

Preliminary Ranking Study of Hydro Electric Schemes

Central Electricity Authority have completed the preliminary ranking study of hydro electric schemes to harness the hydro electric potential in the country. Hon'ble Union Minister of Power Shri Suresh Prabhu released the report "Preliminary Ranking Study of Hydro Electric Schemes" on 5th February 2002 at the International Conference and Exhibition Meet on Non-fossil fuel generation organized by NHPC, CII and NPCL under the aegis of Ministry of Power and Mineral Non-Conventional Energy Sources. The identified potential hydro electric sites in the various river basins have been prioritized in the reports in the order of their attractiveness for implementation. The ranking studies would serve as a guide for the potential developers to choose hydro schemes for investigations and implementation. The report is in seven volumes under.

Volume	Description	Price (Rs)
Volume - I	General Report	300/-
Volume - II	Preliminary Ranking Study of Indus Basin	300/-
Volume - III	Preliminary Ranking Study of Ganga Basin	300/-
Volume - IV	Preliminary Ranking Study of Brahmaputra Basin	300/-
Volume - V	Preliminary Ranking Study of West Flowing River System	300/-
Volume - VI	Preliminary Ranking Study of East Flowing River System	300/-
Volume - VII	Preliminary Ranking Study of Central Indian River System	300/-

The report may be obtained from Joint Secretary (Adm.), Electric Power Information Society (EPIS), Central Electricity Authority, Sewa Bhawan, R.K. Puram New Delhi 110066 by sending an A/C payee demand draft drawn in favour of 'Secretary Electric Power Information Society' payable at New Delhi for the price of report(s) plus postage charge 50/- each.

The Volume-I of the report is available on this site.

GENERAL REPORT

1.0 PHYSIOGRAPHIC FEATURES OF INDIA

Physiographically India can be divided in three major divisions namely Himalayas and their associated young fold mountain block of Peninsular India and the Indo-Gangetic plains lying between the two. The three regions are vastly different in geology and in character of their terrain. Out of these three divisions, the Himalayan range comprising Greater Himalayas, the Lesser Himalayas and the Shivalik range possess vast hydro potential. Greater Himalayas being inaccessible provide little opportunity for hydro potential but they do act as reservoirs of water for all the rivers of this range. This leaves the other two ranges viz. Lesser Himalayas and Shivalik as potential source for development of hydro electric potential.

2.0 MAJOR RIVER SYSTEMS

For the purpose of hydro electric potential survey, the country has been classified into six major river systems namely Indus, Brahmaputra, Ganga, Central Indian River System, East flowing River System and West flowing River System. These river systems have been further divided into 49 basins. The details of these river systems/basins are given below:

INDUS BASIN:

The Great Indus basin draining areas in the states of J&K, Himachal Pradesh and Punjab is one of the major basins of the Great Indus basin comprises six major rivers namely Indus, Jhelum, Chenab, Sutlej, Ravi and Beas. Rising in Tibet +5182m behind the mountains of Great Himalayas, Indus River traverses a total of about 2880 CMS. of which about 1114 CMS. is 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. is in the Indian territory.

GANGA BASIN:

The Ganga basin with about 1/4th of the total geographic area of the country has a total drainage area of about 10.5 lakh sq. Kms. of which about 8.7 lakh sq. Kms. lies in India. The basin covers areas in U.P., Punjab, Haryana, Himachal Pradesh, Rajasthan, Madhya Pradesh, Bihar, West Bengal and Delhi. The basin comprises rivers like Upper Ganga, Upper Yamuna, Lower Yamuna, Lower Ganga, Gomti – Ghaghra, Sone, Betwa – Sind, Kosi- Gandak- Mahananda, Lower Ganga, Damodar.

BRAHMAPUTRA BASIN:

The Great Brahmaputra Basin with a total drainage area of about 5.54 lakh sq. Kms. of which about 2.65 lakh sq. Kms. lies in India. The basin covers areas in the states of Arunachal Pradesh, Assam, Meghalaya, Manipur, Tripura, Mizoram, Nagaland, Sikkim and a substantial part of West Bengal. The Great Brahmaputra Basin, including Barak and other south flowing rivers of North-Eastern states, has been divided into several sub-basins. The rivers in this basin are Upper Brahmaputra, Teesta, Subansiri, Kameng, Kalang, Dihang-Dibang, Lohit, Lower Brahmaputra, Barak and neighboring river system.

CENTRAL INDIAN RIVER (CIR) SYSTEM:

The Central Indian River system involves a total of 105 rivers with a total river course of about 19,780 Kms. This system covers an area of about 7.6 lakh sq. Kms. contains eight major river basins namely Narmada, Tapi, Subernrekha, Brahmani-Baitarni, Sabarmati, Mahi and Luni-Banas and other rivers of Rajasthan and Gujarat.

WEST FLOWING RIVER (WFR) SYSTEM:

The West flowing river system of Southern India has a length of about 1540 Kms. with width varying from a minimum of 40 Kms. to a maximum of 130 Kms. and covers almost whole of Kerala, Goa, Union Territory of Daman and Diu, parts of TamilNadu, Karnataka, Gujarat and Konkan Region of Maharashtra State. This basin comprises of rivers like Minodhola – Damanganga, Vaitarna-Sardar, Vashishta –Tillari, Mandvi – Sharavathi, Varahi – Kuttiyadi, Baypore – Periyar and Pamba – Paraliyar.

EAST FLOWING RIVER (EFR) SYSTEM:

The East flowing river system of Southern India constitutes the largest river system of the country draining a total catchment area of about 10.5 lakh sq. Kms. and comprises major inter-state basins of Godavari, Krishna, Cauvery and other rivers. In this river system, the major rivers account for a major part of about 73% of the entire drainage area. This river system consists of rivers between Mahanadi and Godavari, Godavari, rivers between Godavari and Krishna, Krishna, rivers between Krishna and Penner, Penner, rivers between Cauvery and Cauvery, Cauvery and rivers between Cauvery and Kanyakumari.

3.0 HYDRO POTENTIAL OF INDIA & ITS ASSESSMENT

3.1 FIRST SURVEY (1953-59)

The first systematic and comprehensive study to assess the hydro-electric resources in the country was undertaken during 1953-1959 by the Power Wing of the erstwhile Central Water and Power Commission on the basis of prevailing technology, construction and the constraints imposed by topographical and hydrological considerations etc. These studies placed the utilizable hydro power potential of the country at 42100 MW at 60% load factor (corresponding to an annual energy generation of 180000 units).

The basinwise potential was assessed as below:

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Basin/Rivers	Potential at 60% Load Factor (MW)
Indus	6583.00
Ganga	4817.00
Central Indian Rivers	4300.00
West-flowing Rivers	4350.00
East-flowing Rivers	8633.00
Brahmaputra	13417.00
Total:	42100.00

3.2 RE-ASSESSMENT STUDIES (1978-87)

The re-assessment studies of hydro-electric potential of the country, completed by Central Electricity Authority in 1987, found a hydro power potential at 84044 MW at 60% load factor. A total of 845 hydro-electric schemes have been identified in various basins which will yield 442 billion units of electricity. With seasonal energy, the total energy potential is assessed to be 600 billion units per year. In addition, the reassessment studies have also identified 56 sites for Pumped Storage Schemes (PSS) with total capacity of about 94,000 MW. The hydro potential of 84044 MW at 60% load factor when fully developed would result in an installed capacity of 1,50,000 MW on the basis of probable average load factor.

The Great Indus, the Ganga and the Brahmaputra rivers with their innumerable tributaries originating from the Himalayas constitute about 70% of the country's assessed hydropower potential. The peninsular plateau, flanked on one side by the Eastern Ghats and on the other side by the Western Ghats is a receptacle of enormous hydro power. The basin-wise estimated hydro potential and probable installed capacity are given below:

Basin/Rivers	Potential at 60% Load Factor (MW)	Probable Installed capacity (MW)
Indus	19988.00	33832.00
Ganga	10715.00	20711.00
Central Indian Rivers	2740.00	4152.00
West-flowing Rivers	6149.00	9430.00
East-flowing Rivers	9532.00	14511.00
Brahmaputra	34920.00	66065.00
Total:	84044.00	148701.00

3.3 ASSESSMENT OF SMALL HYDRO POTENTIAL (1987-96)

In addition to potential of medium and major hydro schemes, a sizable potential also exists for development of micro, mini and pico hydro schemes on rivulets and canal drops. A systematic study for the development of small hydro potential was undertaken in 1987 and completed during June, 1996. As per this assessment, 1512 small hydro-electric schemes having aggregate installed capacity of above 6782 MW on canal falls/rivers have been identified.

4.0 PRESENT STATUS OF HYDRO DEVELOPMENT:

On all India basis, as on 1.9.2001, the hydro Electric schemes in operation accounts for only 16.7% and those under execution for 1.5% of the total potential. Thus the bulk of the potential (77%) remains yet to be developed. The basin-wise details of present hydro development are given at Annexure-I. The maximum exploitation has been achieved in west flowing rivers of South India and the least development is in respect of Brahmaputra basin at 1.54% though this basin has maximum potential.

The region-wise/state-wise details of the hydro potential and its development are given at Annexure-II. It would be seen that the hydro potential is available in Arunachal Pradesh at 26,756 MW at 60% load factor (probable installed capacity around 11,647 MW) followed by Himachal Pradesh at 11,647 MW at 60% L.F. (probable installed capacity about 25,000). The potential in other states is relatively less.

Out of 845 schemes identified by CEA in Reassessment Studies, at present, 288 hydro schemes with an aggregate installed capacity of 1,50,000 MW are in operation.

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42,000 MW are either under operation / implementation or cleared by CEA. The balance schemes include about 164 sc which having an installed capacity of 25 MW or less, development of which stands transferred to Ministry of Non-Conv Sources. Total installed capacity of such schemes is about 2300 MW. Thus, about 400 schemes having total likely insta about 1,00,000 MW are yet to be considered for development Category wise break –up of the schemes is summarised below

	Appx. Inst. Capacity	
	Nos	(MW)
SCHEMES IDENTIFIED (Reassessment studies 1978-87)	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

5. STRATEGY FOR DEVELOPMENT OF BALANCE HYDRO POTENTIAL

It is proposed to take up the balance 400 schemes for systematic development of remaining capacity of about 1,00,000 MW 1,50,000 MW available Hydro power capacity in the country in the phased manner as per the following Action Plan:

PHASE I - VISION PAPER

A vision paper highlighting comprehensive approach for development of 1,50,000 MW of Hydro Power corresponding to potential of 84044 MW was prepared by CEA and submitted to Ministry of Power during March 2001. This gives a road map for hydro development so as to harness total potential by 2025-26.

PHASE II – PRELIMINARY RANKING STUDY

The Prioritization of the schemes yet to be developed based on the available data and weightage criteria for various aspects of development of a hydro project has been done under this phase. This would provide inter-se-prioritisation of schemes to be implemented in a systematic manner. Ranking Study has been made generally based on desk studies of all secondary and hydrological data. For this purpose latest topo sheets have been obtained from Survey of India. Land use aspect Satellite maps obtained from NRSA and inputs from state authorities have also been addressed for Indus Basin at first study will form a base for Detailed Ranking Study and later on, for preparation of Pre-feasibility Reports.

PHASE III – DETAILED RANKING STUDY

Based on the preliminary ranking study, further studies would be carried out for schemes considering land use aspects, power evacuation aspects, cost estimates, tentative tariff etc. so as to arrive at detailed/final ranking of the schemes.

6.0 THE VISION PAPER AT A GLANCE

The Vision Paper outlines the approach and provides a road map for development of the balance untapped potential of the year 2025-26. The paper analyses the Anticipated Demand-Supply scenario likely to prevail in the country by making use of Long term Perspective Plan Studies carried out by CEA (up to the end of 11th Plan i.e. 2011-12) as well as Demand Forecast up to the end of 12th Plan (2016-17) as per 16th Electric Power Survey

The Demand Projections for the period beyond 2017 have been made by extrapolating the projections made in 16th EPS above, the demand for power by the year 2025-26 is likely to be of the order of 353000 MW with corresponding probable increase of 463000 MW. Further, hydro capacity additions in different Plan periods till 2025-26 have been so planned as to develop

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potential by the year 2025-26 which would gradually improve the share of the hydro in the system to about 32% by 2025-26.

The Paper discusses about status of hydro schemes under various stages of Development i.e. projects under construction, under examination in CEA, under Survey & Investigation etc. and outlines various factors inhibiting the growth of hydro in the country. It stresses upon the need to complete the on-going projects and to develop the projects already cleared by CEA. It also stresses upon the need to carry out Survey and Investigations works in a time bound manner by the year 2016-17 in development of the balance hydro potential in the country by the year 2025-26.

The Vision Paper analyses projects languishing due to various reasons like funds constraints, Inter-state aspects etc. and suggests quick development by addressing the involved issues at appropriate level. In addition, by resolving the pending issues, 4,000 MW installed capacity of about 13250 MW, which were examined earlier in CEA and returned to project authorities for resubmission, can be taken up for implementation with minimal of S&I works.

The Vision Paper suggests the Action Plan/ Methodology for preparation of Pre-Feasibility Reports for balance about 40,000 MW. It broadly discusses criteria for carrying out prioritisation / ranking study for their development in order to provide a shelf of projects in each basin which could be developed in a systematic manner starting from sites which are ranked to be attractive.

The Paper proposes carrying out of Survey and Investigation of the selected schemes by Central Agencies like CWC, NT, WAPCOS etc. These S&I activities have been proposed to be completed in next 10-15 years so as to accomplish development of untapped potential in the country by 2025-26. The cost of development of the remaining untapped potential in the country is estimated as about Rs. 5,00,000 Crs. while requirement of funds by 2016-17 for carrying out S&I activities would be of the order of 5000 Crs. In view of the massive fund requirements over next 20 to 25 years, the paper impresses upon the need to explore all avenues for mobilisation of funds.

The Vision Paper also calls for review of studies carried out for Re-assessment of Hydro Electric Potential of major/ medium size projects to bring out most realistic features of the sites by making use of updated hydrological/ topographical data with inter-action v

The paper contains following recommendations for expeditious development of the balance hydro potential in the country by 2026:

- About 4759 MW of hydro capacity can be added without much of efforts, if funds to the tune of Rs.14522Crs. are available. These include projects languishing due to funds constraints and those projects that are awaiting Planning Commission/ CC approval.
- By expeditious resolution of pending issues, the "Returned" projects could be taken up for implementation which would add to the addition of about 13268 MW of Hydro capacity in the Indian system at a cost of about Rs.35,000Crs. In addition, by resolving inter-state aspects, about 4797 MW of capacity could be added to the system at an estimated cost of about Rs. 13500 Crs. Preliminary surveys and investigations for most of these schemes have already been carried out for preparation of Detailed Project Reports. These projects could be taken up immediately for implementation and are likely to yield benefits during the next 10-15 years.
- In order to achieve development of an installed capacity of about 150,000 MW from the entire identified hydro potential in the country (excluding about 25,000 MW already developed), Plan-wise additions of hydro capacity has to grow substantially above present levels to comparatively much higher additions during the subsequent Plans as given below:

Plan Period	Likely Hydro Capacity Addition (MW)	Likely funds requirement (Rs. Crs.)
9th Plan (1997-2002) (Balance)	5800	23200
10th Plan (2002-2007)	10432	41728
11th Plan (2007-2012)	21288	85152
12th Plan (2012-2017)	23000	92000
13th Plan (2017-2022)	31000	124000
Part 14th Plan (2022-2026)	35000	140000
Total :	126520	506080

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- The total requirement of funds for development of entire untapped potential in the country is likely to be around Rs.5, the next 25 years at present price level.
- The sources / agencies for raising necessary funds need to be identified well in advance to arrange large fund requirement of about Rs.1,00,000Cr. per plan period on an average i.e. about Rs.20,000Cr. on an average per annum, so implementation of these projects could be undertaken expeditiously.
- In order to develop the entire potential by the year 2025-26, Survey & Investigation activities have to be completed by 12th Plan i.e. by 2016-17. Completion of Survey & Investigation activities by the year 2016-17 for development of balance 1,50,000 MW by 2025-26 would involve an expenditure of around Rs.5,000Cr.
- Prioritisation studies would be carried out for ranking of the schemes for their implementation considering their relative attractiveness in terms of their location, cost effectiveness, minimal civil works etc. based on the available data. They provide classification of schemes to be undertaken for implementation in a systematic manner starting from sites of low risks to others having difficult terrain and accessibility.
- The share of hydro in the system would gradually improve from 25% at present to about 32% by 2025-26 as given below

PLAN PERIOD	Likely I.C. (MW) at the end of Plan Period		Hydro as % of Total
	Total	Hydro	
9th Plan (1997-98 to 2001-02)	108362	29593	27
10th Plan (2002-03 to 2006-07)	160034	40025	25
11th Plan (2007-08 to 2011-12)	212107	61613	29
12th Plan (2012-13 to 2016-17)	279000	84000	30
13th Plan (2017-18 to 2021-22)	370000	115000	31
Year 2022-23 to 2025-26	463000	150000	32

7.0 METHODOLOGY FOR PRELIMINARY RANKING STUDY

Ten major aspects pertaining to development of the identified projects, which play vital role in the implementation of the project, have been adopted in the criteria considered for ranking study. For each of the criteria, certain mark with weightage ranging from 0 to maximum of 15 has been allotted on its applicability to each individual project. The brief details of the aspects are given below:

- i. R&R Aspects:** This aspect has been one of the main reasons for delay/ problems in the execution of the projects. The environmental and forest aspects have also been considered. Generally large storage projects in view of vast area involved cause these problems. 10 marks have been allocated for project which do not involve large storage and no marks allocated to project with large storage/submergence. Further, for every 50 persons affected due to submergence, 1 mark deducted subject to a maximum of 10 marks for 500 and above affected population.
- ii. International Aspects:** The development of projects located in Indus basin (viz. Indus main, Chenab, Jhelum) are covered under Indus Water Treaty and involve International aspects. There are certain restrictions in development of H.E Projects in Indus basin. 15 marks have been allocated to projects, which do not involve international aspects and 0 marks allocated for schemes in Indus basin viz. Main Indus, Jhelum and Chenab River as such projects are likely to have longer gestation period due to international aspects.
- iii. Interstate Aspect:** Several HE schemes have been held up due to non-resolution of interstate problems and allocation of water between the riparian States. Projects, which are not likely to have interstate problem have been given 15 marks and schemes involving interstate problem 0 marks. All the schemes in Cauvery basin have been held up due to non-resolution of interstate aspects. It is however not possible to identify the various likely interstate problems, at identification stage.
- iv. Potential of Schemes:** The schemes having potential of 500 MW and above at 60% load factor have been given 10 marks. The reduction of potential of every 100 MW, 1 mark have been deducted to provide weightage for higher benefits from the schemes.
- v. Type of Scheme:** For ROR without storage type development 7 marks have been allocated while for ROR with storage type development 10 marks have been allocated.

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development 0 marks have been given. ROR schemes provide useful peaking power with diurnal storage only.

- vi. Height of Dam:** Out of maximum of 10 marks for schemes with dam height upto 50m height full marks are allotted & additional 20m beyond 50m height, 1mark is deducted.
- vii. Length of Tunnel/Channel:** Construction of long tunnel in mountainous region has caused delays and long gestatio of maximum of 11marks allocated for this aspect, for each 1km. of tunnel involved, 0.5 marks have been deducted . Channel length upto 10 kms. have been allotted 11 marks, thereafter 0.5 marks have been deducted for each additic channel length.
- viii. Accessibility to Site:** 0 marks have been allocated to schemes located in higher reaches of the rivers where acces difficult and other schemes which are topographically accessible have been allocated 8 marks.
- ix. Status of the Project:** Identified schemes where no developmental activity have been initiated has been given 0 ma schemes which are under S&I stage have been given 3 marks and for those schemes which have been cleared by C prepared are given maximum 8 marks.
- x. Status of Upstream or Downstream Hydel Development:** Maximum of 6 marks have been given for projects havir upstream or downstream projects already developed. Since this would be very useful in terms of infrastructure and o already available for implementation of the projects. Other schemes, which do not have any upstream, or downstrea developments in place have been allocated 0 marks.

The schemes are categorized into following grades depending upon the total marks obtained by each of the scheme base mentioned criteria.

Category / Grade	Total Score (Marks)
A	80 & above
B	60 to 79
C	40 to 59
D	20 to 39
E	up to 19

8.0 DETAILED RANKING STUDY

The detailed ranking of schemes include the land use aspects, submergence cost economics etc. based on the sat Detailed Ranking will be done for all basins but at present , for Indus basin, land use aspects based on satellite maps inputs from state authorities have been addressed. Besides weightage criteria, land use aspects have been given due c Indus basin while ranking of schemes. Due to paucity of time, satellite maps for other basins have not been obtained. The would be reviewed after obtaining satellite imageries from NRSA and the ranking may undergo some change. After cc detailed ranking study, preparation of Pre-feasibility Reports (PFRs) of selected schemes could be taken up by concerned a

9. CONCLUSION

Based on the preliminary Ranking Study, about 400 schemes with an aggregate installed capacity of about 1,07,000 I prioritised in all the six River Systems of the country. Out of this, 98 schemes with probable installed capacity of 15,650 MW Category, 247 schemes with probable installed capacity of 69,850 MW under "B" category and 54 schemes with pr capacity of 21,420 MW under "C" category. The Basinwise details are given at Annex-III to VIII.