

User guide for Large Hydroelectric Projects

**India Energy Security Scenarios,
2047**

Contents

I Overview of the large hydroelectric sector.....	3
II Drivers	3
III Assumptions	4
IV Trajectories	5
V References.....	7

I Overview of the large hydroelectric projects sector

The Indian power sector is largely thermal-based, with nearly 68% of the installed capacity accounted for by coal, gas, and diesel-based plants. Large hydro and other Renewable Energy Sources (RES – Small hydro, biomass, solar and wind) account for 17% and 12% respectively as of September 2013.

Capacity addition in the 12th Plan (2007-2012) is in accordance with the Government's Low Carbon Growth strategy for sustainable development of the power sector in the long run. The 12th Plan estimates a capacity addition in generation by conventional sources of about 76,000 MW by 2017, to meet the projected energy demand in the country. Of this, emphasis has been given to sustainable energy sources for nuclear, hydro and RES to reduce greenhouse gas emissions. In order to accelerate hydro power development in India, the Ministry of Power (MoP) introduced the National Policy on Hydropower Development in 1998. Through various measures, the Government of India (GoI) aims to realize 100% hydropower potential for the country by 2025 – 26. To this effect, the Central Electricity Authority (CEA) has undertaken feasibility and ranking studies in order to determine the feasible completion of large and small hydro projects that are under development, in the 12th and 13th Plans.

As per the CEA, India has nearly 1, 50, 000 MW of economically exploitable large hydro potential. This is available mainly in the Brahmaputra, Indus and Ganga river basins, at a Load Factor (LF) of 60% or lower. Figure 1 and Table 1 represent the major river basins and their share in the installable potential.

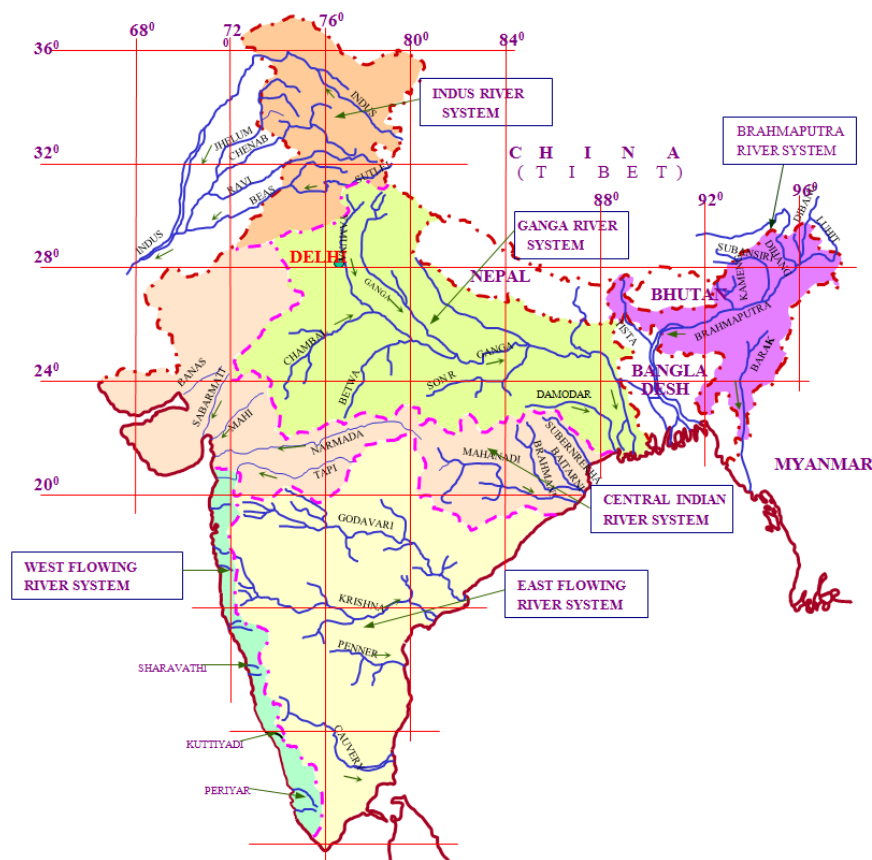


Figure 1: Basin-wise Large Hydro potential in India

Source: CEA

Table 2: Basin-wise Large Hydro potential in India (CEA)

River Basin	Probable installed cap. (MW)
Indus	33, 832
Ganga	20, 711
Central Indian rivers	4, 152
West flowing (southern)	9, 430
East flowing (southern)	14, 511
Brahmaputra	66, 065
Total	~ 1, 49, 000

Of the estimated potential, around 39, 416 MW is currently installed. The trend in the growth of installed capacity in the Hydro sector, and its current position, is indicated in Figures 2 and 3. Large hydro projects, however, are accompanied by significant ecological impacts and displacement of local population and livelihoods, which limits its viability to account for a major share of the electricity generation mix in the long run. (The share of small hydro generation in the power sector has been accounted for in the trajectories of the Renewables sector).

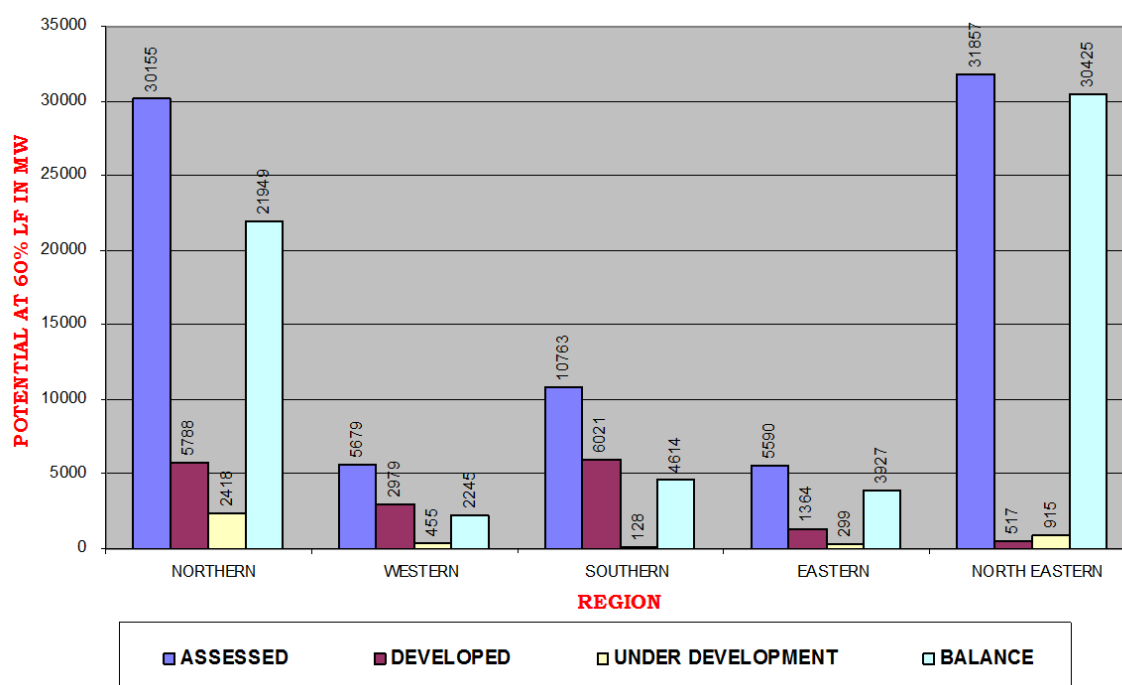


Figure 2: Status of Hydro Potential Development in India

Source: CEA

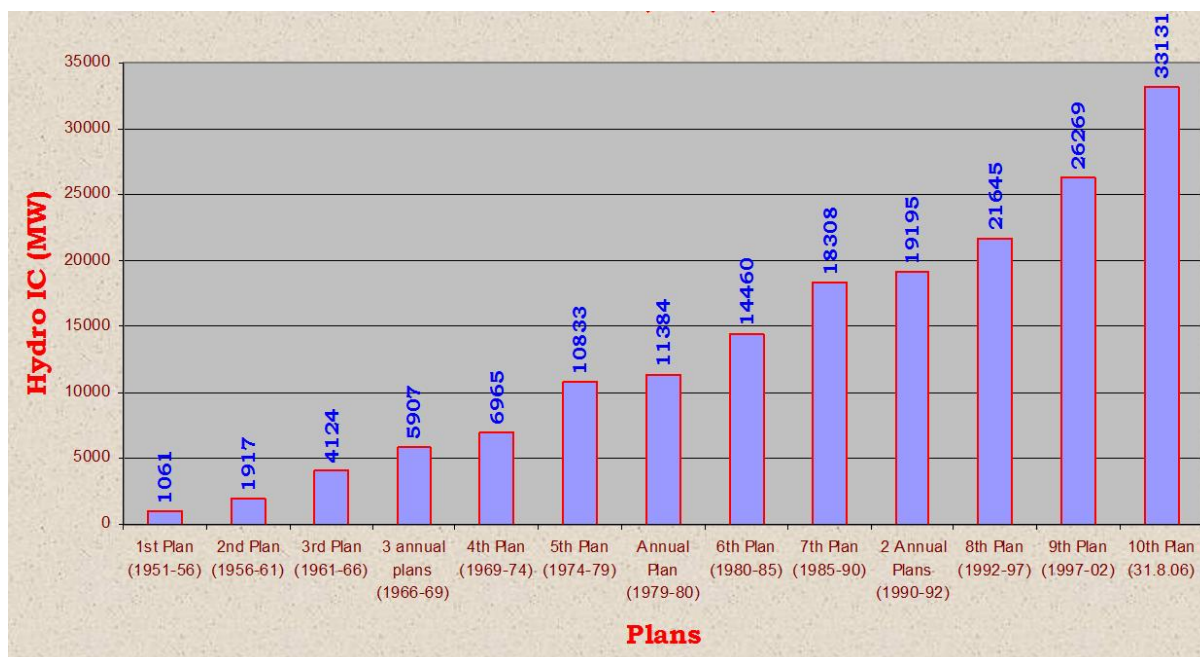


Figure 3: Plan-wise growth of Hydro Installed Capacity (IC) in India

Source: CEA

In addition to large hydro, Pumped Storage Plants (PSP) provides flexibility to dispatch, if accompanied by short-term storage (pondage). This can be of value in balancing the intermittency that would be introduced by increased penetration of other RE sources such as wind and solar in the electricity mix. Similarly, pumped hydro storage schemes utilize off-peak electricity from intermittent sources to pump water from a river or lower reservoir, to a higher reservoir to allow its usage during peak times. Other advantages of PSP include increasing the availability of reactive capacity for regulation, provision of spinning reserves in the system to meet sudden load changes in the network. PSP may result in considerable savings in fuel usage when operated in an integrated manner. At present, for the purpose of calculating the trajectories, the capacity added through pumped hydro schemes have not been accounted for, as their usage is dependent on the extent of RE penetration in the grid.

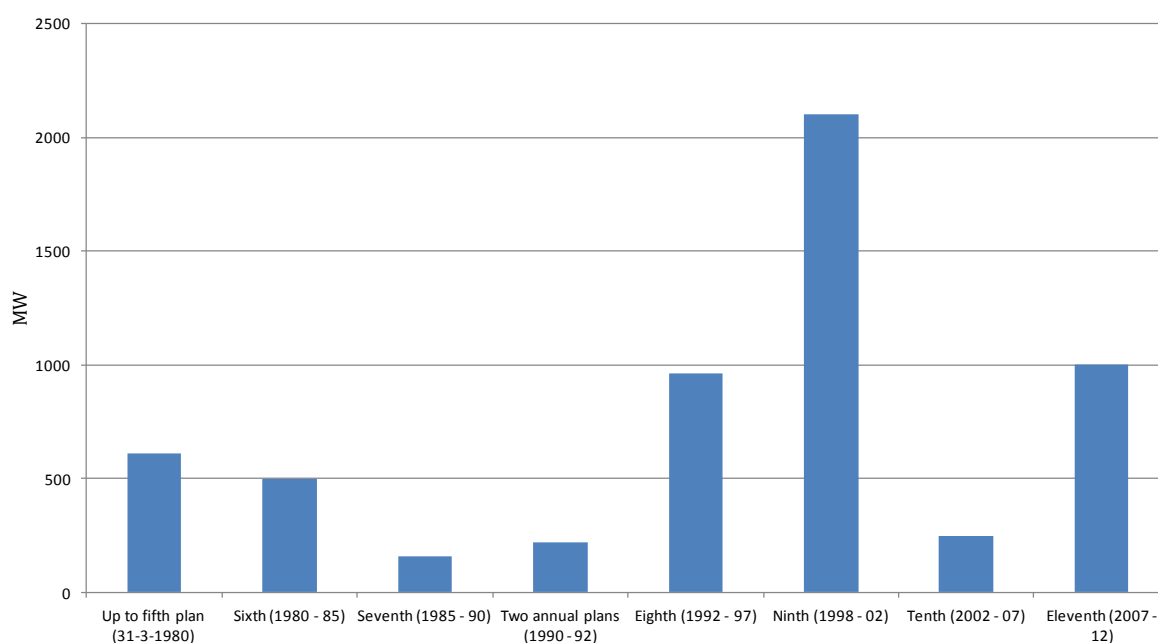
About 96,500 MW is estimated to be the potential available from pumped hydro schemes, across 56 sites. Individual capacities vary from 600 MW to 2800 MW. Out of these, 7 PSP with an installed capacity of 2604 MW were under operation/construction at the time of reassessment by CEA. The region-wise distribution of Pumped hydro potential is presented in Table 2 below. A more detailed list of the states in which the potential is estimated, is presented in Annexure 1.

Table 2: Region-wise PSP potential (CEA)

Region	Probable Installed Capacity (MW)
Northern	13065
Western	39684
Southern	17750
Eastern	9125
North Eastern	16900
Total	96524

As can be observed in Table 2, most of the potential (about 41%) is concentrated in the Western region, mainly due to topological features with steep river gradients in the Western Ghats region. Recent studies have shown that ecological impacts of run of the river and storage projects vary according to region, and can be significant in some cases. Hence, some states like Karnataka have mandated impact assessment clearances for projects which so far have been considered to be environmentally benign. Integration of PSP into the system will require further site-specific evaluation to estimate the extent to which they can contribute to future installed capacity.

At present, 9 PSPs are installed in the country. Of these, 5 are operating in the pumping mode with an installed capacity of 2600 MW. Trends of Plan-wise addition of PSP in the country are presented in Figure 4 below:

**Figure 4: Plan-wise growth of PSP Installed Capacity in India, Source: CEA**

Additionally, 2 PSPs with an installed capacity of 1080 MW are under construction, namely in Tehri, Uttarkhand (1000 MW), and Koyna Left Bank, Maharashtra (80 MW). Further, 3 PSPs with an aggregate installed capacity of 2100 MW are under survey and investigation.

II Drivers

- Economically feasible potential
- Policy environment in the country
- Level of socio-ecological impact of large hydro construction
- Benefits from Refurbishment & Modernization (R&M), and Life Extension (LE) activities

III Assumptions

- Current Installed capacity and potential estimates are as reported by CEA
- A capacity utilization factor of 40% has been assumed as per the national norms specified by the Central Electricity Regulatory Commission (CERC)
- Since large hydro plants have long operational lifetimes, current plants are assumed to continue operation without retirement within the timeline of analysis. However, R&M and LE activities are assumed to continue for improved performance
- PSPs are not accounted for in the installed capacity. Usage of PSPs is dependent on the ability of the system to utilize off-peak generation to pump the water for storage. Since the purpose of this exercise is for capacity planning at an aggregate level, scheduling of pumped hydro to meet peaking load is out of its current scope. In each trajectory, a foreseeable installed capacity from PSPs are mentioned for further discussion
- Status of PSPs is as per the latest reassessment study available from CEA

IV Trajectories

Level 1

In this 'Least effort' scenario, it is assumed that current plants continue to operate with scheduled maintenance efforts through the period of analysis. Due to unresolved constraints on issues of large-scale ecological damage, resettlement and rehabilitation, no new large hydro construction is assumed to happen. Installed capacity remains at 39,416 MW in 2047. No new pumped hydro schemes are completed (2047 Installed operational capacity: 2,600 MW)

Level 2

As per estimates by CEA and the Working Group on Power for 12th FYP, it is assumed that up to 9,204 MW of large hydro schemes would yield benefits in the 12th plan, and 12,000 MW in the 13th plan (2047 Installed capacity: 60,735 MW). This is the 'Determined effort' scenario, wherein Government Plans are implemented. A detailed list of the projects assessed for likely benefits are presented in Annexure 2. Under construction pumped hydro schemes are completed (2047 Installed operational capacity: 3,680 MW).

Level 3

In addition to achievement of Government Plans, level 3 being the 'Agressive effort' scenario, it includes the benefits from completion of R&M and Life Extension (LE) efforts. This results in additional capacity of 4, 064 MW across 12th FYP (as per Report of the Working Group on Power for Twelfth Plan), and assumed to continue over the 13th Plan. Beyond the 13th Plan, past trends in capacity addition are expected to continue till 2047 (2047 Installed capacity: 79, 416 MW). In addition to previous levels, Pumped Hydro Schemes under survey and investigation are completed (2047 Installed operational capacity: 9, 630 MW).

Level 4

This is the 'Heroic effort' scenario, wherein advances in technology development, and R&D efforts in de-silting, integration of regional grids, forecasting etc. are assumed to take place. Benefits from advances in R&M and LE are assumed to increase to 20, 000 MW per FYP for the period of analysis, to reach up to 1, 50, 000 MW (100% of potential) by 2047. As indicated by various studies, preferable capacity of pumped storage installation for a thermal dominant power system is assumed to be 5% of total installed capacity (2047 Installed capacity dependent on total installed capacity from other sources).

Figures 4 and 5 show the energy generation trajectories from the four levels, and comparison with global trends, respectively:

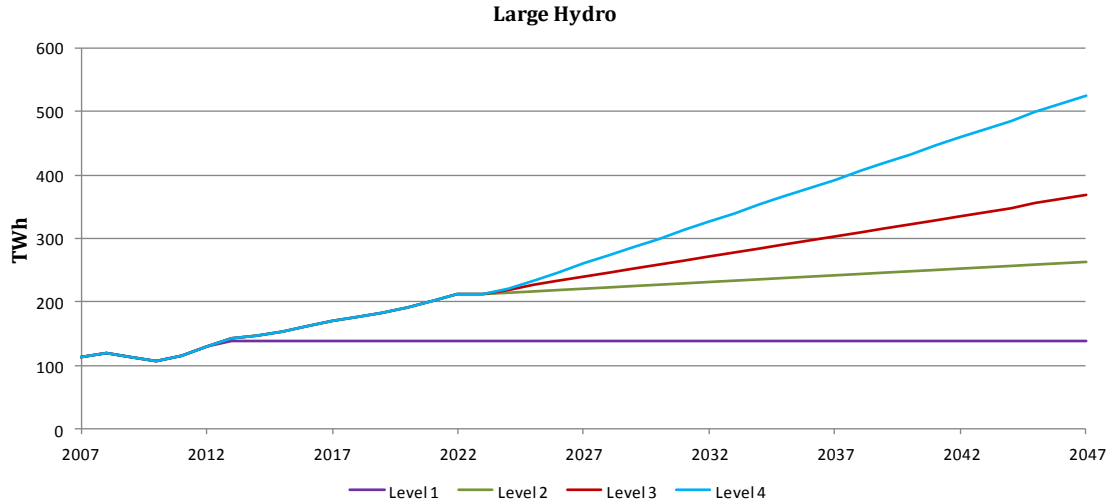


Figure 4: Large Hydro Energy Generation under Levels 1 to 4 (TWh)

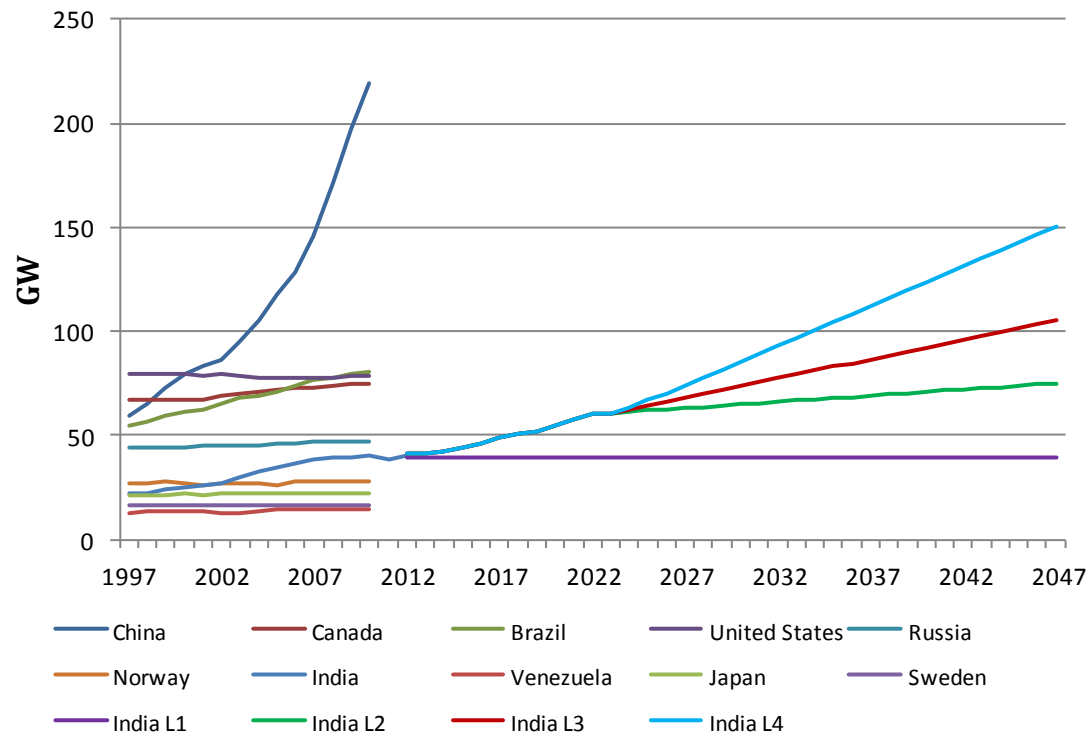


Figure 5: Large Hydro Installed Capacity comparison with global trends (GW)

Hydro-power can provide the much needed balancing requirement to renewable energy from intermittent sources such as wind and solar. The growth of the latter sources will depend on the ability of the Indian power system to absorb this variable source, wherein hydro plays a major role. As mentioned earlier, the growth of this sector in turn depends on local ground conditions based on sound environmentally sustainable practices as has been highlighted by the recent floods in North India. Even pricing is likely to play an important role as hydro projects particularly large ones, are capital intensive and have a long gestation period. This sector is, however, poised only for growth as only a quarter of its potential has been exploited so far and resource is generally well dispersed across all regions (excepting central India).

V References

Central Electricity Authority. (2013). All India Electricity Statistics, General Review. Government of India, Ministry of Power.

Central Electricity Authority. (2013). Large Scale Grid Integration of Renewable Energy Sources – Way Forward. Government of India, Ministry of Power.

Planning Commission. (2012). Report of the Working Group on Power for Twelfth Plan. Government of India, Ministry of Power.