India's hydropower potential

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Introduction

Hydropower, often called the “backbone of clean energy,” is India’s largest renewable energy source after solar and wind and a crucial enabler of the country’s low-carbon transition.India has developed only about one-third of this capacity. Beyond electricity generation, hydropower serves multi-purpose functions—from irrigation, flood control, and water storage to providing grid flexibility through pumped storage, making it indispensable for integrating variable renewable energy into India’s power mix.

India's status of hydropower potential at present

lIn 2022, hydropower capacity of 46,512 MW (megawatts) accounted for ~12%of total capacity.

lIndia's installed large hydro capacity currently stands at 46.92 GW, constituting approximately 10% of the nation's total power generation capability of 442.85 GW

lCapacity addition of large hydropower projects witnessed a decline in FY24, with only 60 MW added compared to 120 MW in FY23.

Advantages of Hydropower in India

1.Renewable, Clean, and Low Emission Source

Hydropower is renewable and has negligible GHG emissions compared to coal.

Example: MNRE recognises large hydropower (>25 MW) as part of the renewable energy mix since 2019, helping India move towards its Net Zero 2070 target.

2.Reliable & Flexible Grid Support

Hydro stations can start/stop quickly, making them ideal for balancing variable solar and wind.

Example: During peak summer demand in 2024 (May–June, record 250+ GW peak), hydro stations were ramped up to stabilise grid frequency.

3.Pumped Storage for Energy Security

Acts as a natural battery—stores excess solar/wind power and releases at peak demand.

Example: 7.5 GW of PSH projects got CEA concurrence in FY 2024–25 (highest ever); more PSH approvals planned in FY 2025–26.

4.Energy Self-Reliance & Import Reduction

Domestic hydro reduces coal imports and gas dependence.

Example: In FY 2024–25, higher hydro output (10% growth) helped reduce power sector's coal import bill.

5.Supports Irrigation & Flood Control

Multipurpose dams provide irrigation water, flood moderation, and drinking water.

Example: Dibang Multipurpose Project (2,880 MW, Arunachal Pradesh) will combine power generation with flood control in the Brahmaputra basin.

6.Boosts Regional Development & Employment

Large hydro projects create jobs, improve infrastructure (roads, bridges), and stimulate local economies.

Example: Lower Subansiri (2,000 MW, Arunachal–Assam) has spurred local infrastructure upgrades and employment.

7.Energy Access in Remote Areas

Small hydro (<25 MW) provides decentralised, off-grid electricity in hilly & tribal regions.

Example: 5,109 MW small hydro installed (as of July 2025), with significant contribution in Himachal Pradesh, Uttarakhand, and NE states.

8.Water & Climate Resilience

Reservoirs help manage seasonal variability in rainfall and strengthen climate adaptation.

Example: In 2024 weak monsoon, hydro reservoirs were used strategically to manage peak deficits, demonstrating resilience.

Challenges in Expanding Hydropower in India

1.High Capital Cost & Long Gestation Period

Hydro projects require large upfront investment and 8–10 years of construction, compared to faster solar/wind deployment.

Example: Lower Subansiri (2,000 MW) project has faced delays for nearly two decades, pushing up costs from initial ?6,285 crore (2003) to over ?20,000 crore.

2.Environmental & Ecological Concerns

Dams submerge forests, disrupt river ecology, and affect aquatic biodiversity.

Example: Dibang Multipurpose Project (2,880 MW, Arunachal Pradesh) faced opposition due to submergence of over 5,000 ha of forest land, one of the largest clearances in India.

3Displacement & Social Resistance

Large projects involve rehabilitation of tribal and rural populations, sparking protests.

Example: Resistance from local communities in Arunachal Pradesh and Assam delayed Subansiri project for years.

4.Interstate & Transboundary Water Disputes

Shared rivers create disputes among states and with neighbours.

Example: Chenab basin projects (like Ratle, J&K) face objections from Pakistan under the Indus Waters Treaty.

5.Seismic & Geological Risks

Many hydro sites are in the Himalayas, a seismically active and landslide-prone zone, raising safety concerns.

Example: The 2021 Chamoli disaster in Uttarakhand severely damaged Tapovan-Vishnugad project, highlighting geological risks.

6.Seasonal & Climate Variability

Hydro generation depends on monsoons and snowmelt, making it vulnerable to climate change and droughts.

Example: In FY 2023–24, hydro generation dipped due to a weaker monsoon, creating power shortages and higher coal use.

7.Financing & Private Sector Hesitancy

Long payback period and policy uncertainties deter private players.

Example: Most recent hydro capacity additions are by public sector (NHPC, SJVN); private investments remain minimal.

Projects under Construction

1.KirHydroelectric Power Project (624 MW, J&K)

Located in Kishtwar district, this project aims for commercial operation by July 2025 and is developed by a JV of NHPC, JKSPDC, and PTC. Wikipedia

2.Ratle Hydroelectric Plant (850 MW, J&K)

A run-of-the-river project currently 21% complete (as of May 2025) and slated for completion by 2028. India's suspension of the Indus Waters Treaty enables smoother project progress. Wikipedia

3.Pakal Dul Dam (1,000 MW, J&K)

Expected to be completed by September 2026, the concrete-face rock-fill diversion dam is currently 66% complete (as of May 2025). Wikipedia

4.Dibang Multipurpose Hydro Project (2,880 MW, Arunachal Pradesh)

A flagship project under construction; it will also serve flood control functions in the Brahmaputra basin.

Way Forward for Hydropower in India

1.Speedy Clearances with Environmental Safeguards: Streamline approval processes while ensuring cumulative impact assessments (not project-wise alone).

Example: MoEFCC's fast-track clearances for ~12 GW of pumped storage (2024–25) show that quicker decisions with strict environmental conditions are possible.

2.Promote Pumped Storage Hydro (PSH) as Grid Battery: Expand PSH to balance solar/wind variability; incentivise hybrid RE + PSH projects through viability gap funding (VGF) and tariff mechanisms.

Example: Pinnapuram (1.68 GW, Andhra Pradesh)—India's first large PSH expected to be commissioned in 2025.

3.Financial Reforms & Private Sector Participation: Introduce hydro purchase obligations (HPOs), extend softer loan terms & tax incentives, and strengthen long-term PPAs to reduce risk.

Example: NHPC and SJVN dominate capacity additions, but private players like Greenko & JSW in PSH show growing confidence with proper support.

4.Focus on Small Hydro & Decentralised Models

Encourage community-based mini/micro hydro in hilly & tribal regions, reducing transmission costs and aiding rural electrification.

Example: Himachal & Uttarakhand successfully run village-level small hydro units for local grids.

5.Geological & Climate Risk Mitigation

Use advanced tunneling tech, AI-based monitoring, and landslide early-warning systems for Himalayan projects.

Example: After the Chamoli 2021 disaster, Uttarakhand projects now mandate stricter disaster-management plans.