larger then 100 MW takes place in a time bound manner a shelf of meaningful and bankable project reports, duly vetted by an agency of international repute should be available within a reasonable time. The central government will adopt mechanisms to prevent avoidable delays such as constitution of task forces, shell Companies and other statutory/ non statutory bodies which will take action in advance for activities that are time consuming.

4.1 Hydropower Clearance Guidelines Issued by CEA (Jan 2007)

Guidelines have been framed to describe the procedure to be followed by Central Electricity Authority for accord of concurrence to Hydro Electric Schemes submitted to it under Section 8 of the Electricity Act, 2003. It has objectives and scope

(i) Hydro Electric Schemes constitute an integral part of the overall development of the water resources of the river basins for multipurpose use and often are a part of a series of single or multipurpose schemes. In the overall river basing context, the impart of the operation of the upstream Hydro Electric Schemes, water availability undergoing changes over the life of the Hydro Electric Scheme on account of

progressive development in the River basin, constraints imposed by the downstream Hydro Electric Schemes, requirements of drinking water, irrigation diversion downstream, flood moderation, navigation and other related matters are to be considered.

(ii) Hydro Electric Scheme shall be designed for optimum benefits and shall not adversely affect the operation of the upstream and downstream Hydro Electric Schemes and shall take into consideration the impact of the future upstream and downstream developments in the river basing as identified by the concerned State and the Authority.

(iii) To meet the objectives as above, the following should be ensured:

(a) The Hydro Electric Schemes meets the requirement of the best ultimate development of the river basing as provided in the National Electricity Policy and National Electricity Plan.

(b) The Hydro Electric Scheme is consistent with water requirement for irrigation, navigation, flood control, drinking water or other public purposes.

(c) The Hydro Electric Scheme takes into account the progressive development of consumptive use of water and new water resources development schemes in the river basing due to which the water availability may undergo change over the period,

(d) The Hydro Electric Scheme meets the requirement of optimum location of dams and other river works.

(e) The Hydro Electric Scheme meets the norms regarding dam design and dam safety.

(f) The Hydro Electric Scheme is either included in National Electricity Plan drawn by the Authority under section 3(4) of the Act of results in generation of power at reasonable tariff.

4.2 State Policy for Hydropower

As water is a subject of state government, development of hydropower projects relates to the constitutional provision by the state government. Most potential states including J&K have announced their policy for development of small hydropower. In interstate rivers, the central government has a say in the development of projects.

4.3 Private Investment

As a result of various reforms introduced by the Government, confidence is gradually building up among private investors. An increase in interest within the private sector is illustrated by the following facts:

- At present in India, out of 17 hydro electric schemes with 1336.5 MW which are in operation, 7 schemes with a capacity of 2191 MW are under construction in the private sector.
- Further, 40 schemes (12925 MW) have been offered for development in the private sector by different states, on which work is yet to start.
- In addition, 33 schemes which will have an installed capacity of 5742 MW are under consideration for allotment to the private sector.
- During 11th &12th five year plans, capacity addition through private sector would be about (increased) 21% and 25% respectively.

5. IMPLEMENTATION EFFORTS FOR SHP DEVELOPMENT

The Ministry of New and Renewable Energy (MNRE) is responsible for Small Hydropower development. However, since the water is a subject under the jurisdiction of the State Government, primarily they have to encourage that within the broad framework prescribed by the Government of India, necessary facilities are available to the power producers. The Electricity Act 2003 provides that the State Electricity Regulatory Commissions would promote generation of electricity from Renewable sources by providing suitable measures for connectivity with grid and sale of electricity to any person and also by specifying, for purchase of electricity from such sources, a percentage of the total consumption of electricity in an area. SERCs are now determining preferential tariffs for renewable electricity. 16 States have policies in place for private sector participation (for details see chapter 3). These states have offered sites with an aggregate potential of over 2500 MW to the private sector. So far, over 120 private sector SHP projects with an aggregate capacity of about 450 MW have been set up mainly in Andhra Pradesh, Karnataka, Himachal Pradesh, Punjab, Uttaranchal and Maharashtra. Over 110 SHP projects aggregating 450 MW commissioned by the private sector.

The MNRE has been providing subsidy for public sector as well as private sector SHP. For private sector, subsidy is released after successful commissioning and commencement of commercial generation from the project, to the Financial Institution (FI). The subsidy is given for the purpose of offsetting it against the term loan provided to the Indian developer. Small hydropower scenario is given in table 8.

TABLE 8: SMALL HYDRO (UP TO 25 MW) SCENARIO

Overall Potential	15,000 MW
Identified Potential	14294 MW (5403 Sites)
Installed Capacity (as on 31. 07.2007)	2141 MW (645 Projects)
Under Construction	1233 MW (349 projects)
Target capacity addition -11th Plan (2007-2012)	1400 MW
Policy for Private Sector Development announced	16 states

State wise the status of small hydropower development is given in table 9.

6. . INCENTIVE FOR DEVELOPMENT OF SMALL HYDROPOWER

The Ministry of New and Renewable Energy has issued guidelines to the State Governments for training policy for small hydro and renewable energy development. The main features of the policies are given below:

1. 16 States have permitted private sector participation in Hydropower including SHP.
2. Charges of power wheeling vary from 2 to 5% of the power fed to the grid or generated
3. Power banking is permitted by many for a period of one year but in some cases it is for 6 to 8 months.
4. Buy back of power per unit and HP generally at the rate of Rs. 2.25 although in the case of Gujarat it is Rs. 1.75, Kerala Rs 2.50, Punjab Rs 3.01 and Rajasthan Rs. 2.75. Many States provide for annual escalation of the rates.

Table 9: State-Wise Numbers of Small Hydel Sites Up to 25 MW Capacities

State	IN OPERARTION		UNDER IMPLEMENTATION		FUTURE		TOTAL	
	Project No.	Capacity(MW) (MW)	Project No.	Capacity (MW)	Project No.	Capacity (MW)	Project No.	Capacity (MW)
Andhra Pradesh	61	190.54	51	111.25	377	251	489	552.29
Arunachal Pradesh	**82**	**46.94**	**32**	**42.635**	**452**	**1243**	**566**	**1333.04**
Assam	3	21.10	17	73.2	40	120	60	213.84
Bihar	7	50.40	13	14	74	149	94	213.75
Chhattisgarh	**5**	**18.00**	**27**	**206.2**	**132**	**482**	**164**	**706.62**
Goa	1	0.05	4	4.45	4	5	9	9.10
Gujarat	2	7.00	3	3.6	287	186	292	196.97
Harayana	5	62.70	5	10.8	23	37	33	110.05
Himachal Pradesh	**63**	**140.73**	**27**	**108.65**	**457**	**2019**	**547**	**2268.41**
Jammu & Kashmir	**31**	**110.29**	**7**	**7**	**208**	**1294**	**246**	**1411.72**
Jharkhand	6	4.05	8	34.85	89	170	103	208.95
Karanataka	84	487.37	29	123.59	15	32	128	643.16
Kerala	**18**	**119.27**	**22**	**135.3**	**207**	**454**	**247**	**708.10**
Madhya Pradesh	9	33.16	5	41.1	85	326	99	400.58
Maharashtra	**29**	**263.83**	**3**	**14.25**	**221**	**485**	**253**	**762.58**
Manipur	10	7.10	4	10.25	99	92	113	109.10
Meghalaya	3	30.71	9	1.775	90	197	102	229.81
Mizoram	17	14.81	5	16.2	53	136	75	166.94
Nagaland	9	28.67	6	19	84	149	99	196.98
Orissa	6	7.30	10	70.175	206	218	222	295.47
Punjab	29	122.55	0	0	205	267	234	390.02
Rajasthan	10	29.85	2	5.5	55	28	67	63.17
Sikkim	16	38.81	5	12.4	70	214	91	265.54
Tamil Nadu	14	89.70	7	36.15	155	373	176	499.31
Tripura	3	16.01	0	0	10	31	13	46.86
UT (A & N Islands)	1	5.25	6	1.51	5	1	12	7.91
Uttar Pradesh	9	25.10	0	0	211	267	220	292.16
Uttaranchal	**69**	**76.26**	**35**	**54.75**	**354**	**1478**	**458**	**1609.25**
West Bengal	45	99.02	17	81.25	141	214	203	393.79
TOTAL	**645**	**2141.31**	**349**	**1233.875**	**4409**	**10919**	**5403**	**14294.24**

5. Most States except Kerala, Tamilnadu, and West Bengal permit sale of power to third parties. Himachal Pradesh allows sale of power to third parties outside the State.
6. States provide other concessions such as lease of land, exemption from electricity duty and entry tax on power generation equipment.
7. Some States do not levy any water charges while some levy it as a percentage of electricity tariff.

8. All States have appointed coordinating agencies to facilitate the participation of developers.
9. Some States have prescribed the minimum quantum of power produced from renewable sources that the State Distribution Licensee must purchase.

The Ministry of New and Renewable Energy has announced by its notification no. F.NO.14/8/2004-SHP dated Dec. 26, 2006, the capital subsidy for SHP projects is for Special Category States (North-Eastern Region, Sikkim, Jammu & Kashmir, Himachal Pradesh and Uttarakhand) the amount of subsidy will be Rs. 2.25 x CMW^0.646 crore. For Other States the amount of subsidy will be Rs. 1.5 x CMW^0.646 crore. (CMW means SHP stations capacity in MW)

7. CONTRIBUTIONS BY AHEC IN J&K SHP DEVELOPMENT

Alternate hydro Energy Centre , IIT Roorkee is contributing in its limited capacity for small hydropower development in the state of J&K.

Table 10 ; List of Projects for which DPR and Tenders have been prepared

Sl.No.	PROJECT	CAPACITY (k.W)	District	Report prepared	Tender prepared
1	Hanu	2x1500	Leh	Dec. 2003	Dec. 2006
2	Tangtse	2x250	Leh	Dec. 2003	Mar. 2006
3	Dha	2x1500	Leh	Dec 2003	Mar.2006
4	Kumdok	2 x 75	Leh	Dec 2003	Nov. 2005
5	Chilong	2x200	Kargil	Jan. 2004	Mar.2006
6	Thusgam	2x250	Kargil	Jan 2004	Mar. 2006

Table 11 : List of Projects for which DPR have been prepared

Sl.No.	PROJECT	CAPACITY (k.W)	District	Report prepared
7	Rajouri	3x1000	Rajauri	March 1995
8	Umbulung	2x10000	Kargil	Jan 2004
9	Gulabgarh	2x600	Udhampur	Jan 2004
10	Sasoma	3x250	Leh	Jan. 2005
11	Bogdong	3x300	Leh	Jan. 2005
12	Dumkhar	2x250	Leh	Jan. 2006

Table 12 :List of R & M Projects

Sl.No.	PROJECT	CAPACITY (k.W)	District	Report prepared
13	Stakna	2x2000	Leh	Jan. 2005

Table 13 : List of Projects for which DPR are under Preparation

S.N	PROJECT	CAPACITY (k.W)	District	Remark
14	Wakha	2x600	Kargil	Report to be prepared by Nov 2007
15	Thambis Kanore	22x100	Kargil	Report to be prepared by Oct 2007
16	Chingus	2x500	Rajauri	Report to be prepared by Sep 2007

8. BENEFITS UNDER CLEAN DEVELOPMENT MECHANISM (CDM)

Hydropower Projects provide an excellent opportunity availing the benefits under CDM for carbon trading. The purpose of a hydropower project activity is to generate electricity using renewable hydro energy and supply it to various consumers through National grid. In the Northern Regional grid more than 70% of the power supplied is generated using fossil fuels (coal, Diesel, Gas etc) and as the project activity is a renewable energy based power project, it will reduce anthropogenic Green House Gases (GHG) emissions that would have been generated to supply power to NR grid using fossil fuel. The hydropower project activity shall also contribute to sustainable development in following manner:

- Sustainable development through utilization of renewable hydro resources available in the project region.
- Catering to power demand in Northern India by augmenting power supply in the NR Grid.
- Conservation of natural resources (like coal, gas, petroleum fuels etc.) through use of renewable source of energy.
- Adhering & contributing to India's national policy of promoting clean power.

The hydropower project applies the approved baseline methodology ACM0002 "Consolidated baseline methodology for grid-connected electricity generation from renewable sources" (version 06) for availing the CDM benefits.

The application of the approved baseline methodology is justified as the proposed project is a grid connected run-of-river hydro power project. The generated electricity will be supplied to the Northern region grid and adequate data is available to estimate the grid emission factor.

The baseline scenario as per CEA prepared document is that electricity delivered to the grid by the project would have otherwise been generated by the operation of grid-connected power plants and by the addition of new generation sources, as reflected in the combined margin.

As the project activity is feeding power to the J&K state grid which is a part of northern regional grid, the baseline for this project activity is the function of the generation mix of northern regional grid. The weighted average of the "operating margin" and the "build margin" emission coefficient for northern regional grid of India has been estimated to be 0.737 tCO_2e / MWh.

9. PROBLEMS BEING FACED IN EXECUTION OF SMALL HYDRO PROJECTS

General problems in executing small hydro electric projects in India are listed below:

1. Environment
2. Forest clearances
3. Political (change of parties)
4. Delay in issuing license like blasting, stone crushers, quarrying of river
5. Lack of liaison and coordination (with multiple cooperation)
6. Delay in design drawings for execution

7. Political interference
8. Labour laws
9. Lack of involvement of local people
10. Lack of cooperation from local population
11. Shortage of local labour, local contractors, quality assurance, manpower
12. R&R issue in some specific cases
13. Lack of awareness of utilizing power potential on existing water supply schemes and irrigation water releases.
14. Lack of awareness and legal tools with state government to regulate minimum flows in the streams.

Specially for J&K

15. Starting the execution of project without achieving financial closure.

10. HUMAN RESOURCE REQUIREMENT

Hydropower involves a multi-disciplinary for planning, design, execution and operation & maintenance. Civil, electrical, mechanical, electronic engineering and socio-economy are the disciplines in which hydropower personnel needed to be trained. Being small it cannot have luxury of having persons specialist in each discipline. Small hydropower may need personnel having fairly good background in each of these fields.

10.1 Manpower Requirement for SHP

In an optimistic estimate, a plant of 1 MW (an average size) requires the human resource as given in Table 14.

Table 14: Man power requirement for SHP

Stage	Education Level		
	Engineering	Diploma in Engg	Technician ITI
Planning	1	1	2
Design	1	1	--
Execution	½	2	1
O&M	¼	1	4
total	2.75	5	7

10.2 Availability of Manpower for SHP Development

Due to rather difficult conditions in the areas where hydropower source exist the volunteers to take up hydropower as their field of expertise, are not easily available. One needed to motivate the person, may be by training local people only specially at Energy Diploma & Technician level. The multi disciplinary specialist course(s) at different level to match the requirement is required.

11. EQUIPMENT MANUFACTURING BASE IN INDIA

India has a reasonably well-established manufacturing base for the full range and type of small hydro equipment. There are over 11 manufacturers (some of them international tie up) in the country in the field of small hydro manufacturing/ supplying various compact and efficient types of turbines, generators, control equipment, etc given in Table 15.

Table 15: Manufacturers – For small hydropower generating equipment in India

S No	Manufacturers	Collaboration	Type
1	Alstom, Baroda	Alstom, France	JV
2	BHEL, Bhopal	Fuji, Japan	Technical
3	Boving Fouress, Bangalore	Kvaernaener Boving now GE UK/ Norway	JV
4	HPP, Delhi	HPP France	JV
5	Jyoti, Vadodra	Gilks, UK (now expired), Turbo Institute of Slovenia	Technical
6	Kirloskar, Pune	Ebara Corp , Japan	Technical
7	VA Tech Escher Wyss Flovel, Faridabad	VA Tech, Austria	JV
8	Flovel Mecamidi, Faridabad	Mecamidi, France	JV
9	Steel Industies, Thissur	Koessler,Ausria	Technical
10	USMIL, Sahibabad	US	Technical
Offices of Voith Siemens (Germany), ABB, Fuzi and Hitachi (Japan), Technip Ganj (Hungary), CKD Blansko (Czech) are there in India			

(Source: Indian Manufacturers)

12. PERFORMANCE TESTING AND EVALUATION

Since year 2003 Ministry of New and Renewable Energy sources introduced the concept of testing and performance evaluation of SHP projects with the release of subsidy with aim of improving the quality and performance of Small Hydro Power (SHP) stations in the country. By testing and performance evaluation one confirms that all parts, systems and auxiliaries in the power station are performing their assigned functions correctly and that the generating units are operating efficiently as planned.

Alternate Hydro Energy Centre (AHEC), IIT Roorkee due to its long and vast experience in SHP was entrusted the responsibility of testing and evaluation. AHEC has carried out testing and evaluated the performance of 22 SHP stations so far.

With such initiative the SHP developers have started taken the keen interest by way providing the necessary conditions and making the provisions in the structure/ equipment for facilitating the testing and such evaluation help plant owners for regular monitoring of performance of their plant.

13. STANDARDS FOR SHP DEVELOPMENT:

To make Small Hydropower cost effective, reliable and quality standards, guidelines and manuals are required covering entire range of shp activities. Necessity of the standards/ guidelines and manuals was long felt by developers, manufactures, consultants, regulators and others. AHEC has been entrusted to prepare the standards, guidelines for SHP through consultative process recently

14. ACTIVITIES IN SMALL HYDROPOWER PROJECT CYCLE

SHP projects involve certain activities. In the table 16, the main activities have been listed and the time taken in each has been estimated.

Table 16: Activities and Time Taken for Small Hydropower Project Cycle

	Activities	Time Taken
A.	**Administrative**	
	Advertisement	Yearly
	Allotment	6 months to one year
	Signing of implementation agreement	1-3 months
B.	**Pre- implementation**	
	Detailed Investigation & surveys	4 months – 2 years
	Pre feasibility Report (PFR)	1-3 months
	Detailed Project Report (DPR)	3-6 months
	Approval of DPR	4-6 months
	Land Acquision – Forest Land Acquision – Civil Land Acquision - Private	6- 4-12 months 4-12 months
	Clearance for Environment	4-12 month concurrently
	Power purchase agreement	2-4 month concurrently
	Clearance from different	6 months concurrently
	Preparation of plan for Resettlement & rehabilitation	Normally not involved
	Financing	3-6 month concurrently
C.	**Implementation**	
	Construction License	2-3 months
	Engineering design & construction drawings	3-6 month concurrently
	Equipment supply	8-16 month concurrently
	Civil works construction	10-18 months concurrently
	Resettlement & rehabilitation	Normally not involved
	commissioning	12-24 months concurrently
D.	**Post commissioning**	
	Receipt of payment from utility / trading / user	1 month
	Refund of borrowing to FIs	As per schedule

15. ACKNOWLEDGEMENT

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16. REFERENCES:

1. "Hydropower and World's Energy Future", Paper by IHA, IEA, ICOLD, CHA, Nov. 2000.
2. "SHP – Initiatives and Private Sector Participation", III Edition, AHEC, IIT Roorkee, May 2003.
3. Arun Kumar, "Small Hydropower Development in India", International Hydropower Association India, New Delhi, Oct. 2004.
4. Naidu, BSK, "Planning and Management of Hydro Power Resources in India", CBIP, New Delhi, July 1992.
5. Sharma, J.D. and Arun Kumar "Country Paper", Experts' consultative on private MMHP Development in the Hindu Kush Himalayan Region - A review of inputs and Methodologies, Feb.' 98, Kathmandu.
6. Sectorial Overview Report On Hydropower Development In India, Royal Norwegian Embassy, New Delhi and AHEC, IIT Roorkee, Feb 2007.
7. Sectorial Overview Report On Small Hydropower Development In India, Sun Technics Energy Systems, Bangalore & AHEC, IIT Roorkee, March 2007.
8. Shafat Sultan, "Developing of Small Hydropower in Jammu & Kashmir (India)", In SHP International Conference, Hangzhou, April 2005.
9. PDD, Allain Duhangan Hydroelectric Project (ADHP), UNFCC site, April 2007
10. Central Electricity Authority CO2 Baseline Database for the Indian Power Sector User Guide Version 2.0, June 2007