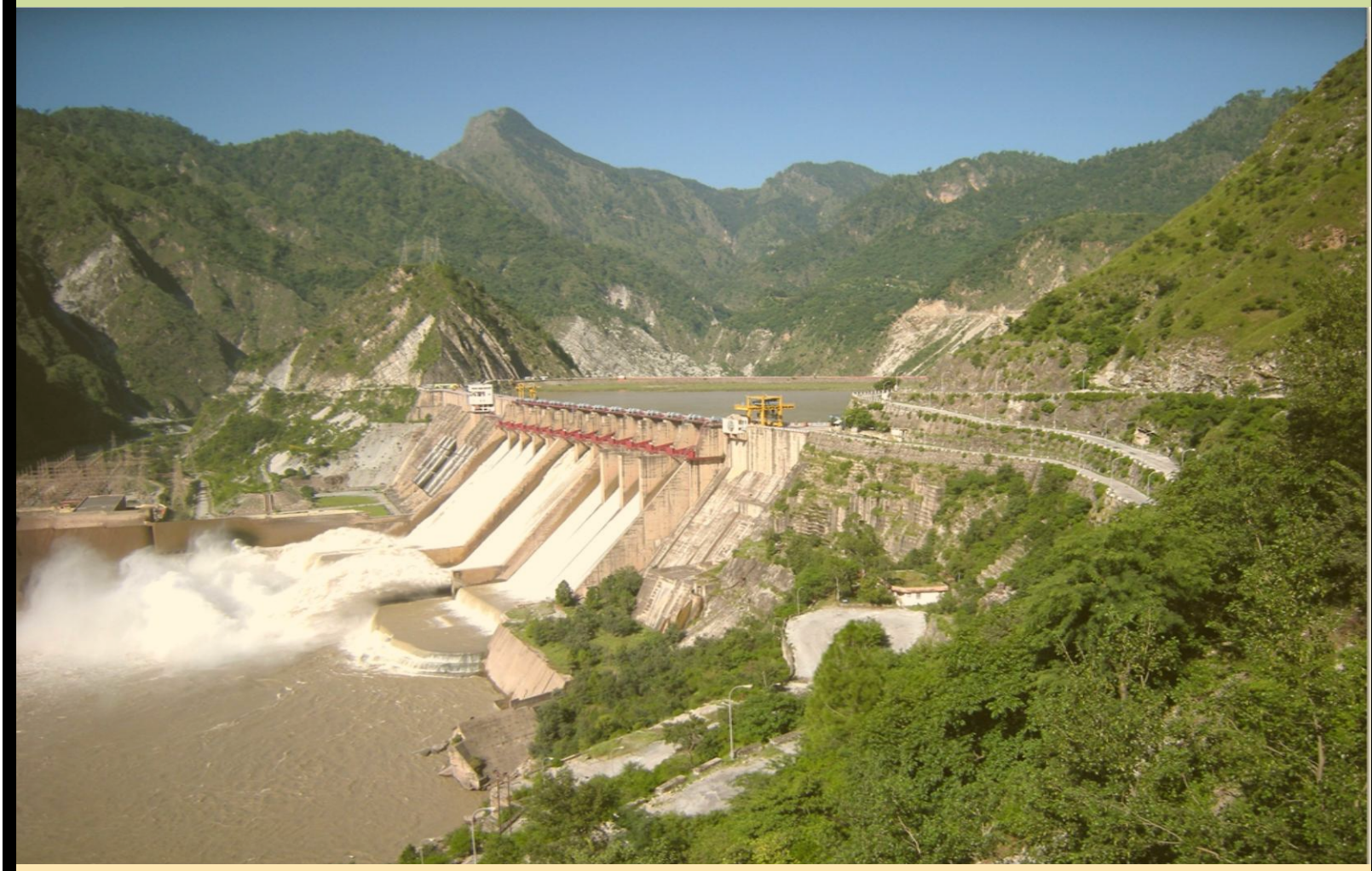
FORUM OF REGULATORS



Report on

Accelerating the Development of Hydropower Particularly Pumped Storage for Grid Stability in India

March - 2025

REPORT OF THE FOR

ON

ACCELERATING THE DEVELOPMENT OF HYDROPOWER, PARTICULARLY PUMPED STORAGE FOR GRID STABILITY IN INDIA

March 2025

Forum of Regulators

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Abbreviations

BBMB	Bhakra Beas Management Board
BESS	Battery Energy Storage System
CA	Compensatory Afforestation
CERC	Central Electricity Regulatory Commission
CPSE	Central Public Sector Enterprises
CPSU	Central Public Sector Undertaking
CWC	Central Water Commission
DVC	Damodar Valley Corporation
FRA	Forests Rights Act
IHA	International Hydropower Association
IREDA	Indian Renewable Energy Development Agency
ISTS	Inter State Transmission System
JV	Joint Venture
MoEF&CC	Ministry of Environment, Forest and Climate Change
MoP	Ministry of Power
MoU	Memorandum of Understanding
NHAI	National Highways Authority of India
PFC	Power Finance Corporation
PPA	Power Purchase Agreement
PPP	Public Private Partnership
PPSP	Purulia Pumped Storage Plant
PSPs	Pump Storage Plants
SERC	State Electricity Regulatory Commission
TBCB	Tariff Based Competitive Bidding
ToR	Terms of Reference
TRT	Tail Race Tunnel
UMPP	Ultra-Mega Power Project

EXECUTIVE SUMMARY

Background

Hydropower power plants, including Pumped Storage Projects, play a crucial role in ensuring grid stability, facilitating the integration of renewable energy sources into the grid network, and significantly contributing to India's clean energy goals. Recognizing the importance of hydropower, the Forum of Regulators (FOR), in its special meeting held on February 8, 2024, decided to constitute a Working Group on "**Accelerating the Development of Hydropower, Particularly Pumped Storage for Grid Stability**," under the Chairpersonship of the Chairperson of the Himachal Pradesh Electricity Regulatory Commission. The Terms of Reference (ToR) for the Working Group was decided as follows:

i. Evaluate the current regulatory framework, policies, and practices governing hydropower development and identify any difficulties that impede the efficient development of hydropower projects.
ii. Explore measures aimed at encouraging the development of hydropower resources, including pumped storage within the country.
iii. Suggest strategies and mechanisms for accelerating the harnessing of hydroelectric potential.
iv. Address any other related matters incidental to above.

Approach & Action of the Working Group

The Working Group convened seven meetings and conducted a comprehensive review of the existing regulatory and policy environment at both pan-India and global levels. It identified areas where interventions and reforms are needed to meet the country's evolving energy needs. Moreover, three visits were made to Hydro and Pumped Storage Plants (PSPs) to interact with project officials and gain insights into the challenges and perspectives involved in the development and operation of PSPs.

As part of the detailed deliberations, the Working Group prepared a comprehensive questionnaire for hydro developers to identify and analyse the key issues faced by them. This questionnaire covered various aspects, including:

- **Policy Issues** such as environmental clearances, compensatory afforestation, mandatory free power obligations, and deadline-driven challenges.
- **Preplanning phase** including site identification and allocation matters, clearances, surveys, and invitations.
- **Selection of Developer** with regard to qualification requirements, limited opportunities for private developers, etc.
- **Selection of Contractor** concerning the limited availability and qualification criteria.
- **Tariff Determination** due to the capital-intensive nature of the projects, regulatory uncertainties given long gestation periods.
- **Project Development** which involves a complex, multi-step process that can take several years due to the technical, regulatory, environmental, and financial challenges involved.
- **Attributes/Monetisation** of Services by Hydro and PSP plants
- **Insights and Recommendations** concerning the areas bulleted above

Drawing from the feedback received and suggestions provided by the project developers, the Working Group formulated actionable recommendations which were further discussed and endorsed in the Special meeting of the Forum of Regulators held on 28th February 2025 .

This report suggests a comprehensive and detailed recommendations that addresses the current status and proposes pathways for harnessing India's true Hydropower potential. The recommendations have been categorized under various thumbnails, with each one briefly outlined below:

a) Policy Reforms - Legislation should prioritize recognizing hydropower as a strategic national resource that enhances grid security and stability. An Empowered Committee on Hydro Development, comprising representatives from relevant departments at both the Central and State levels be established, along with a robust online portal, to streamline the clearance process at various levels. Degraded forest land should be allowed for CA purposes without mandating a non-availability certificate for non-forest land. A land bank of suitable degraded forest areas should be created for CA, organized division-wise and state-wise. River valleys/courses should be excluded from CA land calculations, as 25-30% of forest land required for project construction often falls within the river course. State Governments to facilitate NoC clearances from the Gram Sabha or

local villages, as applicable, to expedite approvals. The appointment of a Nodal Officer at the State level as a primary contact could be highly helpful. Given that Off-Stream Pumped Storage Projects are essentially non-polluting and share characteristics with other small-scale renewable projects (such as small-Hydel power plants [< 25 MW]), they should be classified under the White Category. Additionally, since these projects do not require significant resettlement or rehabilitation efforts, the requirement to create a Local Area Development Fund (LADF) should be waived.

b) For Preplanning phase - As a crucial prerequisite for the successful implementation of projects, establishing a Special Purpose Vehicle (SPV), similar to the Ultra Mega Power Projects (UMPP) model, can enable the pooling of resources, reducing project risks, and improving coordination for project development efficiently. The SPV along with Central Electricity Authority (CEA) should undertake centralized preplanning activities. This would reduce uncertainties during the preplanning period and enable competitive tariff discovery. The progress of conventional Hydro/PSP projects from planning to execution should be monitored through the PMO portal "PM Gati Shakti." Also, creation of private testing agencies for all required tests and enhancing testing capacity, as well as the establishment of zone-wise Directorates (North, South, East, West) within the extended structure of the CEA to review and scrutinize the DPR chapters, can effectively rationalize these processes**.**

c) Selection of Contractors - Selecting the right contractor is crucial for the successful execution of Hydro and PSPs. The Quality-Cost-Based Selection (QCBS) model should be adopted to evaluate contractors based on both technical quality and financial capability, with execution time also considered as a bidding parameter. Timely completion should be incentivized with performance-based bonuses.

d) Selection of Developers: The success of any large, complex, and capital-intensive project is dependent on the selection of the right developer. The government should implement a transparent bidding mechanism for selecting developers for government-identified projects. Comprehensive set of Bidding parameters, including technical capability, financial strength, experience in similar projects, and regulatory compliance (e.g., environmental approvals, safety standards, and compliance with local laws) should ensure that developers possess the required technical expertise, financial stability, and commitment to project delivery are selected, while maintaining fairness and transparency. For self-identified projects by developers, the Swiss Challenge method should be

explored as a procurement model, allowing for private sector innovation through unsolicited proposals.

e) For Tariff determination: Tariff regulations should incorporate more flexibility to account for the evolving cost structures and long gestation periods of these projects. Extending the useful life of new Hydro/PSP projects from 40 to 50 years would have a minimal impact on tariff reductions but could help improve project longevity without significant financial losses. The expenditure limits for local infrastructure development around power plants should be increased to at least ₹20 lakh/MW, with allowances for pass-through costs after the Commercial Operation Date (COD). Additionally, a three-part tariff structure for PSPs should be implemented to distinguish between charges for energy conversion, ancillary services, and fixed cost recovery, addressing both grid services and energy usage for pumping. To improve acceptability of tariffs, steps must be taken to reduce tariffs in the initial years.

f) On Operation of PSP: In PSPs, the three main stakeholders—Project Developers, Discoms/Users, and System Operators—often have differing interests, which can lead to conflicts, particularly when scheduling PSPs for either pumping or generation. A clear regulatory framework need to be established to outline the procedure for scheduling PSPs and a compensation mechanism for situations where the system operator requires the PSP to generate power instead of storing energy. This would help project developers assess the viability of PSP projects and ensure fair compensation for any changes in operational modes required for grid stability.

g) Fast pace project development through project management and monitoring tools: For fast-paced development, a strong contractual framework that defines roles, responsibilities, and deliverables for all parties involved will provide a guiding light for each stakeholder. Leveraging AI and predictive analytics can help identify potential risks and generate early warning signals. Also, establishing a centralized data repository will enable real-time information sharing**.**

h) Monetisation: To effectively monetize Hydro and PSPs, a comprehensive strategy should focus on both direct and indirect revenue generation. Key opportunities include providing ancillary services such as frequency regulation, voltage support, and system restart capabilities, which are essential for grid stability and can generate additional revenue. Hydro tourism in reservoirs is another potential revenue stream, that benefit both the local economy and financial viability of

PSPs. Additionally, extracting and monetizing silt from reservoir beds can provide value by repurposing it for construction and soil conditioning. PPPs should also be explored to attract investment and expedite project development.

i) Electricity Duty Exemption: Exempt input energy for pumping in PSPs from electricity duty and cess to reduce costs and promote investments in hydropower.

j) **Reduction in Land Acquisition Costs:** Implement measures such as leasing government land at nominal costs and exempting stamp duty to lower project capital costs and attract private investment.

k) Contractor Identification: Establish a government-led nodal agency to streamline contractor identification and collaboration for PSP development.

l) Loan Interest Reduction: Adjust the debt-to-equity ratio for public sector PSPs from 70:30 to 80:20 to lower generation costs and improve financial viability.

m) Specialized Tribunals: Set up specialized tribunals for swift resolution of disputes, such as land acquisition and resettlement issues related to Hydro/PSP projects.

n) Introducing a REC Multiplier for hydropower projects (e.g., 2x-3x) and PSPs (e.g., 3x-4x) as a policy measure may be considered to facilitate demand growth for Hydro/PSP development. Additionally, an extension of the waiver of ISTS charges for new Hydro and PSP projects beyond June 30, 2025, should be considered.

Accelerating the development of hydropower, especially Pumped Storage, is crucial to meeting the growing energy demand in a sustainable manner. Hydro and PSPs can provide long duration storage complementing BESS for short duration storage requirements (2-4 hrs). By addressing the challenges and fostering & enabling supportive interventions will substantively accelerate the growth of RE technologies. And conclusively this would certainly address climate change challenges to a greater 'positive' extent.

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1 Background

The Forum of Regulators (FOR) was constituted vide Notification dated 16th February 2005 in pursuance of the provision under section 166(2) of the Electricity Act 2003 (EA or Act) and vide notification dated 08.09.2022 FOR has been assigned some additional functions. It consists of Chairperson of Central Electricity Regulatory Commission (CERC) and Chairpersons of State and Joint Electricity Regulatory Commissions (JERCs and SERCs). The Chairperson of CERC is the Chairperson of the Forum.

The FOR in its Special meeting held on 08th February 2024, extensively deliberated on the topic of **'Accelerating the Development of Hydropower, Particularly Pumped Storage for Grid Stability'**. Recognizing the critical role of hydropower, including Pumped Storage, in stabilizing the grid, the Forum decided that a Working Group (WG) may be constituted for Hydro and Pumped Storage Plants (PSPs). The purpose of the Working Group would be to explore strategies and propose actionable measures for encouraging hydropower development and PSPs in India. The Working Group would also provide recommendations to the Government of India (GoI) on how to accelerate the harnessing of India's hydroelectric potential, including PSPs.

1.1 Working Group – Composition and Terms of Reference

The Working Group is chaired by the Chairperson of Himachal Pradesh Electricity Regulatory Commission (HPERC) and comprises of Chairpersons from various State Electricity Regulatory Commissions. The composition of Working Group is as follows:

1.	Chairperson, Himachal Pradesh Electricity Regulatory Commission (HPERC)	Chairperson of the Working Group
2.	Chairperson, Assam Electricity Regulatory Commission (AERC)	Member
3.	Chairperson, Arunachal Pradesh State Electricity Regulatory Commission (APSERC)	Member
4.	Chairperson, Chhattisgarh State Electricity Regulatory Commission (CSERC)	Member

5.	Chairperson, Karnataka Electricity Regulatory Commission (KERC)	Member
6.	Chairperson, Maharashtra Electricity Regulatory Commission (MERC)	Member
7.	Chairperson, Punjab State Electricity Regulatory Commission (PSERC)	Member
8.	Chairperson, Sikkim State Electricity Regulatory Commission (SSERC)	Member
9.	Chairperson, Uttarakhand Electricity Regulatory Commission (UERC)	Member
10.	Chairperson, Uttar Pradesh Electricity Regulatory Commission (UPERC)	Member
11.	Chairperson, West Bengal Electricity Regulatory Commission (WBERC)	Member
12.	Chief, (Reg. Affairs), Central Electricity Regulatory Commission	Convener

The Terms of Reference (ToR) of the WG **(Annexure-1)** include the following objectives:

1. Evaluate the current regulatory framework, policies, and practices governing hydropower development and identify any difficulties that impede the efficient development of hydropower projects..
2. Explore measures aimed at encouraging the development of hydropower resources, including pumped storage within the country.
3. Suggest strategies and mechanisms for accelerating the harnessing of hydroelectric potential.
4. Address any other related matters incidental to above.

The scope of the Working Group encompasses a comprehensive review of existing regulatory and policy environment and identifies areas where intervention and reforms are required to meet the evolving energy needs of the country. The outcomes of discussions in this group will help shape the national strategy for harnessing India's vast hydropower potential, particularly pumped storage to support grid stability.

2 Working Group Meetings on Accelerating the Development of Hydropower, Particularly Pumped Storage for Grid Stability

The WG held seven meetings and visited three hydropower and Pumped Storage Plants (PSPs) sites to interact with project officials and understand their perspective and issues involved in hydropower and PSPs development and operation and maintenance. The proceedings of these meetings are summarized as below.

2.1 First Meeting of the Working Group

The First Meeting of the WG was held in New Delhi on 9th May, 2024 under the Chairmanship of Chairperson, Himachal Pradesh ERC. The agenda of the meeting was to discuss the ToR of the WG and the background note on Accelerating the growth of Hydro Power in India.

The WG deliberated on the current status of Large Hydro, Small Hydro and PSP in India along with the barriers, risks, and mitigation strategies associated with hydropower development. The WG also deliberated on the cost analysis comparing PSPs with other grid scale energy storage technologies.

After a detailed discussion, the WG decided to further examine several key issues including the status of hydroelectric and PSP development in other countries; the impact of cost and time overruns on tariff viability for hydroelectric and PSPs; the need for SPV detailing for the allotment of sites following the preparation of a bankable DPR and required clearances; the importance of expediting environmental clearances for hydroelectric projects with pondage and pumped storage; and the potential benefits of granting "national status" to hydroelectric and PSPs that supply electricity to multiple states.

The minutes of the 1st meeting are attached as **Annexure-2.**

2.2 Second Meeting of the Working Group

The second meeting of the WG was held at Himachal Pradesh on 28th June and 29th June, 2024. The agenda of the meeting was to discuss the status of development of hydroelectric and PSPs in other countries.

Officials of SJVNL presented a brief overview of India's existing installed capacity, the national target for PSPs as per the National Electricity Plan, SJVNL's existing and proposed hydroelectric capacity, budgetary support for enabling infrastructure and flood moderation provided to hydroelectric plants, and concessions offered by the States to hydroelectric projects.

Thereafter, Chairperson, West Bengal ERC presented a brief overview of the Purulia Pumped Storage Plant located in Purulia, West Bengal. Further, the consultants assisting the WG apprised the WG members about the policy overview of PSPs in countries such as USA, Japan and China along with the key policy reforms and incentives introduced in the countries for promotion of PSPs.

After detailed discussions, the WG decided to further examine cost and time overruns that could render tariffs unviable for hydroelectric and PSPs; the structuring of SPVs for site allotment following the preparation of bankable DPRs and required clearances; the need to expedite environmental clearances for hydroelectric projects with pondage and pumped storage; and the potential for granting "national status" to hydroelectric and PSPs that provide electricity to multiple states.

The minutes of the 2nd meeting are attached as **Annexure-3.**

2.3 Third Meeting of the Working Group

The WG held its third meeting on 08th August, 2024, in New Delhi. The agenda was to gather insights and experiences on various issues related to hydroelectric and PSPs development from developers such as Greenko and JSW. The consultants assisting the WG also updated the WG on best practices being implemented in countries such as USA and China, along with specific recommendations for adoption in India.

The WG discussed suggestions, including forming SPVs to conduct pre-feasibility and Environmental Impact Assessment (EIA) studies, securing advance project approvals, providing incentives to existing hydroelectric plants to improve efficiency, and offering incentives for ESS projects using 100% domestic content (such as iron or steel). Additionally, the group considered exemptions from environmental clearance for off-stream closed-loop PSPs, relaxation of

requirements for identifying Compensatory Afforestation (CA) land, using degraded forest land for PSPs, and implementing tax credits for hydroelectric and PSPs.

After discussions, the WG decided that in order to understand more on the PSPs issues, representatives from other developers may also be invited in the subsequent meeting(s).

The minutes of the 3rd meeting are attached as **Annexure-4.**

2.4 Fourth Meeting of the Working Group

The WG held its fourth meeting on 23rd September, 2024, in Purulia, West Bengal. The agenda was to gather insights and experiences on policy issues, clearances, tariffs, and future recommendations, as well as to learn from DVC and WBSEDCL's experiences with hydro and PSP development. The Consultants assisting the WG provided a brief overview of the responses received from 12 developers to the questionnaire, which covered various aspects of PSPs development, including policy issues, challenges, and the monetization of PSPs. The developers highlighted key issues, such as obtaining NOCs from village panchayats, challenges related to approvals from the Ministry of Environment and Forest, and hurdles posed by State government policies. The WG at the close of the meeting decided that subsequent meetings will focus on:

(a) Detailed review of the suggestions provided by the developers;
(b) Discussion on the utilization of pumped storage plants as a grid asset;
(c) Discussion on different business models of PSPs.
(d) Discussions with other approval agencies, such as the CWC, CSMRS, and GSI during next meeting of WG at New Delhi

The minutes of the 4th meeting are attached as **Annexure-5.**

2.5 Fifth Meeting of the Working Group

The WG held its fifth meeting on 8th November, 2024, in Gangtok, Sikkim. The WG discussed the new scheme released by the Ministry of Power, which provides Central Financial Assistance (CFA) for equity participation by State Governments in the development of hydroelectric projects in the North Eastern Region. The WG was also apprised about the modification in the scheme for budgetary support for the cost of enabling infrastructure for Hydro Electric projects. During the meeting the members deliberated on the requirement of accelerated development of Hydroelectric and PSPs for energy transition as well as energy security of the country.

Additionally, officials of NHPC made a presentation and provided an overview of the current installed projects and upcoming projects, with a total capacity of 54 GW and highlighted several issues impacting project execution, including delays due to clearance requirements, geological challenges, and law and order concerns, leading to cost and time overruns

The WG concluded that further meetings could involve discussion on the utilization of pumped storage plants as a grid asset and discussion on Business Models for Pumped Storage Plants.

The minutes of the 5th meeting are attached as **Annexure-6.**

2.6 Sixth Meeting of the Working Group

The Working Group (WG) convened its sixth meeting on 20th and 21st December, 2024, in Uttarakhand. During the discussions, the WG reviewed modifications to the budgetary support scheme for the cost of enabling infrastructure for hydroelectric projects. The members unanimously recognized the need to simplify the procedure for accessing budgetary support to facilitate the swift execution of projects.

Further, THDC officials presented an overview of India's existing installed capacity, the national PSP targets outlined in the National Electricity Plan, THDC's current and proposed hydroelectric capacity, budgetary support for enabling infrastructure, flood moderation in hydro plants, and state-level concessions for hydroelectric projects. The team outlined the different clearance requirements such as environmental and forest clearances for hydro project development and advocated for streamlining the same for the investigation stage for expediting the DPR preparation.

The WG concluded that subsequent meetings would focus on discussing a simplified procedure for implementation of the budgetary support scheme for the cost of enabling infrastructure for hydroelectric projects issued by the ministry of power on 28th September2021 and formulating recommendations for inclusion in the final Report.

The minutes of the 6th meeting are attached as **Annexure-7.**

2.7 Seventh Meeting of the Working Group

The Working Group (WG) convened its seventh meeting on 10th January, 2025 in Guwahati, Assam. During the discussions, the WG discussed and agreed that the draft report of the WG may be shared with all members of the WG to allow them to provide their feedback and comments. It was also decided that the WG members be given 2 to 3 days to share their inputs. It was further agreed that a revised version of the report would be prepared based on the comments received and shared with the other members of the Forum of Regulators (FOR) for their views.

The minutes of the 7th meeting are attached as **Annexure-8.**

2.8 Special FOR meeting

The Special FOR Meeting was held virtually on 28th February 2025 to discuss the WG's report on "Accelerating the Development of Hydropower, Particularly Pumped Storage for Grid Stability". The discussion emphasized on the need for long-term options like hydropower. The Working Group conveyed strong commitment to promoting hydropower as a critical component for sustainable energy development.

After detailed deliberation the Forum decided that the report will be finalised after suitably incorporating the following recommendations:

a. Input energy for pumping in a PSP should not be treated as 'consumption" and hence, electricity duty should not be levied on PSP. Exempting Pumped Storage Plants (PSPs) from Electricity Duty and Cess can reduce input energy costs and promote hydropower. This exemption could be recommended for broader implementation.
b. Reducing costs in acquiring land for PSPs, leasing government land at a nominal cost, exempting stamp duty etc, can be implemented in States which will eventually reduce the capital cost of the project and attract private players for new investment in this sector
c. With respect to identification of contractors, it was suggested that a government-led nodal agency could identify reliable contractors for PSP development,

streamlining the process for developers who want to collaborate with trusted contractors.

d. The Members also suggested reduction in interest on loan for PSPs. The Members recommended adjusting the debt-to-equity ratio to 80:20 for public sector projects which could lower the cost of generation by 10-20%, making PSPs more financially viable.

e. The Members suggested setting up of specialised Tribunals for priority resolution of disputes (such as land acquisition, R &R issues etc) involving implementation of Hydro / PSP projects

3 Introduction to Hydro and Pump Storage Plants (PSPs)

India's hydropower sector is a key pillar in the country's path towards country's clean energy transition. Hydro plants and PSPs are at the forefront of India's path towards sustainable energy, playing a crucial role in energy generation mix, fulfilling peak demand as well as grid stability. Hydro and PSPs, have the proven ability to provide a range of other invaluable services to energy grids, such as storage and flexibility to balance solar and wind, while also supporting communities through agriculture services, water management and climate mitigation.

3.1 Operational Structure of PSPs

Pumped Storage Plant basically consists of two water reservoirs at different elevations that can generate power as water moves down from upper reservoir to the lower reservoir (discharge), passing through a turbine. The system also requires power as it pumps water back into the upper reservoir (recharge) from the lower reservoir.

PSPs can be categorized as on-stream and off-stream (open-loop or closed-loop). Open-loop (On-river) pumped storage hydropower systems connect a reservoir to a naturally flowing water feature via a tunnel, using a turbine/pump and generator/motor to move water and generate electricity.

Closed-loop (Off-River) pumped storage hydropower systems connects two reservoirs without flowing water features via a tunnel, using a turbine/pump and generator/motor to move water and generate electricity.

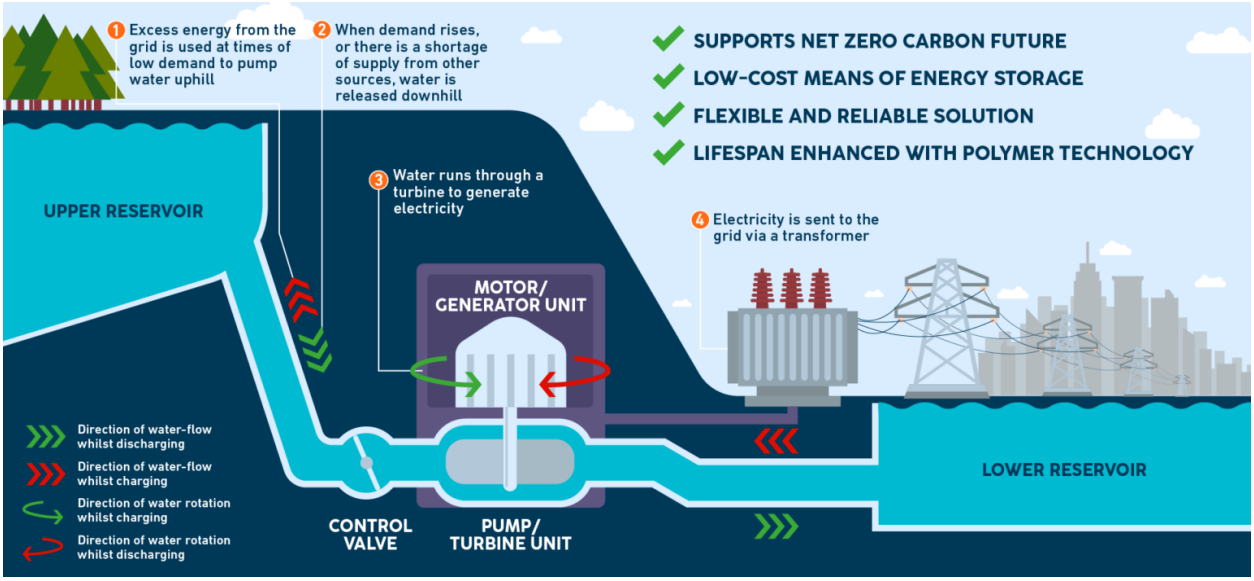


Image courtesy: https://blog.belzona.com/how-to-improve-pumped-hydro-storage-efficiency/

The details of flexibility capabilities of typical thermal and pumped storage plants are depicted below:

Table 1: Flexing capabilities of different technologies

Particular	Pumped Hydro Storage	Hydro Plants	Open-cycle gas turbine	Combined-cycle gas turbine	Coal-fired plants
Start-up time (cold start)	75 – 120 sec	0-5 min	5-10 mins	120-240 mins	300-600 mins
Minimum load (% of Power Output)	35 – 45%	35 – 45%	40-50%	40-50%	25-40%
Average ramp rate (% of Power Output/min)	80-100%	80-100%	8-12%	2-4%	1-4%

Source: TERI Report[1]

[1] Pumped Storage Plants Report 2023_11.12.2023.pdf

The Government of India's initiatives such as declaration of large Hydroelectric Projects (above 25 MW) as renewable sources, financial support towards enabling infrastructure such as roads, bridges etc., guidelines to promote PSPs, waiver of ISTS charges, hydro power purchase obligation and reduction of timeline for concurrence of detailed project report (DPR) indicates a positive growth of Hydro and PSPs development in the country. As per assessment carried out by Central Electricity Authority (CEA), India's exploitable large hydropower potential stands at 133 GW, while its identified pumped storage plant (PSPs) capacity stands at 181.4 GW.

3.2 Need of Hydro and Pump Storage in India

India has pledged to embark on a historic journey to achieve net zero emissions by 2070. Following the 2015 Paris Agreement, India has made significant strides in reducing emissions intensity. At COP26, India raised its goal to 500 GW of energy derived from non-fossil fuels by 2030. This is one of the notable pledges made under the Panchamrit to create large green infrastructure for generating clean energy.

India's renewable energy (RE) capacity has also witnessed a multi-fold increase over the past decade, growing from around 20 GW in 2010-11 to approximately 201.45 GW in FY 2024-25, with significant contributions from intermittent sources like wind and solar over the last one and a half decade. According to various optimal capacity expansion studies and India's focus on clean energy, the power sector is expected to experience substantial RE capacity additions, owing to their low cost of installation and the thrust on sustainable and green energy. The current pace of installation is going to lead to higher variable renewable energy (VRE) penetration in the electrical grid.

A breakup of current installed capacity (as of September 2024) of renewable in India's energy mix is depicted in the figure below:

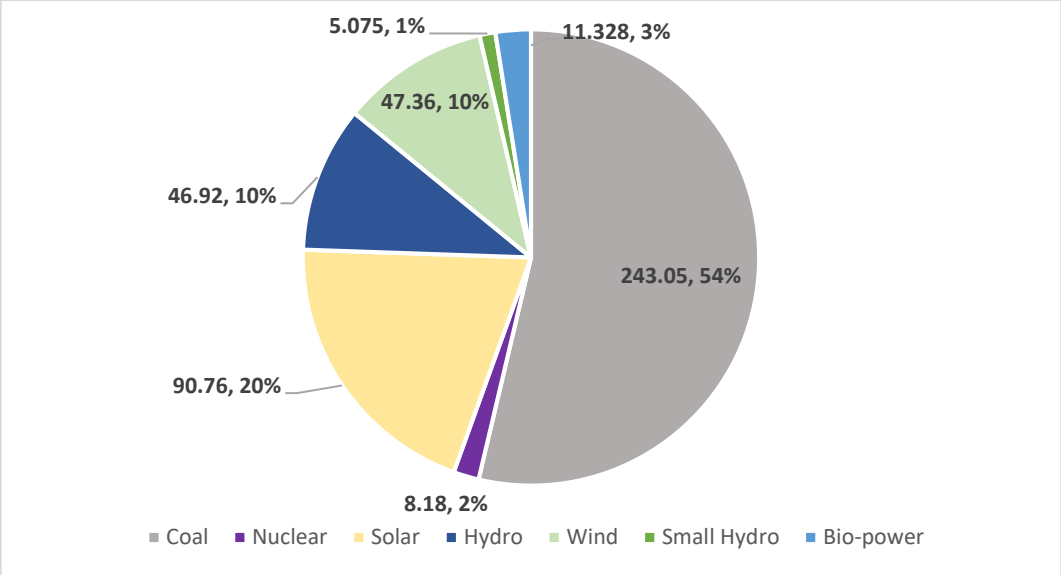
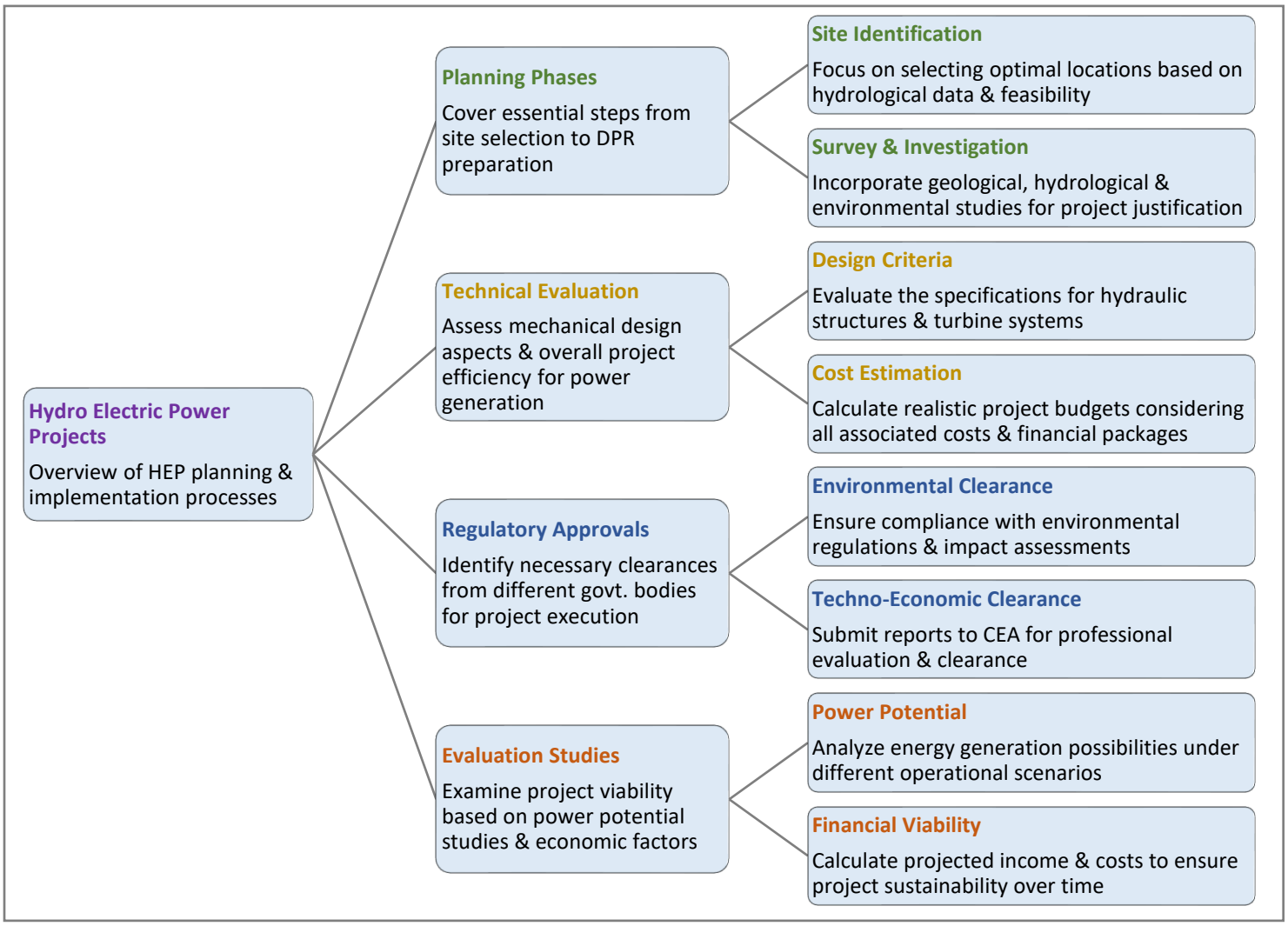


Figure 1: Breakup of installed capacity (GW)

The generation output from VREs is intermittent and broadly relies on the time of day, the seasons, and the whims of weather and therefore, their energy supply cannot be controlled without curtailment. As per Central Electricity Regulatory Commission (Indian Electricity Grid Code), 2010, Solar and Wind are granted must run status and the power from these plants can only be curtailed for reasons pertaining to grid safety or equipment safety, and not for other commercial or merit order dispatch reasons. However, curtailment of wind and solar power is already being witnessed in some areas although they presently constitute only around 25% of the total energy capacity. With the increasing presence of VREs, the need for curtailment will be more acute if there is insufficient storage in the grid.

The intermittent nature presents unique challenges in balancing the quality of grid infrastructure, thus underscores the need for efficient, grid-scale storage solutions to maximize capacity during low-demand periods and ensure reliability during low-generation periods. Energy storage systems (ESS) allow stored wind and solar energy to be used when needed, essential for integrating VRE into the grid—particularly in India, where flexible generation resources are limited. With a power system dominated by thermal sources and lack of sufficient gas resources for flexibility, hydro resources play a crucial role in providing the necessary generation-side flexibility. Despite the increase in the renewable energy capacity, installation of pump storage plants in the country is sluggish with total operational capacity of PSPs at 4.745 GW.

3.3 Different stages of Hydro/PSPs development in India



The development of PSPs requires multilevel administrative and technical approvals from the Government and its authorized agencies. The related matters are covered in section 8 and its subsection of the Electricity Act, 2003. The Detailed Project Report (DPR) of Pumped Storage Schemes requires concurrence of Central Electricity Authority (CEA) in compliance with the requirement of Section 8 of the Electricity Act, 2003 and must incorporate the considerations mentioned in relevant sub-section. For setting up a hydro generating station, interested generating company is required to obtain CEA concurrence, for the scheme estimated to involve a capital expenditure exceeding the benchmark cost fixed by the Central Government, from time to time.

3.4 Need for Pump Storage Plants (PSPs) in India

Pumped Storage is a mature and proven technology, and its operational experience is also available in the country. The speedy development of PSPs is a key driver for achieving the highly ambitious 2030 targets, and success on this front would take India to the global frontier in the deployment of energy storage solutions. Energy storage resources will become increasingly important for integrating high levels of renewable energy in India's grid while ensuring grid stability and power quality. Amidst several grid-scale energy storage technologies currently available, PSPs are most mature and have the longest operational history in India and globally[2]. During the period from 2015 to 2022, the Global pumped storage installed capacity increased with a CAGR of about 2.93%. This growth in PSP installed capacity speaks the global trajectory of PSP development. Growth of global PSP installed capacity during 2015-22 is depicted below in figure 2[4].

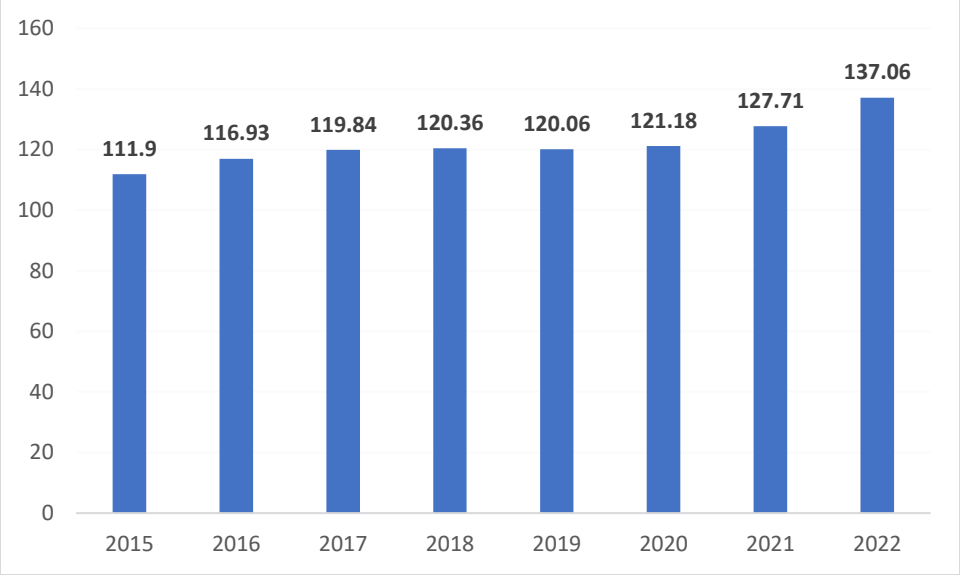


Figure 2: Growth of global pumped storage installed capacity, 2015-2022

PSPs have a multitude of applications in the energy sector and can be used either independently or as a part of power system infrastructure at various levels in generation, transmission, and

[2] https://iitr.ac.in/Departments/Hydro%20and%20Renewable%20Energy%20Department/static/special_publ/Advanced_grid-scale_energy_storage_technologies_Nov_2023_HRED_IIT_Roorkee.pdf

3 2022 Hydropower Status Report

[4] PowerPoint Presentation

distribution. PSPs provide several benefits for grid management under high levels of renewable energy. Some of the advantages are depicted below:

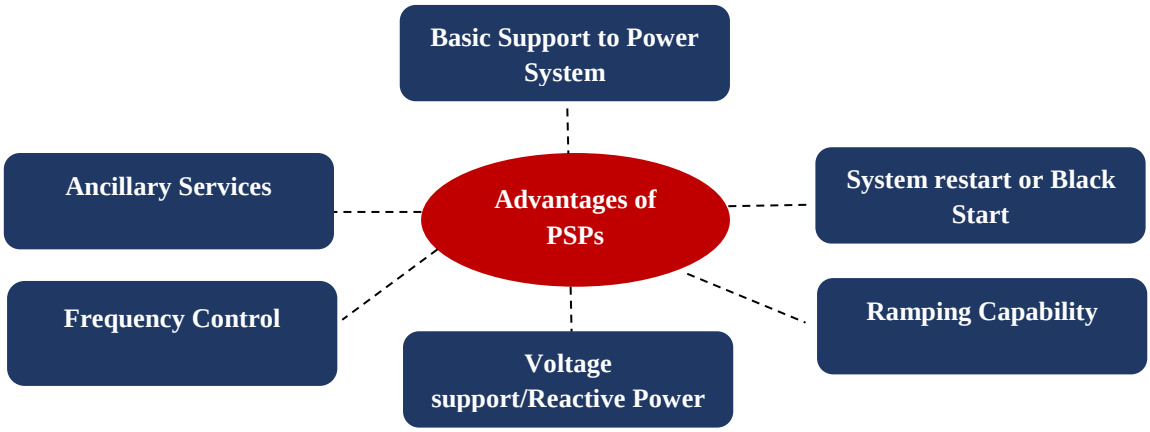


Figure 1: Advantages provided by the PSP Plants to the Grid

As PSPs can be bundled in any domain of energy be it generation, transmission or distribution, the detailed application wise use of PSPs is outlined below.

a) **Basic Support to Power System:** The basic support that a PSP provides for grid balancing during off-peak hours is to act as a demand source, where excess power available in the grid is utilized for pumping and water is stored into the upper reservoir. Later, during peak load, PSPs act as a supply source by contributing generation to the grid from the stored water.

b) **Ancillary Services/Balancing service/Flexible operations in Power System:** With fast ramp rates, PSPs can provide frequency control, voltage control, fast response, and ancillary services over time horizons ranging from seconds to minutes. Ancillary services are necessary support to the power system in maintaining system reliability and avoid disturbance in grid operation.

c) Frequency Control: Frequency control is required to maintain the nominal grid frequency. The mismatch between the electricity generation and the demand curve causes variation in frequency. PSPs have capability to maintain continuous frequency in a desirable range (normally 50 Hz) of active power and to keep power system free from any fluctuations. Thus, when the frequency of grid is above 50 Hz, power can be taken from the grid for pumping mode operation and when it drops below 50 Hz on

grid, the PSPs can be run in generation mode so that a constant frequency can be maintained on the grid.

d) **Voltage Support and Reactive Power:** Voltage support is provided by the system to maintain near constant voltage over a wide range of load conditions. Voltage control can be provided by PSPs through rendering reactive power balancing services. Reactive control is an important tool for voltage regulation and for optimizing available power utilization. To improve the system power factor, PSPs can work in synchronous condenser mode to improve the system power factor.

e) **System restart or Black Start:** To restore the system after a full or partial blackout, PSPs can provide a vital support. PSPs have the capability to provide additional power supply to the power system within few seconds whenever there is a situation of blackout.

f) **Ramping Capability**: PSPs have a capacity to ramp up from 50% to full production capacity in about 15 seconds and from standstill to full production capacity within less than two minutes. Similarly, it can operate from standstill to full pumping capacity within less than five minutes, depending on the plant configuration. PSPs may have a ramping capability of ~200 MW/ min and may start taking just a few minutes. Thus, PSPs are efficient and relatively saves cost in start-up and shutdown as compared to other generation sources such as thermal plants.

g) Spinning reserve: The spinning reserve is the amount of stored capacity of a PSPs asset which can compensate for power shortages or frequency drops within a given period of time. Thus, under situations when load changes or sudden outages or failure of any load in the Grid, PSPs can provide support to the grid to maintain stability.

h) **Peak Shaving:** Due to high ramping capability of a PSP, it can meet peak demand in a short period of time and it also does not require minimum load requirement for operations. Thus, PSPs provide a unique capability of steady restoration of power system.

4 Overview of Hydro and Pumped Storage Plants (PSPs) in India

Hydropower makes significant contribution to flexibility in the power system by bridging the gap between supply and demand caused by the non-dispatchable variability of renewable energy sources (RES). The storage capabilities of many hydropower plants make them an ideal instrument for optimizing the utilization of variable RES over both short and long durations. This enhances the integration of variable RES into the power system while being considered as a critical tool to maintain grid stability and balance.

In addition to this, hydropower delivers various ancillary services essential for managing the transmission system, ensuring system stability and security of supply.

As per the study carried out by CEA during the period 2017-2023, the exploitable large hydro potential in the country is about 133.4 Giga Watt (GW). Further, the identified pumped storage potential is about 181.4 GW

The levelised tariff for pumped storage hydro projects in the base case (capital cost of Rs 6.5 crore per MW and 16.5% return on equity) is estimated at Rs 4.98 per unit while the landed tariff including cost of energy required for pumping is estimated at Rs. 8.92 per unit. Timely implementation of market reform proposals as highlighted in the final guidelines[5] issued by MOP on Pump Storage Projects also remains important to improve the financial viability of PSPs.[6]

Pumped storage hydro projects have a long economic life of 40 years, based on very mature and indigenous technology and are efficient. They are also cost competitive.

4.1 Hydro and Pumped Storage Plants Profile

The details related to operational PSPs are provided in the Table below:

[5] Guidelines_to_Promote_Development_of_Pump_Storage_Projects.pdf
[66] Hydro Power-Strong policy focus on pumped storage hydro schemes to encourage rapid development, ICRA, March 2023

Table 2: Operational Pump Storage Plants in India

S No	Name of PSP	State	Commissioning year	No of units x Unit size (MW)	Installed capacity (MW)	Project Operated by	Status
1	Nagarjuna Sagar	Telangana	1978-85	7x100.60	700.6	TSGENCO	Operational
2	Kadamparai	Tamil Nadu	1987-88	4x100	400	TANGEDCO	Operational
3	Bhira	Maharashtra	1995	1 x 150	150	TATA POWER	Operational
4	Kadana	Gujarat	1987-88	4 x 60	240	GSECL	Not Operating in Pumping
5	Srisailam LBPH	Telangana	2000-04	6x150	900	TSGENCO	Operational
6	Sardar Sarovar	Gujarat	2004-06	6x200	1,200	SSNNL	Not Operating in Pumping
7	Ghatghar	Maharashtra	2008	2x125	250	MAHAGENCO	Operational
8	Purulia	West Bengal	2007	4x225	900	WBSEDCL	Operational

(Source: CEA)

According to CEA's latest report (as of September 2024), there are currently 58 Pumped Storage Project (PSP) sites in various stages of development across India, with a combined installed capacity of approximately 69.9 GW. Of these, 19 are on-river sites with a total installed capacity of about 16 GW, and 39 are off-river sites, accounting for around 53.8 GW. In total, eight PSP projects have been constructed specifically as PSPs with a combined installed capacity of 4,745.6 MW. However, two projects—Kadana (240 MW) and Sardar Sarovar (1,200 MW)—are not currently operating in pumping mode.

Table 3: Status of PSP Development in India (As on Sep. 2024)

Status	On River		Off-River		Total	
	No of Schemes	Installed Capacity (MW)	No of Schemes	Installed Capacity (MW)	No of Schemes	Installed Capacity (MW)
In operation	6	3,305.60	-	-	6	3,305.60
Not working in Pumping mode	2	1,440	-	-	2	1,440
Under Construction	3	2,850	1	1,200	4	4,050
Construction held-up	1	80	-	-	1	80
Concurred by CEA	1	1,000	-	-	1	1,000
Under S & I	6	7,440	38	52,610	44	60,050
Total	19	16,115.60	39	53,810	58	69,925.60

(Source: CEA)

The PSP sites currently operational or in various stages of development are spread across 12 Indian States, with majority located in Andhra Pradesh and Maharashtra.

States	PSP On-River						PSP Off-River		Total PSP	
	Operating	Not Operating in Pumping	DPR concurred by CEA	Under Construction	Construction held-up	Under Survey and Investigation	Under Construction	Under Survey and Investigation	Sites	Capacity
Andhra Pradesh				1			1	18	20	23,020 MW
Gujarat		2							2	1,440 MW
Karnataka						1		2	3	3,900 MW
Madhya Pradesh						1		1	2	2,560 MW
Maharashtra	2				1	2		8	13	17,280 MW
Odhisha						1		2	3	1,420 MW
Rajasthan								3	3	5,560 MW
Tamilnadu	1			1		1			3	1,900 MW
Telangana	2								2	1,605.6 MW
Uttar Pradesh								4	4	8,340 MW
Uttrakhand				1					1	1,000 MW
West Bengal	1		1						2	1,900 MW
Total	6	2	1	3	1	6	1	38	58	69,925.5 MW

Figure 2: State Wise PSP Sites Under Operation and Various Stages of Development (Source: CEA)

4.2 Policy Framework and Government Initiatives

The Indian Government has implemented various policy initiatives over the years to foster the growth of the hydropower sector in the country, including the National Electricity Policy 2005, Tariff Policy 2016, National Rehabilitation & Resettlement Policy 2007, and the Right to Fair Compensation & Transparency in Land Acquisition, Rehabilitation and Resettlement Act 2013. Following are various initiatives taken up in the Hydro Power sector for faster development and improvement of infrastructure:

I. Key Developments

- On March 8th , 2019, Large Hydro Projects (>25 MW) was declared as Renewable Energy source

- Introduction of Hydro Purchase Obligation (HPO) : The latest trajectory for the period 2024-25 to 2029-30 has been notified by the Government on 20.10.2023.
- Scheme for bundling of Hydro Power with Renewable Energy has been notified vide MoP order dated 15.11.2021
- In April 2023, the Ministry of Power (MoP) notified guidelines for pumped storage hydropower projects, considering the significant role of PSPs in stabilising the grid and meeting the peaking power demand. It provides recommendations for the PSPs market, PSPs policies and safe PSPs development. It includes aspects such as monetisation of ancillary PSPs services to meet critical electricity market requirements; reimbursement of the State GST tax, exemption of fees on land acquisition for off-river PSPs; removal of an upfront premium for project allocation; and the identification and safe development exhausted mines for prospective PSP sites.
- In December 2024, the Ministry of Power circulated the draft National Hydro Power Policy 2024 internally. The policy applies to all large hydropower projects, including those with capacities exceeding 25 MW and Pumped Storage Projects (PSPs). It emphasizes the critical role of hydropower in meeting the nation's energy requirements, ensuring grid stability, and supporting the developmental aspirations of various regions. Furthermore, the policy underscores the importance of evaluating project viability by considering the diverse value attributes associated with hydropower.

II. Tariff rationalization measures for reducing hydropower tariff

- Announced on March 8th, 2019, providing flexibility to the developers to determine tariff by back loading of tariff after increasing project life to 40 years, increasing debt repayment period to 18 years and introducing escalating tariff of 2%.
- Waiver/ reduction in transmission charges for PSPs commissioned upto 30.06.2025 have been notified by Govt. vide MoP order dated 21.06.2021.
- In May 2023, waiver of ISTS charges has been inter-alia extended to Pumped Storage Projects for which construction work is awarded up to 30.06.2025, subject to certain conditions. Subsequently, part waiver of ISTS charges, in steps of 25%

from 01.07.2025 to 01.07.2028, have been extended for PSP for which construction work is awarded upto 30.06.2028.

- The Ministry of Power (MoP) on August 22, 2024 issued draft guidelines for the procurement of storage capacity and stored energy from Pumped Storage Plants (PSPs) through competitive bidding. These guidelines aim to promote the development of PSPs and create a transparent framework for their integration into the national power grid. It also encourages risk-sharing between stakeholders involved in PSPs.

  The draft proposes a single-stage two-part bidding process, consisting of technical and financial bidding stages for procuring storage capacity from pumped storage projects. For on-river PSPs, operations must begin within 66 months after signing the power purchase agreement (PPA). On the other hand, off-river PSPs require completion within 48 months of signing the PPA. The developers can start operations early with a 15-day notice, and the first phase of part commissioning must have a capacity of at least 50 per cent of the total project or 50 MW, whichever is lower.

  According to the draft, the government proposes two modes for procuring storage capacity from PSP. The first mode involves PSP located on sites pre-specified by the government, where the procurer can choose to develop the project on a site mentioned in the bidding document. If the site belongs to the government or a government entity, the project will be developed on a build own operate transfer basis for 25-40 years. The second mode allows the bidder to supply storage capacity from a PSP developed on a self-identified site or an existing commissioned PSP. In this case, the project may be developed on a finance own operate basis for a period of 15-25 years.

III. Budgetary Support

- 8th March , 2019 - declaration of Budgetary Support for Flood Moderation/ Storage Hydro Electric Projects (HEPs)

- 8th March, 2019 - declaration of Budgetary Support to Cost of Enabling Infrastructure i.e., roads/bridges. This has further been modified in September 2024 with a total outlay of ₹12461 crore. The scheme would be implemented from 2024-25 to 2031-32. The modifications include expanding eligible costs to cover not only roads and bridges but also transmission lines, ropeways, railway sidings, and communication infrastructure. The scheme will support projects with a cumulative generation capacity of about 31,350 MW, including private sector and pumped storage projects. The projects with a letter of award issued up to June 30, 2028 are eligible. The support limit is set at Rs 1 crore per MW for projects up to 200 MW and Rs 200 crore plus Rs 0.75 crore per MW for projects exceeding 200 MW, with a potential increase to Rs 1.5 crore per MW for exceptional cases.
- In September 2021, the Ministry of Power issued a procedure for providing budgetary support to flood moderation and storage hydroelectric projects. In September 2024, the Ministry of Power issued modifications to the scheme of budgetary support for the cost of enabling infrastructure for hydroelectric projects. The revised scheme expanded its scope beyond strengthening existing roads and bridges to include additional components such as:
    a) Transmission Line from power house to the nearest pooling point, including upgradation of pooling substation of State or Central Transmission Utility;
    b) Ropeways;
    c) Railway sidings
    d) Communication Infrastructure

IV. Operational and Administrative Initiatives

- Construction of Hydroelectric Projects usually gets delayed on account of various reasons resulting in time and cost overruns. Guidelines to reduce the incidence of time and cost overruns in hydro power projects were issued on 08.11.2019. These guidelines covered various aspects viz. realistic scheduling, usage of software tools, concept of sunset date, listing critical/ non critical works, delegation of power, timely settlement of claims, adoption of international best practices, resource

mobilization, dispute resolution, incentivizing labour on achieving project milestones in time, etc.

- The expenditure towards the idling cost leads to overall increase in the project cost. In order to reduce the same, MoP issued an advisory to all CPSEs on 19.07.2022 for rationalization of manpower at stalled projects
- In March 2023, CEA published revised guidelines for the formulation and concurrence of DPRs for PSPs. These guidelines reduce the timeline for the concurrence of DPRs from 90 days to 50 days for PSPs awarded under Section 63 of the Electricity Act, 2003 (tariff determined by bidding). PSPs that are part integrated renewable energy projects including wind and solar energy, and PSPs are being developed as captive or merchant plants.
- In June 2023, the timeline for the concurrence of detailed project reports (DPRs) for other PSP were reduced from 125 days to 90 days to expedite the process. As per the study carried out by CEA during the period 2017-2023, the exploitable large hydro potential in the country is about 133.4 Giga Watt (GW). Further, the identified pumped storage potential is about 181.4 GW. CEA has concurred 11 Hydroelectric (H.E.) schemes including PSPs with an aggregate installed capacity of 9,048 MW during the last five years. Further, 11 H.E. Schemes aggregating to 8,036 MW and 44 PSPs aggregating to 60,050 MW are under Survey & Investigation (S&I) for preparation of Detailed Project Report.
- The design, construction and maintenance of the slopes is one of the major challenges during planning, construction and operation of Hydro Power projects. Generally, slope instabilities in hydro power projects are encountered during execution as well as operation. In this matter, CEA issued Guidelines for Slope Stability in/around hydro electric projects on 05.10.2023

V. Policy Thrust on CPSUs

- With strong project management capabilities, past experience in development of large-scale projects and access to competitive cost of capital, CPSUs are most suited for development of hydro power projects, including pumped storage

schemes. In this matter, MoP has identified project sites aggregating 73 GW capacity and allocated these to CPSUs for faster roll-out of capacities.

- Central Financial Assistance (CFA) is granted to the State Governments of North Eastern Region (NER) towards their equity participation for development of Hydro-electric Projects in the NER through Joint Venture collaboration between State entities and Central Public Sector Undertakings.

VI. Dispute Settlement Measures

- Contingent liabilities arising due to contractual disputes are not conducive for financial health of the developer. To prevent this, MoP issued Guidelines on 18.03.2022 for early settlement of disputes and to minimize the arbitral claims/disputes in hydro sector.
- Notification of a "Dispute Avoidance Mechanism" through "Independent Engineer (lE)" and "Dispute Resolution Mechanism" through "Conciliation Committee of Independent Experts (CCIE)" to expeditiously and effectively address contractual disputes. The Government has decided to constitute three (3) Conciliation Committees of Independent Experts (CCIE), for settlement of disputes through Conciliation for Contractual Disputes in Projects implemented by CPSUs / Statutory Bodies under the administrative control of Ministry of Power. Each CCIE shall have three members having high level of integrity and proven track record. Till Mar'24, 15 disputes have been allocated to CCIE and 7 disputes have been resolved by CCIE.

4.3 CERC Tariff Regulations 2024-29

Considering the unique features and benefits of hydro power, following provisions have been formulated for development of Hydro Power projects in the CERC Tariff Regulations, 2024:

1) Measures to reduce front loading of Tariff:

Until 2019-24 tariff period, recovery of Depreciation for the first 12 years of the useful life of hydro generating station is based on the Straight-line method (@ 5.28%) and remaining depreciable value to be spread over the balance useful life.

Under the Tariff Regulations, 2024 applicable for 2024-29 tariff period, to reduce front loading of tariff, a new provision has been introduced specifically for new projects wherein recovery of Depreciation, based on the Straight-line method has been extended till first 15 years (@ 4.22%) (considering repayment period of 15 years) of the useful life and remaining depreciable value to be spread over the balance useful life. There is no change for existing projects.

Further, Hydro Generating stations are also allowed to charge depreciation lower than the rates specified in the Tariff Regulations, 2024 so as to enable reduced front loading of tariff. The enabling provisions introduced in the Tariff Regulations, 2024 are as under:

> *"Provided further that in the case of an existing hydro generating station, the generating company, with the consent of the beneficiaries, may charge depreciation at a rate lower than that specified in Appendix I and Appendix II to these Regulations to reduce front loading of tariff."*

2) New provisions introduced to allow **expenditure towards development of local infrastructure in the vicinity of the hydro power plant not exceeding Rs. 10 lakh/MW** which would be adjusted on receipt of budgetary support for the same.

3) **Separation of Insurance expenditure from normative O&M expenses:**

Till 2019-24 tariff period, Insurance expenses formed a part of normative O&M expenses. Thereafter, new provisions have been introduced in the Tariff Regulations, 2024 which provides that Insurance expenses arrived through competitive bidding for hydro stations will be allowed separately after prudence check (There is huge increase in cost of insurance premium for hydro stations due to recent incidents including flash floods etc.).

> *"c) The Security Expenses, Capital Spares and Insurance expenses arrived through competitive bidding for hydro generating stations shall be allowed separately after prudence check:*
> *Provided that the generating station shall submit the assessment of the security requirement, capital spares and insurance expenses along with its estimated expenses, which shall be trued up based on the details of year-wise actual capital spares consumed, actual insurance and security expenses incurred with appropriate justification."*

4) Hydro generating companies have considerable resources in the form of assets such as land banks and other enabling infrastructure that can be utilised to increase non-core revenues ecotourism, etc.

   Accordingly, in order to encourage Hydro generating companies to further strengthen the eco-tourism, provision of sharing of Non-tariff income from eco-tourism has been introduced.

   > *"84. Sharing of Non-Tariff Income: The non-tariff net income in case of generating station and transmission system from rent of land or buildings, eco-tourism, sale of scrap, and advertisements shall be shared between the generating company or the transmission licensee and the beneficiaries or the long term customers, as the case may be, in the ratio of 1:1."*

5) Monetizing Primary response - Higher AFC up-to 3% of Capacity Charge if primary frequency response is provided beyond a threshold level of 30% of Beta.

6) Incentivising peak generation - Incentive of 50 paisa/kWh for ROR Hydro station in case the saleable scheduled energy during peak hours of the day is in excess of average saleable scheduled energy during the day (24 hours).

5 Global Best Practices

In the late 20th century, many countries, including USA, Japan, Europe, and China, developed large-scale hydro and utility-scale energy storage projects to support the growing use of large nuclear and coal power plants. Pumped Storage Projects (PSPs) played a crucial role in managing load and utilizing surplus electricity generated by these plants during nighttime, while also serving as a reserve in case of unexpected outages. Consequently, PSPs operated on a daily cycle, drawing electricity for pumping at night and contributing to power generation during peak demand periods in the day.

The global Hydropower and Pump storage Installed capacity is given in the figure below:

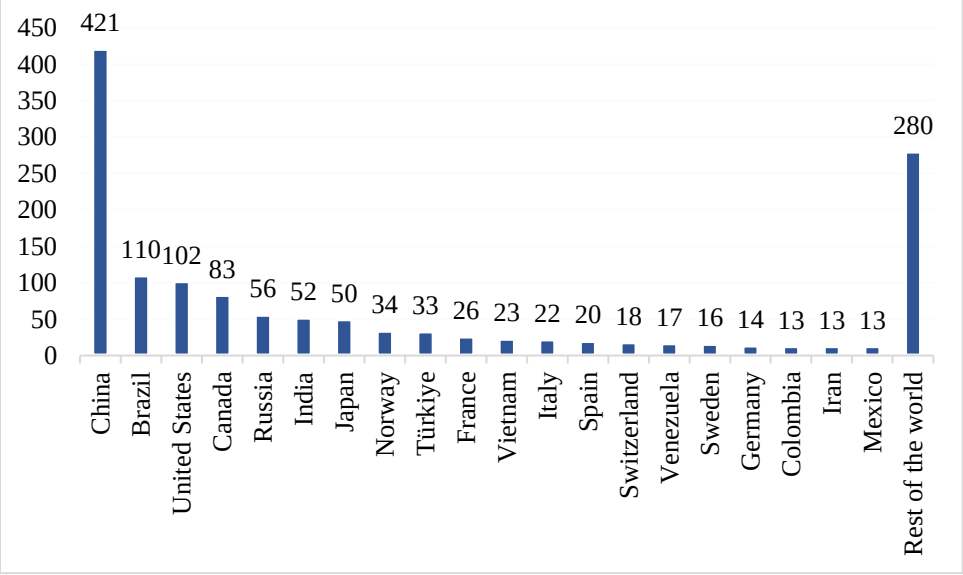


Figure 3: Installed Hydro Power Capacity (in GW) (Source: IHA)

The Global PSPs installed capacity as of 2023 is shown below:

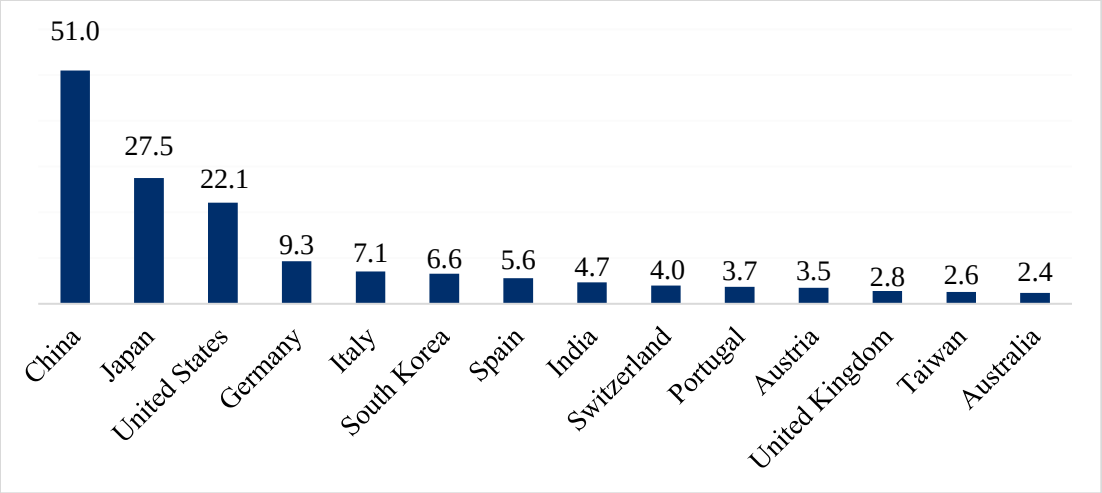


Figure 4: Countries leading in PSPs installation (GW)

Region	Pumped storage capacity added in 2023 (MW)
North and Central America	162
South America	0
Europe	121
Africa	0
South and Central Asia	0
East Asia and Pacific	6,206
TOTAL	**6,489**

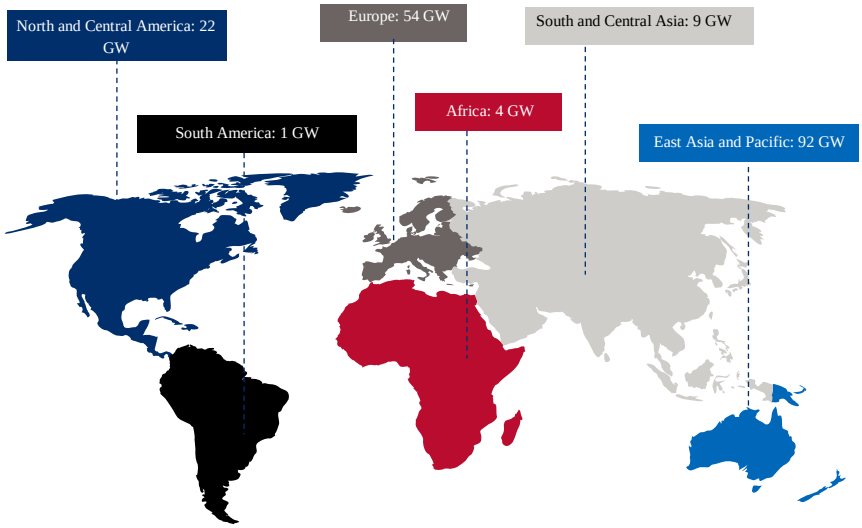


Figure 5: Global PSP overview by region

5.1 Drivers for PSPs development in various countries

Country wise important drivers for PSPs development are presented below:

China

In order to meet its growing electricity demand and to improve its energy mix, China has been actively developing PSPs since 2010. As of 2023, China has more than 26 PSPs totaling about 50

GW under construction and another 30 PSPs with an aggregate installed capacity of 42 GW planned to be built. The key assessment of different parameters along with key details are provided below:

Table 4: China PSP Market Overview

S. No.	Parameters	Details
1	PSP Target	• National Energy Administration (NEA) – mid-term and long-term plan for PSPs development starting from 2021 to 2035 at least up to 62 GW by the end of 2025 and 120 GW by 2030. Presently, 89 GW PSP capacity under construction. • China aims to add another 80 GW of PSP by 2027 (as per new national policy 'Guidance Opinions on Strengthening Grid Peaking Energy Storage and Smart Dispatch Capacity'
2	Institutional context surrounding the PSPs market	The National Energy Administration oversees the PSP industry. The majority of PSPs are developed by state-owned enterprises (SOEs). However, private companies are increasingly entering the market.
3	Operating Business Models	• In China Market-Driven Model introduced competition and price fluctuations. • For large-scale pumped storage projects, bilateral contracts between PSPs and power generators or grid operators. • Government-Supported Model: This models rely on government subsidies or feed-in tariffs to incentivize PSPs development.

The tariff mechanism for pump storage projects is provided below:

Table 5: Tariff Mechanism for Pump storage plants in China

Sr. No.	Type of Tariff	Summary	Payment mechanism	Cost Recovery Mechanism
1	Capacity Tariff	Reflect the value of pumped storage to provide ancillary services such as frequency regulation, voltage regulation, system backup, black start, etc.	Areas without spot power market: 6.5% internal rate of return (IRR) on capital for a 40-year operating period	Transmission and distribution tariff

Sr. No.	Type of Tariff	Summary	Payment mechanism	Cost Recovery Mechanism
		Recovering costs other than water pumping and power generation operating costs to obtain reasonable benefits	Areas with spot power market: The proportion of installed capacity that obtains capacity tariff is gradually reduced, and costs are recovered by participating in the power market (electricity tariff), mainly in the ancillary service market	Ancillary services market
2	Electricity tariff	Reflect the value of pumped storage to provide peak shaving services	Areas without spot power market: The on-grid tariff adopts the baseline tariff of coal-fired power generation, and the price of water pumping adopts 75% of the baseline price of coal-fired power generation	Grid enterprises purchase and sell electricity
		Recovery of operating costs for water pumping and power generation	Areas with spot power market: The on-grid tariff and water pumping price are both settled according to the spot market price and rules	Spot power market

Source: CET Program China[7]

Japan

Japan seeks to optimize its energy infrastructure and enhance grid stability for which PSPs have emerged as an essential component. Japan has a long history of utilizing PSPs technology, with

[7] CET_Pumped-storage-development-in-China_January-2023.pdf

over 20 operational PSPs currently providing over 27.4 GW of capacity and is the second largest in the world (JEPIC, 2024). The country is a global leader in PSP technology, with facilities such as the Okinawa Yanbaru Seawater Pumped Storage Power Station, a unique plant that has used seawater for energy storage. With regard to new Projects and Construction, Japan continues to invest in the development of new PSP projects to further enhance its energy infrastructure. One notable project is the Kannagawa Hydropower Plant. As of February 2024, the Kannagawa Hydropower Plant (KHP) in Nagano, Japan is partially active. This project will have a capacity of 2.6 GW, making it one of the largest PSP plants in the world. Additionally, the Japanese government is actively seeking partnerships and investments to identify other potential PSP sites throughout the country.

The growth of the PSP industry in Japan can be attributed to several key factors:

- Abundant water resources: Japan's numerous rivers, lakes, and mountainous terrain offer an ideal foundation for PSP project development.
- Government's commitment to enhancing the nation's energy infrastructure and PSPs are part of its strategy.
- The Govt. provides various financial incentives for PSPs development, including feed-in tariffs, subsidies, and tax breaks.
- Demand for a stable and reliable power supply as Japanese economy expands.
- Carbon neutrality target of 2050.
- Japanese Government is committed to achieve 36-38% of electricity generation from Renewable energy sources and 9.6% from hydropower sources by the year 2030.
- Japanese Govt. has planned to develop 10 GW of PSPs.

USA

By the end of 2023, the total hydropower installed capacity in USA was 102,120 MW. The Pumped storage installed capacity was 22.17 GW and the total generation by hydropower was 240 TWh[8]. While PSPs are supporting the integration of renewable energy in the US, the share of PSPs in total installed utility-scale energy storage has declined rapidly to 70% in 2022 from 93% in 2019.

[8] https://www.hydropower.org/region-profiles/east-asia-and-pacific

The rapid decrease in the PSPs share of power storage capacity in the past three years is explained by the very fast growth in battery installations in 2021 and 2022. U.S. utility-scale battery capacity was 1.52 GW at the end of 2020. New battery installations added 3.4 GW in 2021 and 4.1 GW in 2022. Thus, by the end of 2022, utility-scale battery capacity reached 9 GW (USDE, 2023).

Interest in PSPs development persists primarily as a resource that can complement renewable energy being added and to provide critical capacity, flexibility, energy balancing, and grid stability[9] along with long duration (8-12 hours) energy storage capability[10]. Also, US has setup a target to achieve PSPs capacity of 30 GW by 2030 and to achieve a 100% clean energy economy by 2050. Recently, Rye Development announced in early 2024 that it was selected by the DOE to receive US$81 million as funding for the Lewis Ridge PSP. This support came from DOE's Clean Energy Demonstration Program on Current and Former Mine Land, funded under the BIL[11].

Spain

In 2023, the total installed hydropower capacity in Spain was 20,425 MW with a total PSPs installed capacity of 5,650 MW. The total generation by hydropower was 25 TWh[12]. Further, as of 2024, 6 PSPs with total installed capacity of 2.5GW and over 740GWh of energy storage are in permitting stage or under construction[13]. The key drivers for PSPs development in Spain are:

- Spanish Government has an ambitious goal to develop 22GW of storage capacity by 2030 and for this, there is a grant scheme of €100 million for the development of PSPs.
- Spain has a unique law that is the first in the world under which all companies are required to set out clear climate action plans with emissions reduction targets that must be achieved over a period of five years. The law has prioritized the development of PSPs.
- Further, there is a support for the development of technology for energy storage for renewables, to increase the system's flexibility and stability. The strategy envisages having a storage capacity of about 20 GW by 2030 and 30 GW by 2050, considering both large-scale and distributed storage.

[9] https://www.energy.gov/eere/water/international-forum-pumped-storage-hydropower
[10] https://www.nrel.gov/news/press/2023/news-release-nrel-analysis-reveals-benefits-of-hydropower-for-grid-scale-energy-storage.html
[11] https://www.hydropower.org/region-profiles/east-asia-and-pacific
[12] https://www.hydropower.org/region-profiles/europe
[13] https://www.hydropower.org/region-profiles/europe

6 Key barriers and Issues in development of Hydro Power and PSP Development

Detailed questionnaires **(Annexure 7)** were sent to 12 developers, comprising both government owned public sector and private players, to comprehensively identify and analyze the key issues faced by hydro developers in India. By gathering detailed insights, the questionnaires aimed to understand the challenges at various stages of project development—from obtaining clearances to executing the projects. The objective was to help policymakers develop targeted strategies and solutions to address these obstacles, ultimately facilitating more efficient and successful hydroelectric project development in the country. The key developers whose responses were received include:

Government Developers:

- Maharashtra State Power generation Corporation Limited
- National Hydro Power Corporation (NHPC)
- Satluj Jal Vidyut Nigam Limited (SJVNL)
- Bhakra Beas Management Board (BBMB)
- Himanchal Pradesh State Electricity Board Limited (HPSEBL)

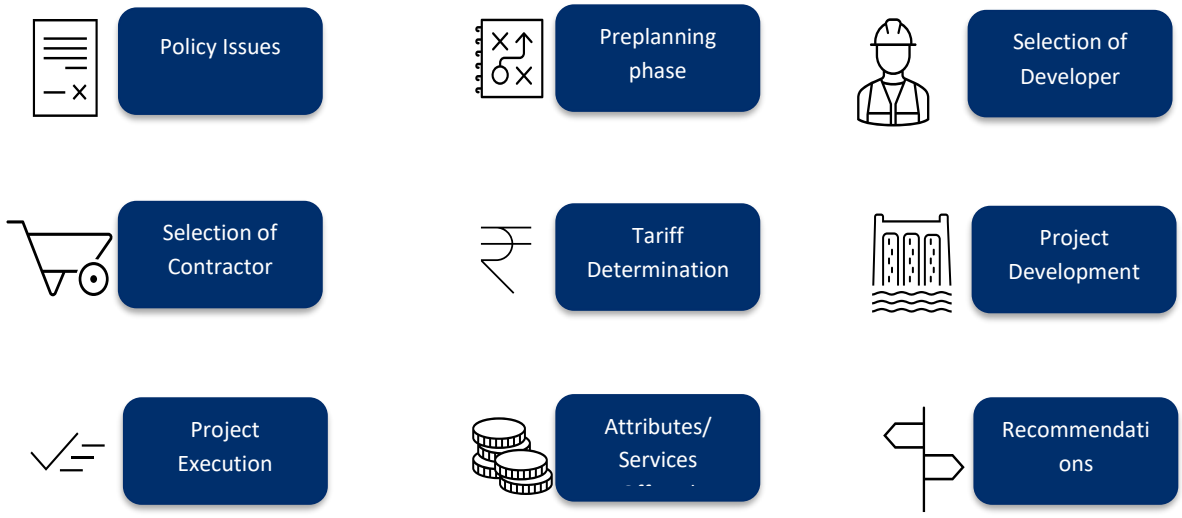
12 responses

Private Developers:

- Greenko Group
- Adani Green Energy Limited (AGEL)
- Tata Power Company Limited
- JSPL
- Devi Energies Private Limited
- Malana Power Company Limited/A D Hydro Power Limited
- JSW Energy Limited

The responses varied from challenges faced by the developers from policy related aspects to clearances related aspects. The developers during the course of different WG meetings submitted different crucial challenges faced by them during the various faces of the project execution. Some of the challenges are shown below:

The questionnaires are covered from various perspectives, as provided below:



The issue wise discussion is provided below:

1) **Policy Issues**: Policy issues in Hydro and Pumped Storage Projects (PSPs) development can create barriers to their timely implementation and economic viability. The developers suggested several constraints under policy issues which are as follows :
    - Environment and forest clearances related rules and policies such as requirement of FRA certificates/NOC from Gram Sabhas under the Forest Rights Act slows project development significantly.
    - Submission of mandatory Compensatory Afforestation (CA) land details during submission of forest diversion proposals and slow approval process for survey/investigation permissions in forest lands.
    - Mandatory free power obligation to States for Hydro Projects. State specific RE policies charging fees such as Harit urja fees, performances fees etc.
    - Waiver of ISTS charges is applicable for Hydro PSPs that have been constructed or are under construction subject to 'award of construction work' by 30th June 2025.
    - No differentiation in clearances for off-stream PSPs .

- The non-acceptance of off-stream Pumped Storage Projects (PSPs) as "White" or "B2 category" industries presents a significant policy challenge. Unlike solar, wind, and small hydro projects—classified under "White" or "B2" due to minimal environmental impact—off-stream PSPs have yet to receive this status.

2) **Issues in Preplanning phase**: The preplanning phase of Hydro and Pumped Storage Projects (PSPs) is critical to their success but fraught with many challenges. These issues often arise due to lack of standardized guidelines, overlapping responsibilities, and stringent requirements. Below is an analysis of the problems outlined by the developers::

a) Site Identification and Allocation:

- **Limited Detailed Mapping**: Insufficient geological, hydrological, and topographical data for potential sites.
- **Site Conflicts**: Overlapping claims by multiple developers due to lack of harmonized site allocation policies.

b) Clearance related issues: The clearance-related issues for Hydro and Pumped Storage Projects (PSPs) often result in significant delays due to centralized testing requirements and capacity constraints at key institutions like the Central Water Commission (CWC), Geological Survey of India (GSI), and Central Soil and Materials Research Station (CSMRS). Below is an analysis of these challenges as mentioned by the developers:

- All soil and construction material samples (often in large quantities, measured in tons) must be transported to the only testing laboratory in Delhi.
- Chapters related to hydrology, geology, and construction materials must be appraised and approved by CWC, GSI, and CSMRS.

c) Survey and Investigation:

- **Lack of Guidelines for Topography and Geological Mapping:** No clear framework for conducting surveys, leading to arbitrary requirements by authorities like DFO (Divisional Forest Officers).
- **Applicability of Mining Guidelines:** PSPs survey and investigation activities are often subjected to MoEF&CC guidelines meant for mining and mineral prospecting, which are time-consuming and costly and are delaying development of these projects.

- **Permission Bottlenecks**: Approvals for seismic and borehole surveys require permission from State Forest Department nodal officers, leading to significant delays.
- **Issues in Borehole Surveys for PSPs:** PSP projects require a significantly higher number of boreholes compared to mining due to the need for detailed geotechnical data to design foundations for large structures like powerhouses, dams, tunnels, and reservoirs. Boreholes for PSPs are often deeper, as they need to provide data for subsurface geological layers critical for the structural stability of deep underground caverns and reservoirs. Existing forest and environmental guidelines, designed for mining projects, restrict the number and depth of boreholes, making compliance burdensome.

3) **Selection of Developers:** The selection of developers for Hydro and Pumped Storage Projects (PSPs) is a critical process that requires transparent, efficient, and equitable mechanisms to attract competent players, ensure timely execution, and maximize project benefits. However, this process faces several challenges. Below is an analysis of the issues highlighted by the developers:
   - **Qualification Requirements:** Lack of standardized criteria for selecting developers results in inconsistent evaluation processes across States.
   - **Limited Opportunities for Private Developers:** Public Sector Undertakings (PSUs) often dominate the allocation process, leaving limited room for private sector participation. Recently 12 Hydro projects were allocated on Nomination basis to Public Sector Undertakings (PSUs) such as SJVNL, NHPC and NEEPCO. In order to expedite development of PSPs, level playing field need to be ensured between IPPs and PSUs.
   - **Selection solely based on financial criteria:** Overemphasis on the lowest cost (L1) bidding or concession fees can lead to compromises on technical expertise and long-term project viability.
4) **Selection of Contractor:** Selection of Contractor for Hydro and Pumped Storage Projects (PSPs) is a critical step that can significantly impact the success of a project. The contractor is responsible for the construction, execution, and delivery of various components, including civil works, electrical and mechanical (E&M) equipment, and operational infrastructure. Ensuring that the right contractor is selected, is key to meeting project timelines, ensuring quality, and managing costs effectively. Below are the main challenges in the contractor selection process for Hydro and PSPs as provided by the developers:

- **Limited pool of Civil Contractors:** The pool of experienced civil contractors and Original Equipment Manufacturers (OEMs) for Electro-Mechanical (E&M) equipment is limited, especially in the context of PSPs, which require highly specialized skills. Due to the complexity of PSPs (including underground works, large dams, and tunnels), there are few contractors who are fully equipped to handle such tasks.
- **Qualification criteria for contractor selection:** Lack of clarity on technical and financial qualification criteria in selection process can lead to ambiguities and inconsistencies. Emphasis on cost-based selection (L1 bidding) may result in the selection of contractors who bid low but may compromise on quality, leading to delays, cost overruns, and performance issues during construction or operations.

5) **Tariff Determination:** It is a crucial aspect of ensuring the financial viability and sustainability of Hydro and PSP projects, while also providing fair pricing for consumers. Below is an overview of the challenges in tariff determination for Hydro and PSPs, as suggested by the developers:

- **Capital Intensive Nature and Long Gestation Period:** Hydro and Pumped Storage Projects are inherently capital-intensive and have long gestation periods, often spanning 6-10 years or more. The nature of these projects involves significant upfront investment in infrastructure, including civil works, dam construction, tunnelling, and electrical infrastructure.
- Given the nature these projects are susceptible to delays, which can result in substantial cost overruns and extended timelines. One of the main challenges developers face, is the uncertainty in pass through of cost and time overruns, as these delays can significantly impact the financial model of the project, including the tariff structure. The pass-through of additional costs due to delays is often subject to the interpretation of tariff regulations and the scrutiny of the Regulatory Commissions, further contributing to the uncertainty in tariff determination.
- **Regulatory Uncertainty:** The regulatory framework for tariffs is typically reviewed and updated every 5 years, and tariff and operational norms are revised based on the prevailing scenario. This creates challenges for long-term projects, especially those with long gestation periods such as Hydro and PSPs, which can take 6-10 years or more to construct.

6) **Project Development:** Project development for Hydropower and Pumped Storage Projects involves a complex and multi-step process, which can take several years due to the technical, regulatory, environmental, and financial challenges involved. The development process includes a series of stages, each with specific requirements, risks, and considerations. Below is an overview of the key phases involved in the development of Hydro and PSP :

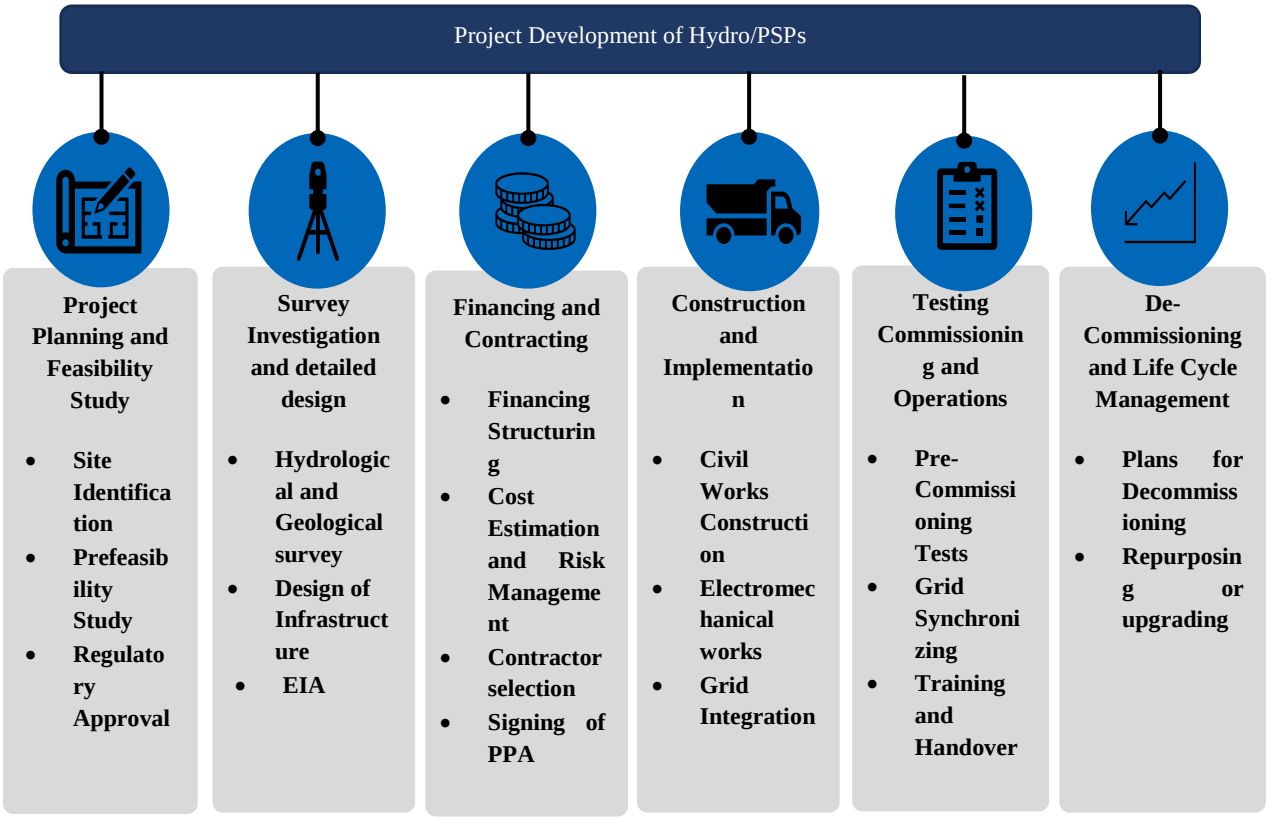


Figure 6: Different phases of Project development of Hydro/PSP project

Project Execution: The execution phase is the most critical part of the lifecycle for Hydro and Pumped Storage Projects (PSPs). It involves the transition from planning and design to physical construction, testing, commissioning, and final handover. Proper execution ensures timely project delivery within budget while maintaining quality and compliance with environmental, regulatory, and safety standards.

Developers encounter significant cost and time overruns during the project development phase due to the following reasons:

a) Adverse Geological Conditions:

- Shear zones with heavy water and mud ingress leading to TBM burial and extensive treatment works.
- Stress-induced phenomena like rock bursting.
- Encountering weak rock masses causing cavities during HRT excavation.
- Back slope failures in power house areas.

b) Natural Calamities:

- Cloudbursts, incessant rainfall, and similar events damaging approach roads and project components.

c) Contractor Performance:

- Poor performance leading to contract termination, re-tendering, and delays in awarding works.

d) Scope and Design Changes:

- Modifications to the project scope or design during execution.

e) Low Bidder Participation:

- Insufficient bidder interest resulting in project delays.

f) Rehabilitation and Resettlement:

- Displacement of communities from homes, fields, and workplaces is sensitive, costly, and time-consuming.
- Often leads to court cases, further delaying project execution.

g) Law and Order Issues:

- Protests by locals over blasting, muck disposal, employment demands, and compensation claims etc. Most of the time these protests are driven by individuals who try to fulfill their personal unjust demands/interests.

h) Contractual Challenges:

- Changes in scope due to geological surprises requiring design alterations or new construction methods.

i) Contractor Mobilization:

- Delays caused by inadequate deployment of manpower and machinery by contractors.

j) Quarry and Crusher Plant Issues:

- Non-availability of quarries near project sites.
- Delays in obtaining clearances for quarry and crusher plant operations.

7) **Attributes/Monetisation of Services by Hydro and PSP plants:** Hydro and PSPs provide a range of attributes and services that go beyond electricity generation, making them critical for grid stability, renewable energy integration, and water resource management. Proper recognition and monetization of these services can enhance their financial viability and attract more investment**.** Some of the services which can be monetised using Hydro/PSP Assets are provided below:

- Reservoir of project can be monetized by promoting activities for Hydro tourism such as boating, surfing, parasailing
- Fishery can be a good source of revenue generation
- Sale of extracted silt/sediments from reservoir beds by private agencies can be considered as an option of revenue generation
- Revenue generation by providing ancillary services

Figure 7: List of Plants providing ancillary support under SRAS mechanism[14]

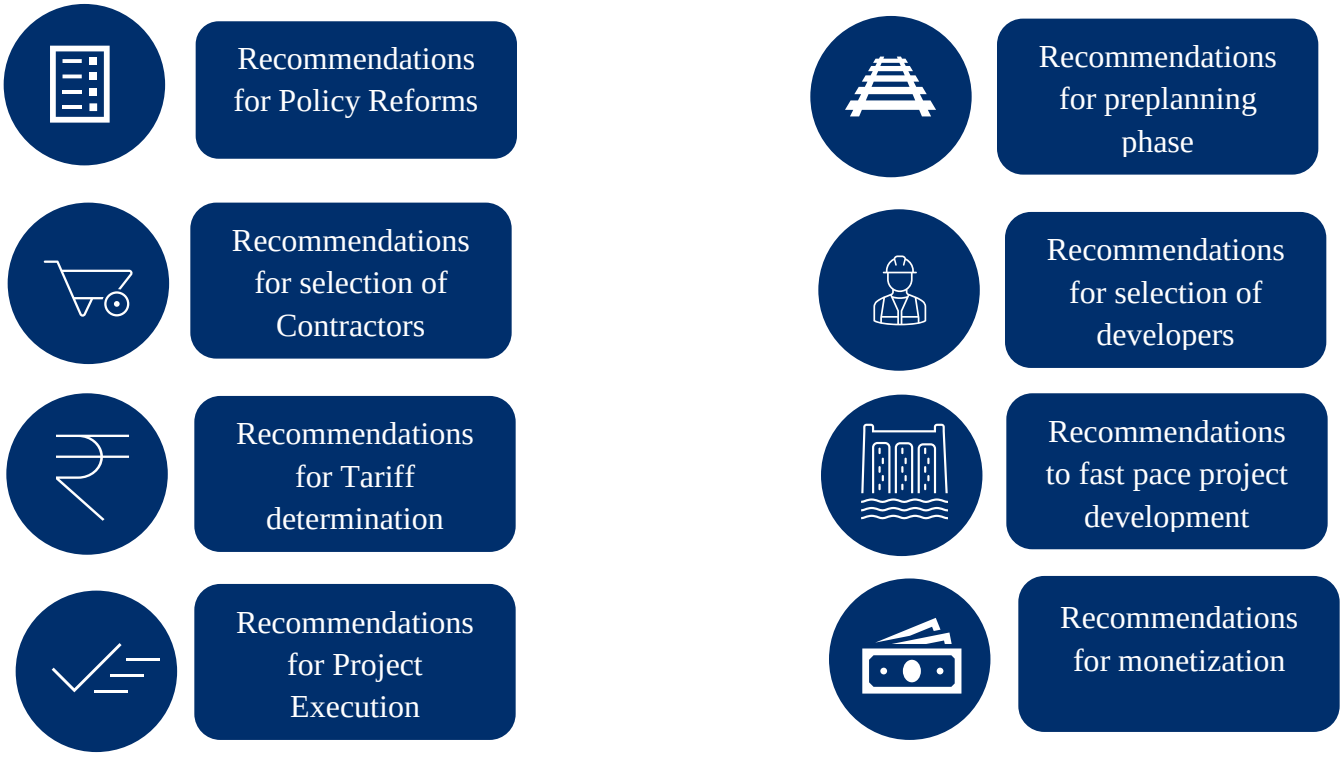
[14] Source: Grid India TRAS/SRAS Monthly Reports

7 Recommendations

This chapter outlines actionable measures to address the challenges and unlock the full potential of Hydro and Pumped Storage Projects (PSPs). As these projects are pivotal for ensuring grid stability, integrating renewable energy, and meeting long-term energy security goals, to realize their benefits, it is essential to adopt a multi-faceted approach that encompasses policy reforms, streamlined regulatory processes, improving contract management, and financial innovations. This chapter provides a roadmap for stakeholders, including policymakers, developers, and regulators, to create an enabling ecosystem that supports efficient project development, execution, and operation.

The recommendations are bifurcated based on the issues and challenges faced by the developers on different aspects as provided below:

Figure 8: Recommendations for accelerated development of Hydro & PSPs



1) Recommendation for Policy Reforms:

Policy play a pivotal role in fostering an enabling environment for development of Hydro and Pumped Storage Projects (PSPs). Addressing challenges and leveraging the benefits of these projects require focused interventions in following areas:

i. **Streamlined Policy Framework:** A streamlined regulatory framework is essential to expedite the development of Hydro and PSPs while ensuring speedy compliance with environmental and safety standards. It is felt that role of various agencies in Central and State Government should be of facilitator of Hydro and PSPs rather making a developer run from pillar to post for getting clearances: Based on inputs from stakeholders, following suggestions can be considered for implementation:

a) **Single Window System for clearance:** Currently, the process of obtaining the necessary technical, administrative, forest, wildlife, and environmental clearances is very time consuming process. Establishing a single-window clearance system can significantly streamline these approvals, and expediting project development by reducing delays.

Recommendation: A single-window system for (i) project allotment and technical clearance from CEA, Central Soil and Material Research Station (CSMRS), Geological Survey of India (GSI), and CWC, (ii) environmental, forest, and wildlife clearances, as well as for (iii) land acquisition and its monitoring, should be implemented at both the Central and State Government levels. For these an **Empowered Committee on Hydro Development** with representatives from concerned departments, should be set up at Central as well as State level. These empowered Committees should grant all clearances in a time bound manner. This system would streamline the approval processes, reduce delays, and facilitate faster execution of hydropower and PSPs.

India's National Single Window System (NSWS) currently accepts applications for 248 G2B clearances from 26 Central Ministries/Departments, along with various State/UT-level clearances across 16 States/UTs. The NSWS streamlines the process of identifying, applying for, and tracking approvals for integrated States and Central Departments, establishing itself as a comprehensive and efficient National Single Window System.

b) **Simplifying the PARIVESH Portal Application Process:** Currently, the PARIVESH Portal 2.0 of MOEF&CC requires extensive data for issuing Terms of Reference (ToR) for EIA and EMP studies.

Recommendation: At the initial project stage, much of this data is unavailable. Permission for Survey & Investigation of Projects should be granted by the State Forest Department without requiring the data at this stage. Instead, the data can be submitted on the portal after ToR issuance and completion of survey work. Role of MoEF&CC should be of a facilitator for Hydro projects to avoid costly delays, working closely with the project developer to ensure faster development of project with adequate safeguards for environmental sustainability.

c) **Exemption for Small Dam-Toe Power houses:** Under the EIA Notification, 2006, fresh environmental clearance is required for increased production capacity, even for additional electricity generated using e-flow discharge via a small dam-toe powerhouse.

d) **Recommendation:** Small dam-toe powerhouses generating upto 15 MW using e-flow discharge should be exempted from clearance requirements. This additional energy generation will also be at lesser cost of generation.**Compensatory Afforestation (CA) Details on the PARIVESH Portal**: Filling details of CA land is a mandatory condition during the Forest Clearance Stage-I application, although the Forest Department prepares the CA scheme.

Recommendation: The responsibility for filling CA scheme details in Form-A should rest with the Forest Department to avoid delays caused by requiring User Agencies to provide this information. Empowered Committee on Hydro should facilitate and guide forest department.

e) **Availability of Non-Forest Land for CA:** The Van (Sanrakshan Evam Samvardhan) Rules, 2023, require that Compensatory Afforestation (CA) primarily utilise equivalent non-forest land not under the control of the Forest Department.

Recommendation: Hydropower projects are typically located in remote and hilly regions where suitable non-forest land is scarce. Therefore, degraded forest land should be allowed for CA purposes without mandating a non-availability certificate for non-forest land. Efforts should focus on creating a land bank of suitable degraded forest areas for CA, organized division-wise and state-wise. The land bank should include:

i. **Compensatory Afforestation Rates:** Comprehensive data on costs related to tree planting, afforestation, and associated activities.

ii. **Digital and Geo-Referenced Maps:** Online tools for preparing and accessing accurate digital and geo-referenced maps to facilitate planning and implementation.

Empowered Committee on Hydro to coordinate and make this data bank available to project developers. This approach would streamline the CA process and reduce delays in obtaining forest land diversion clearances.

f) **Land Acquisition:** The State Government should streamline and reassess the timelines for the land acquisition process to ensure that land is acquired and made available to the developer as quickly as possible. The area of river valleys is currently included in the calculation of CA land requirements.

Recommendation: States could appoint a Nodal Officer as the primary point of contact and implement a single-window system for land acquisition. Additionally, States might establish a standardized system for land valuation, ensuring compensation is based on the market value through third-party assessment.

For Hydro Projects, river valleys/course should be excluded from CA land calculations, as 25-30% of forest land required for project construction often falls within the river course. A provision similar to the 50% NPV rate for riverbed areas (per Revised NPV rate OM dated 6.1.2022) should apply to CA requirements. This would reduce CA land requirements and associated delays.

g) **Carrying Capacity Study Requirements**: MOEF&CC mandates a State Government-conducted Carrying Capacity Study of the river basin as a precondition for Forest Clearance Stage-I and Environmental Clearance.

Recommendation: As this requirement is beyond the Project Proponent's control, it should be relaxed for Hydro Power Projects when granting EC and FC. If considered essential, this work may be carried out by Empowered Committee on Hydro for all river basins.

h) **Specific Geological and Seismic Studies by Designated Agencies:** Sometimes, the Forest Advisory Committee (FAC) mandates studies by a specific agency only. This often causes delays if the agency does not have adequate capacity to conduct the study.

Recommendation: Studies already conducted or vetted by reputed institutes should be accepted. Additionally, the FAC should provide a list of alternative reputable agencies to ensure timely project progress.

i) **Mandatory NOCs for Forest Clearance Process:** Under the Forest Clearance (FC) process, obtaining No Objection Certificates (NOCs) for the Forest Rights Act (FRA) and approval of the Catchment Area Treatment (CAT) Plan are essential steps. These approvals, managed at the State level, often cause significant delays in the overall FC timeline.

Recommendation: To streamline the Forest Clearance (FC) process, it is recommended to develop a centralized online portal for submitting and processing Forest Rights Act (FRA) certificates and Catchment Area Treatment (CAT) Plan approvals. The portal should enable real-time tracking of application status and provide clear guidelines on the required documentation. Additionally, strict timelines should be formulated for reviewing and approving FRA certificates and CAT Plans at the State level to prevent delays. The Ministry of Tribal Affairs should provide assistance by facilitating capacity building, simplifying procedures, and addressing concerns related to the implementation of FRA provisions. These measures will enhance efficiency, promote transparency, and reduce delays in the FC process while ensuring compliance with legal and environmental requirements.

j) **Requirement of NOC from Gram Sabha:** Under the Forest Rights Act (FRA), obtaining a No-Objection Certificate (NOC) from the Gram Sabha is necessary to ensure that the forest rights of the Gram Sabha or village are protected. However, this process can be time-consuming and might cause delays in project development due to unjust demands of the villagers and personal unfair interests of some individuals.

Recommendation: To expedite the process, the forest rights of the Gram Sabha or villages can be proactively addressed by the State Government at the time of project allocation. If the rights of the village/Gram Panchayat have already been settled by the State in general, the NOC for the project should be issued promptly and without unnecessary delays.

k) **Modification of changes proposed:** During the initial stages of project approval, certain details are submitted online, but these may change as the project progresses. However, modifications to these forms are not permitted until the Stage-I Forest Clearance (FC) is granted.

Recommendations: There should be flexibility in allowing modifications to the details submitted online before the grant of Stage-I FC, especially if project details evolve during

the project report preparation phase. This would ensure accuracy and prevent delays caused by the need to resubmit forms or alter information once submitted.

l) **Consideration of Off-stream Pumped storage Project under White Category:** Currently, Off-Stream Pumped Storage Projects (PSPs) are not considered under the White category, which typically includes non-polluting industries. The White category includes sectors such as solar power generation, wind power, small-hydel power (less than 25 MW), and other industries with minimal environmental impact. Off-Stream PSPs, which do not require significant water diversion or impoundment and are not associated with direct emissions or pollution, do not fall into this category.

Recommendation: Given that Off-Stream Pumped Storage Projects are essentially non-polluting and share characteristics with other small-scale renewable projects (such as small-hydel power plants of less than 25 MW), they should be considered under the **White Category**. This would recognize their minimal environmental impact and align them with similar clean energy projects that are considered less disruptive to the environment. This classification would simplify the approval process, reduce regulatory burdens, and incentivize more investments in PSPs technology, contributing to the broader renewable energy goals.

m) **Transfer of Clearances:** The development of hydro power projects has a long gestation period, during which there is sometimes a change in ownership. Hence, the change in ownership may be allowed to be transferred.

Recommendation:

Various clearances, such as Environmental Clearance (EC), Forest Clearance (FC), and DPR concurrence, already issued in the name of a previous developer, should be transferable to the new user agency or developer. The concerned Central and State Departments/Organizations should

The USA (FERC) allows the transfer of a permit in case the developer who has been granted the preliminary permit is not ready to construct the project.

streamline and simplify the process for transferring these clearances to facilitate seamless project continuity.

n) **Strategic Legislation for Hydropower for Priority for Security and Grid Stability:** Hydropower, like nuclear energy, plays a critical role in national security, grid stability, and energy independence, warranting the introduction of legislation akin to the Atomic Energy Act. Such a legislation should recognize hydropower as a strategic resource essential for addressing the challenges of a growing renewable energy grid and energy storage needs**.**

iii. Policy Incentives for Financial Viability: Ensuring the financial viability of energy projects, especially in sectors like renewable energy, hydroelectric, and pumped storage projects, is crucial for attracting investments and ensuring project success. Several policy incentives can be considered to enhance the financial viability of such projects:

a) **Fixation of Free Power Obligation from Hydro Plants as per Original MOU:** Hydropower projects are typically required to provide free power to the home State, as stipulated in the original Memorandum of Understanding (MOU). For instance, many projects are required to supply more than 12% free power to the home State during its years of operation. However, in some cases, States have arbitrarily changed the terms of the MOU for various reasons, impacting the financial stability of the project.

Recommendation: It is recommended that the free power obligation be fixed as per the original MOU to maintain the financial model of the hydropower plants. Altering the terms midway can have significant financial implications, including revenue loss, which affects the viability and sustainability of the project. Ensuring that the MOU terms are honored consistently across the project lifecycle would provide stability for developers and maintain investor confidence in the sector. Since higher revenue is required by project developer for Loan payment in initial years, Free power may be deferred and increased from 8% to 12% in 15 years in a tapered manner in consultation with the State Government. Deferred free power can be provided in the subsequent period after 15 years of operation. Further, as provided by MOP in its Guidelines on Pumped Storage Projects vide dated 10 April, 2023, the PSPs be considered different from normal hydro projects and be exempted from free power obligation.

b) **Measures to reduce front loading of Tariff:**

Until 2019-24 tariff period, recovery of Depreciation for the first 12 years of the useful life of hydro generating station is based on the Straight-line method (@ 5.28%) and remaining depreciable value to be spread over the balance useful life. Under the CERC Tariff Regulations, 2024 applicable for 2024-29 tariff period, to reduce front loading of tariff, a new provision has been introduced specifically for new projects wherein recovery of Depreciation, based on the Straight-line method has been extended till first 15 years (@ 4.22%) (considering repayment period of 15 years) of the useful life and remaining depreciable value to be spread over the balance useful life. Further, Hydro Generating stations are allowed to charge depreciation lower than the rates specified in the Tariff Regulations, 2024 so as to enable reduced front loading of tariff. Enabling provision introduced in the Tariff Regulations, 2024 are as under:

"Provided further that in the case of an existing hydro generating station, the generating company, with the consent of the beneficiaries, may charge depreciation at a rate lower than that specified in Appendix I and Appendix II to these Regulations to reduce front loading of tariff."

Similar provisions may be made for State Hydro projects to reduce tariff in initial years to improve their financial viability**.**

c) **Waiver of creation of Local Area Development Fund:** Hydropower and Pumped Storage Projects (PSPs) are often required to contribute to the Local Area Development Fund (LADF) to support the development of the surrounding community, particularly in areas where the project has significant environmental or social impacts, such as resettlement and rehabilitation (R&R).

Recommendations: For **Off-stream Pumped Storage Projects (PSPs)**, which have minimal environmental impact and do not require significant resettlement or rehabilitation efforts, it is recommended to waive the requirement to create a Local Area Development Fund (LADF). These projects do not cause major disruption to local communities or ecosystems, and therefore, there is no pressing need for additional funds to address R&R or significant environmental damage. Waiving this requirement would reduce the financial burden on developers, making the projects more economically viable while still ensuring

responsible development. Further, hydro and PSPs may contribute a revenue equivalent to 1% of ex-bus power generated from the project towards local area development to ensure that the benefits of the projects are accrued to project-affected families.

d) **Financing the Off stream Pumped Storage Projects at par with other RE projects:** Currently, Off stream Pumped Storage Projects (PSPs) is more challenging as compared to other renewable energy projects like solar and wind, due to their higher capital costs, longer gestation periods, and perceived higher risks. Financing agencies such as PFC, REC, IREDA sometimes hesitate to extend funding to these projects on the same favorable terms offered to solar and wind projects.

Recommendations: Hydro and Pumped Storage Projects (PSPs) should be financed at par with other renewable energy (RE) projects such as solar and wind. These projects play a critical role in stabilizing the grid and supporting renewable energy integration through energy storage, making them just as essential for achieving clean energy goals.

e) **REC Multiplier for Hydro/PSP**

Enabling REC multiplier for Hydro power projects (say, 2x-3x) and for Pumped Storage Projects (say, 3x-4x) as a Policy measure may be considered which would facilitate demand push for Hydro/PSP development, as there is overall shortfall in RPO targets across various States. The REC multiplier factor can be calibrated over the period based on levelized cost of development of Hydro/PSPs. RPO target compliance monitoring and its enforcement is a priority policy agenda and enforcement framework has also been recently revised as per amendments brought under Energy Conservation Act.

f) **Increase in waiver of ISTS for new Hydro and PSP projects beyond 30 June 2025:** Currently, the waiver of the Inter-State Transmission System (ISTS) charges for hydro and pumped storage projects is limited to projects commissioned by 30 June 2025. In contrast, solar and wind projects have been granted a waiver for a much longer period, typically around five years.

Recommendations: It is recommended that the waiver of ISTS charges for new Hydro and Pumped Storage Projects (PSPs) be extended beyond 30 June 2025, with the waiver period potentially extended until 2030. This would help accelerate the pace of development for these crucial projects by providing financial relief during the initial stages, particularly as many new hydro and PSPs are expected to be commissioned by 2028-29.

There is a need for policy reforms, including single-window clearance, simplification of approval processes, and financial policy reforms such as an increased waiver of ISTS and more accessible financing options.

2) Recommendations for Preplanning phase:

The preplanning phase is crucial for the successful implementation of hydro and PSPs. Proper groundwork in this phase can mitigate delays and challenges during the project's execution. Below are key recommendations for the preplanning phase to ensure smoother project development**:**

I. **Single agency for DPR preparation to project development (Creation of SPV similar to UMPP):** In many hydro and pumped storage projects, multiple agencies are involved in different phases, from the preparation of the Detailed Project Report (DPR) to the actual project development. This often leads to coordination challenges, delays, and inefficiencies, as each agency may have different priorities, timelines, and procedures.

Currently, there is no provision for the creation of a Special Purpose Vehicle (SPV) specifically for hydropower projects, like the model followed for Ultra Mega Power Projects (UMPPs) in the thermal sector. UMPPs were established to fast-track the development of large thermal power plants by pooling resources, reducing financial risks, and enabling large-scale coordination for project development. A similar SPV structure could potentially be applied to hydro and pumped storage projects to streamline the process and accelerate development.

Recommendations: It is recommended to create an SPV framework for Hydro and Pumped Storage Projects (PSPs), similar to the UMPP model for thermal plants. The establishment of an SPV would help in the following ways:

i. **Faster Development:** By centralizing the management and coordination of the project, the SPV can reduce delays associated with approvals, land acquisition, and other regulatory hurdles, ensuring that large-scale hydro and Pumped Storage Projects are fast-tracked. SPV should be made responsible for the DPR preparation.

ii. **Financial Structuring:** The SPV can provide a clear and efficient financial structure, enabling easier access to funding from both domestic and international financial institutions. This would help pool resources and distribute risks more effectively.

Coordinated Project Execution: The SPV can be responsible for overseeing all aspects of the project, from planning and design to construction and operation, ensuring that all stakeholders are aligned and that the project progresses smoothly. After obtaining all clearances, Hydro and PSPs may be handed over to selected developer for project execution.

iii. **Government Support:** The creation of an SPV would signal the government's commitment to renewable energy and grid stability, attracting both public and private sector investments. The government could also play a role in facilitating the regulatory processes and offering financial incentives or guarantees.

iv. **Risk Mitigation:** With an SPV, risks related to land acquisition, environmental clearances, and financing could be more effectively managed, reducing uncertainties for investors and developers.

v. Detailed guidelines need be framed for selection of developer and appropriate modalities for handing over of SPV, including milestone/timelines/stage for such hand-over need to be stipulated.

II. **Streamlining Hydropower Clearances: Drawing Cues from other National Projects:** Hydropower development can greatly benefit from the streamlined processes employed in national infrastructure projects like those under the National Highways Act and the Railways Act. These frameworks prioritize fast-tracked approvals, limited public consultations for critical infrastructure, and simplified land acquisition processes, which can be adopted to hydropower development. By incorporating

elements such as urgency clauses, structured grievance redressal mechanisms, and uniform rehabilitation policies for affected communities, the hydropower sector can achieve significant efficiency gains as presented below:

a) **Exemptions and Fast-Track Approvals:** Hydropower and PSPs should be designated as "critical infrastructure," allowing for expedited Environmental Impact Assessments (EIA) and Environmental Clearances (EC), similar to the processes followed during the creation of dedicated freight corridors for Indian Railways.

The Regional Rapid Transit System (RRTS) serves as a prime example of effective DPR (Detailed Project Report) preparation. Sanctioned in 2019, the contracting process was initiated by the end of 2020 and finalized in 2021. Remarkably, the project was commissioned within three years, owing largely to a meticulously prepared DPR. Key alignments, such as road widening, utility relocation, and tree cutting, were planned and addressed before project implementation, ensuring a seamless transition into the main construction phase and minimizing delays.

b) **Exemptions for Smaller Projects:** National infrastructure development, minor or low-impact projects, such as bypasses or small expansions under the National Highways framework, are often exempted from comprehensive EIAs or extensive public consultations. Similarly, off-stream Pumped Storage Projects (PSPs), which typically have a lower environmental impact, can benefit from similar exemptions to streamline approval processes and encourage faster project implementation.

III. **Centralized Preplanning and Clearance by SPV and CEA for Competitive Tariff Discovery:** To enable the discovery of more competitive tariffs, the SPVs and Central Electricity Authority (CEA) should undertake centralized preplanning activities, including site selection, feasibility studies, and securing necessary statutory clearances such as technical, administrative, forest, wildlife, and environmental approvals. Once these processes are completed, the projects can be offered for bidding, allowing developers to focus solely on the development, construction, and operation of the plants. This streamlined approach would reduce uncertainties and facilitate competitive tariff discovery.

IV. **Monitoring Hydro and PSP Progress via PM Gati Shakti Portal:** The progress of the conventional hydro/PSPs projects from planning to execution should be monitored by the PMO portal **"PM Gati Shakti".**

V. **Creation of checklist for each responsible agencies with its timeline:** Hydro and Pumped Storage Projects (PSPs) require multiple clearances from various agencies, such as the Central Electricity Authority (CEA), Central Soil and Material Research Station (CSMRS), Geological Survey of India (GSI), Central Water Commission (CWC), and others. The involvement of multiple agencies lead to delays due to unclear responsibilities, missing documentation, or overlapping requirements.

Recommendations: To streamline the clearance process and ensure timely project execution, it is recommended that a comprehensive checklist be developed for each responsible agency, with clearly defined timelines for each stage of the clearance process. This checklist will ensure that all requirements are met in a structured manner and provide a transparent and efficient way of tracking approvals. Staff from these agencies can be posted directly under control of CEA to fast tract the approval process and to stick to pre-defined timelines.

VI. **Creation of Private testing agencies for all the tests approval:** Currently, developers are required to conduct various tests (such as soil testing, geological surveys, hydrological studies, etc.) for obtaining approvals of the Detailed Project Report (DPR). One of the main challenges faced is that certain testing and approval processes are centralized with government agencies, such as the Central Soil and Material Research Station (CSMRS), which has limited infrastructure (for example, it has only one lab in New Delhi). This results in delays and added costs for developers due to limited testing capacity and long turnaround times.

Recommendations: To expedite the approval process and enhance testing capacity, it is recommended to allow the creation of private testing agencies or accredited third-party labs to conduct the required tests for the approval of DPRs, similar to practices seen in other industries. This would help in increasing the overall efficiency and capacity for conducting necessary tests across multiple locations.

VII. **Creation of Zone-wise directorate for each government agency:** Currently, the Central Electricity Authority (CEA) and other government agencies play a crucial role

in scrutinizing and approving Detailed Project Reports (DPRs) for hydro and pumped storage projects. However, given the growing number of projects, centralizing all the tasks at a single location often leads to delays and inefficiencies due to the high workload at the central office.

Recommendation: To expedite the DPR approval process, it is recommended that an extended structure of CEA be created with zone-wise directorates (East, West, South, and North). Each regional directorate would be responsible for reviewing the DPR chapters and conducting the necessary scrutiny before forwarding the recommendations to the Empowered Committee on Hydro for final approval.

3) Recommendations for Selection of Contractors:

Selecting the right contractor is crucial for the successful execution of hydro and pumped storage projects (PSPs). The selection process ensures that contractors have the necessary experience, technical capabilities, financial strength, and adherence to safety and regulatory standards. The current contracting practices can sometimes lead to inefficiencies, delays, and budget overruns due to the selection of ill-suited contractors or poor evaluation procedures.

i. **Use of Quality-Cost-Based Selection (QCBS) Model:** The Quality-Cost-Based Selection (QCBS) model should be adopted for selecting contractors for hydro and PSPs. This model evaluates contractors based on both the technical quality of their proposals and the financial capability, ensuring that the best-value contractor is selected. Quoted Time of execution should also be a bidding parameter as early completion needs employing more resources.

Incorporation of Experience and Technical Expertise in Evaluation: Contractors should be evaluated based on previous experience in similar hydro and Pumped Storage Projects, their technical capabilities, and their approach to managing the unique challenges of the project (such as site conditions, environmental concerns, and safety measures).

Financial Capability and Performance Bond: The financial stability and capability of contractors should be carefully assessed, with emphasis placed on their ability to mobilize resources for large-scale projects. A performance bond should be required to

ensure that contractors are financially committed to completing the project on time and according to specifications.

ii. **Incentives for Timely Completion:** Contractors should be incentivized with performance-based bonuses for completing projects ahead of schedule or meeting key milestones ahead of time.

iii. **Strengthening the Contract Monitoring and Compliance Framework:** A robust monitoring and compliance framework should be set up to track contractor performance till commissioning of the Project. This includes regular progress reviews, safety audits, environmental assessments, and quality checks. Use of digital tracking systems, drones for site inspections, and data analytics can provide real-time insights into project progress and contractor performance.

iv. **Dispute resolution process:** Many Hydro projects are often delayed due to contractual disputes. Taking disputes through arbitration and court proceedings delays the executions and also increases the cost. It is therefore, recommended to create an Empowered Committee to settle contractual claims quickly and to ensure that work is not held up for any contractual dispute.

v. **Empanelment of Pool of Contractors and Capacity Building:** To address the challenges posed by a potential shortage of competent contractors and the limited manufacturing capacity of OEMs for E&M equipment in India, the government should focus on the empanelment of a pool of contractors and initiate a capacity-building program for contractors and OEMs. Furthermore, OEMs need to be encouraged to establish manufacturing capacities in India.

4) Recommendations for Selection of Developers:

Selecting the right developer for hydro and pumped storage projects (PSPs) is crucial for the success of these large, complex, and capital-intensive projects. The selection process should ensure that developers have the necessary technical, financial, and operational capabilities, as well as a commitment to safety, environmental sustainability, and community engagement**.**

i. **Selection of project developers for Govt. identified projects:** The Government should implement a transparent bidding mechanism for the selection of developers for

projects identified by the Government. This process would ensure that capable developers with the required technical expertise, financial stability, and commitment to project delivery are selected, while maintaining fairness and transparency.

a. **Comprehensive Evaluation Criteria (Technical, Financial, and Regulatory Compliance):** The selection process should evaluate developers based on a comprehensive set of criteria, including technical capability, financial strength, experience in similar projects, and regulatory compliance (e.g., environmental approvals, safety standards, and compliance with local laws).

b. **Consideration of Technical Expertise and Experience in Hydro/PSP Projects:** Developers should have proven expertise in the development, construction, and operation of hydropower and pumped storage plants.

ii. **Swiss challenge method for Self-identified Projects:** A model of PPP mode for self-identified sites by Project Developers should be explored. PPP mode can be enabled through 'Swiss Challenge' method[15]. Swiss Challenge Method is globally recognized procurement method based on PPP Model which provides an opportunity to private sector to conceive an innovative unsolicited project proposal in India under the State and Central government. Governments in India had implemented various projects under Swiss Challenge Method in several infrastructure sectors such as Transportation infrastructure, Road infrastructure, Urban and Municipal infrastructure, Agriculture infrastructure etc.

5) Recommendation for Tariff determination:

Ensuring a robust, transparent, and equitable tariff determination framework is essential for the financial viability of Hydro and Pumped Storage Projects (PSPs). These recommendations aim to address current challenges, incentivize investments, and make tariffs competitive while balancing the interests of all stakeholders.

i. **Viability of Tariff Regulations:** Tariff regulations are reviewed every five years, with tariff and operational norms revised based on prevailing scenarios. However, projects

[15] Guidelines for Procurement of PPP Projects through Swiss Challenge Route [https:// www.adb.org/sites/default/files/institutional-document/31313/ppp-swiss-challenge-route.pdf

under construction for extended periods are often excluded from consideration during the determination of these norms. To address the challenges posed by the long gestation periods of hydro and pumped storage projects (PSPs), tariff regulations should incorporate greater flexibility to account for evolving cost structures and operational scenarios.

ii. **Increase in Useful life of the project from 40 years to 50 years:** Extending the useful life of new Hydro/PSP projects from 40 years to 50 years has a minimal impact on tariff reduction, as the majority of depreciation is recovered within the initial 15 years. Furthermore, tariff calculations over a 40 or 50-year period show negligible differences in revenue during the latter stages of the project due to the reduced time value of money. However, the useful life of hydro power plants can reasonably be extended to 50 years, as these projects are often capable of operating beyond 40 years without requiring Renovation & Modernization (R&M) works.

iii. **Increase in expenditure towards developing local infrastructure in the vicinity of the power plant:** The development of local infrastructure in the vicinity of power plants is crucial for ensuring the timely completion of projects. Therefore, the current expenditure limit of ₹10 lakh/MW, as stipulated in the CERC regulations, may be increased to at least ₹20 lakh/MW or allowed on an actual basis as part of the capital cost. If such infrastructure development works—such as schools, roads, sewerage treatment plants, and drinking water facilities—receive budgetary support from the Government of India (GoI), the funding should be adjusted upon receipt of such funds. Furthermore, if expenditure for local infrastructure development occurs after the Commercial Operation Date (COD) of the project, it should also be allowed as a pass-through in the tariff. This is especially relevant given the higher risks of slope stabilization issues, flash floods, bridge and road washouts, and unpredictable heavy rains, as evidenced by recent trends in States like Himachal Pradesh, Uttarakhand and Sikkim.

iv. **Three Part Tariff for PSP:** As PSP is acting as storage for Discom/User as well as Ancillary Service provider to system operator, to avoid dispute with Discom who is providing energy for pumping mode, its tariff structure should differentiate between ancillary services for the Grid and discharging for Discom. Accordingly, PSP tariff can

have three parts viz 1) fixed cost recovery linked with Availability, 2) Energy charges for conversion of off peak power into peak power (both these are to be paid by contracting Discom) and 3) Ancillary services charges for frequency control, peak shaving, black start services, inertia support etc. (to be paid by System Operator from Pool).

6) **Recommendations on Operation of PSPs:** In PSP, three main stakeholders are, (i) Project Developers who is developing and operating the project, (ii) Discom/User who is using PSP as storage and (iii) System Operator who issue scheduling instruction to PSP for purpose of ensuring smooth Grid Operations. All these stakeholders have different interests and there may be occasion when these interests may create conflicts in certain situation e.g. when Discom/User wants to schedule PSP in pumping mode for storing its excess contracted RE, System Operator may require to run PSP in generation mode for controlling system parameters. Under such circumstances, clear laid down procedure for scheduling PSP and compensation mechanism would help project developers to evaluate viability of such projects. Therefore, it is recommended that appropriate Regulatory framework shall clearly stipulate how decision of scheduling PSP be taken in normal circumstances and in the event of system requirements, how will the PSP developer or Discom/User of PSP be compensated for discharging PSP (generating electricity) for supporting grid operations.

7) **Recommendations to fast pace project development through project management and monitoring tools:**

To ensure timely progress and address potential delays early, regular monitoring of project milestones using advanced project management and monitoring tools is essential. The following measures should be implemented:

i. **Contractual and Risk Management Framework:** Establish a strong contractual framework that defines roles, responsibilities, and deliverables for all parties involved. Implement a risk management framework to proactively identify and mitigate risks, including geological challenges, unforeseen environmental factors, or supply chain disruptions. This could include risk-sharing mechanisms between developers, contractors, and government bodies.

ii. **Project Monitoring mechanism:** Establish a comprehensive project monitoring mechanism to track the progress of key activities, timelines, and budgets. This should include regular progress reports, milestone reviews, and performance assessments. Utilize digital tools and real-time data collection methods to monitor project execution and identify potential delays or issues early. Clear communication among all stakeholders is essential for timely decision-making and project success.

iii. **Efficient Information Monitoring:** Establish a robust system for monitoring and tracking project progress, including timelines, budgets, and key milestones. Use digital tools and platforms to gather real-time data, ensuring that any potential issues are identified early. The implementation of advanced digital platforms (e.g., GIS-based systems, real-time data tracking) is crucial for enabling constant monitoring of key project parameters, such as land acquisition, environmental clearances, construction timelines, and grid connectivity. For example, the Ministry of Roads, Transport, and Highways (MoRTH) has successfully implemented Automated and Intelligent Machine-Aided Construction systems (AIMC). These machines provide real-time data on the status of each project, with surveys conducted simultaneously throughout every stage of the road construction process. This integration of construction and survey processes ensures that progress is monitored continuously and discrepancies or delays are identified early, allowing for more efficient project management. By adopting similar digital monitoring systems for hydro and pumped storage projects (PSPs), stakeholders can gain real-time insights, optimize resource allocation, and reduce delays. Regular updates and transparent communication among stakeholders will facilitate timely decision-making and help maintain project momentum.

iv. **AI and Predictive Analytics:** Leverage AI and predictive analytics to identify potential risks, such as geological challenges or construction delays, and generate early warning signals. This will allow stakeholders to proactively address issues before they escalate into significant roadblocks. AI be also used to reduce carbon emission foot prints during construction phase.

v. **Centralized Data Repository:** A centralized repository for all project data, accessible to all relevant parties (developers, contractors, regulators). This repository should

include real-time updates on construction progress, regulatory approvals, and any changes to the scope or timeline.

8) Recommendations for Monetisation:

A clear strategy for monetizing the benefits of hydro and pumped storage projects (PSPs) should be developed, focusing on both direct revenue generation and indirect economic benefits. This strategy could include mechanisms for selling power, providing grid stabilization services, and leveraging environmental credits or incentives. Additionally, opportunities for public-private partnerships (PPPs) should be explored to enhance investment and accelerate project development. A long-term monetization plan is essential, one that accounts for fluctuating energy prices and ensures a stable return for stakeholders. Some recommendations for better monetization of hydro and PSP resources include:

i. **Providing Ancillary services:** Hydro and pumped storage projects (PSPs) can significantly contribute to the stability and reliability of the power grid by providing ancillary services. These services, such as frequency regulation, voltage support, ramping support and spinning reserves, are essential for maintaining grid balance, especially with the increasing integration of renewable energy sources.

a) PRAS and SRAS: Some CPSU plants already provide Primary and Secondary Reserve Ancillary Services (PRAS and SRAS) to the grid, generating additional revenue. The same approach should be extended to State-owned hydro plants. By offering these services, PSPs can generate additional revenue streams while enhancing the overall efficiency of the energy system.

(b) Frequency Control: Frequency control is required to maintain the nominal grid frequency. The mismatch between the electricity generation and the demand curve causes variation in frequency. PSPs have capability to maintain continuous frequency in a desirable range (normally 50 Hz) of active power and to keep power system free from any fluctuations. Thus, when the frequency of grid is above 50 Hz, power can be taken from the grid for pumping mode operation and when it drops below 50 Hz on grid, the PSP can be run in generation mode so that a constant frequency can be maintained on the grid.

(c) Voltage Support: Voltage support is provided by the system to maintain near constant voltage over a wide range of load conditions. Voltage control can be provided by the PSPs through rendering reactive power balancing services. Reactive control is an important tool for voltage regulation and for optimizing available power utilization. To improve the system power factor, PSP can work in synchronous condenser mode to improve the system power factor.

(d) System restart or Black Start: To restore the system after a full or partial blackout, PSPs can provide vital support. Conventional Hydro and PSP have the capability to provide additional power supply to the power system within few seconds whenever there is a situation of blackout.

These ancillary services need to be monetised with appropriate regulatory framework.

ii. **Promotion of Hydro Tourism in reservoirs of Hydro and PSP plants:** Hydro and pumped storage plants can explore the potential of hydro tourism as an additional revenue source. By promoting recreational activities such as boating, fishing, and nature tours around the reservoirs, these projects can attract tourists and local visitors. This initiative could enhance public awareness of the importance of hydro and PSPs while contributing to the local economy. Establishing proper infrastructure, ensuring safety standards, and integrating sustainable tourism practices would be essential for the success of hydro tourism, benefiting both the plants and the surrounding communities. In order to encourage Hydro generating companies to further strengthen the eco-tourism, provision of sharing of Non-tariff income from eco-tourism has been introduced in CERC Tariff regulations 2024:

"84. Sharing of Non-Tariff Income: The non-tariff net income in case of generating station and transmission system from rent of land or buildings, eco-tourism, sale of scrap, and advertisements shall be shared between the generating company or the transmission licensee and the beneficiaries or the long term customers, as the case may be, in the ratio of 1:1."

iii. **Sale of extracted silt from reservoir beds:** Extracting silt/sediments from the reservoir beds of hydro and pumped storage plants can provide an additional revenue

stream. The extracted silt/sediments, when processed, can be used for various purposes, such as soil conditioning, construction material, and even as a raw material for manufacturing products like bricks and tiles. By exploring the commercial potential of this byproduct, hydro and PSPs can contribute to environmental sustainability while generating financial returns.

9) Other Recommendations:

a. **Electricity Duty Exemption**: Input energy for pumping in a PSP should not be treated as 'consumption" and hence, electricity duty should not be levied on PSP. Exempting Pumped Storage Plants (PSPs) from Electricity Duty and Cess can reduce input energy costs and promote hydro power. This exemption could be recommended for broader implementation.

b. **Reduction in Land Acquisition Cost**: Reducing costs in acquiring land for PSPs , leasing government land at a nominal cost, exempting stamp duty etc, can be implemented in States which will eventually reduce the capital cost of the project, thereby enhancing investment's attractiveness.

c. **Identification of Contractors**: With respect to identification of contractors, a government-led nodal agency could identify reliable contractors for PSP development, which streamlining the process for developers who want to collaborate with trusted contractors.

d. **Reduction in interest on Loan**: A reduction in interest on loan for PSPs. by adjusting the debt-to-equity ratio from 70:30 to 80:20 for public sector projects could lower the cost of generation by 10-20%, making PSPs more financially viable.

e. **Establishment of Special Tribunals**: Setting up Specialized Tribunals can enhance efficiency and ensure speedy resolution processes compared to conventional courts, which often face delays due to high caseloads. These Tribunals would have domain-specific expertise to handle technical, legal,

and social aspects of such disputes, ensuring smoother hydro and PSP project implementation.

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