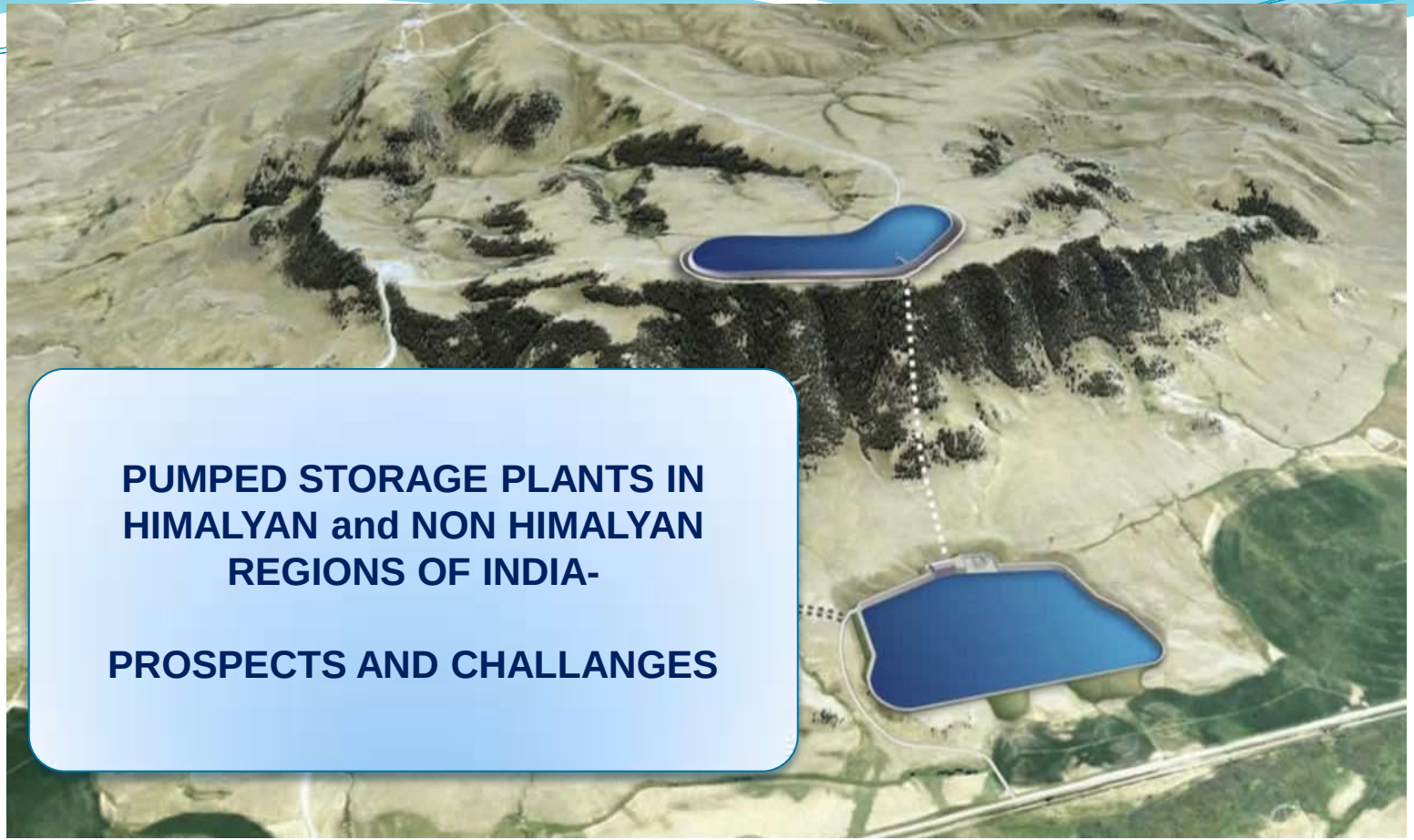


PUMPED STORAGE PLANTS IN HIMALYAN and NON HIMALYAN REGIONS OF INDIA-

PROSPECTS AND CHALLANGES

APR 2022

INTRODUCTION

- A significant grid transition is underway in India, as it gears up to meet its pledge of taking up the share of non-fossil energy capacity to 500 GW by 2030. The large-scale non-fossil RE capacity addition i.e. solar & wind, known for intermittency /variability in generation, may have implications on the reliability and stability of the Indian power system.
- For smooth integration of RE energy into the grid, there is requirement of sufficient balancing power and energy storage solution. That's where Pumped-Storage Projects (PSP) comes in. PSP is a reliable, time-tested technology, particularly suited for load management. The PSP schemes act as a giant battery (also called Water Battery).
- The water is pumped from a lower elevation reservoir to a higher elevation reservoir, which store energy as per availability of cheap power and then use it for producing energy during peak hours.

PSP Potential in India – Earlier CEA Study

- As per the study carried out by CEA during 1978 to 1987, 63 potential Pumped Storage sites were identified with an aggregate capacity of about 96,524 MW all over India.
- Subsequently, Japan International Corporation Agency (JICA) carried out screening of PSPs in 2017, which suggests that many of the 63 sites in the list of CEA are not suitable for development by the respective State Governments, primarily on account of environmental, social or viability concerns and/or refusal of clearance for Survey & Investigation by statutory authorities.

Completed / Under Construction PSPs in India
(As per CEA status report Dec 2021)

8 nos. commissioned/installed Pump Storage plants above 25MW in India with cumulative capacity of 4745.6 MW, viz.

- Nagarjuna Sagar, Telangana 705.60MW
- Srisailam LBPH, Telangana 900MW
- Kadamparai, Tamilnadu 400MW
- Bhira, Maharashtra 150MW
- Ghatgar, Maharashtra 250MW
- Purulia, WestBengal 900MW
- Kadana, Gujarat 240MW
- Sardar Sarovar Project, Gujarat 1200MW

Note: Kadana and Sardar Sarovar PSP are not working in pumping mode at present on account of various technical & non-technical reasons.

Off-River PSPs – NHPC Study

Important Aspects Considered FOR PSP

- Length / Head (L / H) Ratio , Head & Energy stored
- Location of the project & its accessibility
- Geological Aspects
- Reservoir & Sedimentation
- Environmental Aspects
- Proximity to RE (Large solar & wind) Power Centers
- Proximity to Water source

Off-River PSPs – NHPC Study

Favorable Site Conditions for PSP

- Large head with relatively shorter water ways between upper and lower reservoirs, preferably sites with Length / Head (L / H) Ratio < 10.

- Higher head requires lesser pondage thus smaller reservoirs, less civil works like smaller dams, smaller size of water conductor system, smaller electro-mechanical components like smaller size of turbine and other associated E&M components resulting in smaller power house complex.

- Higher head reduces overall requirement of land for various components of project like reservoir , HRT, TRT etc. together with reduction in quarry/borrow and dumping land requirements.

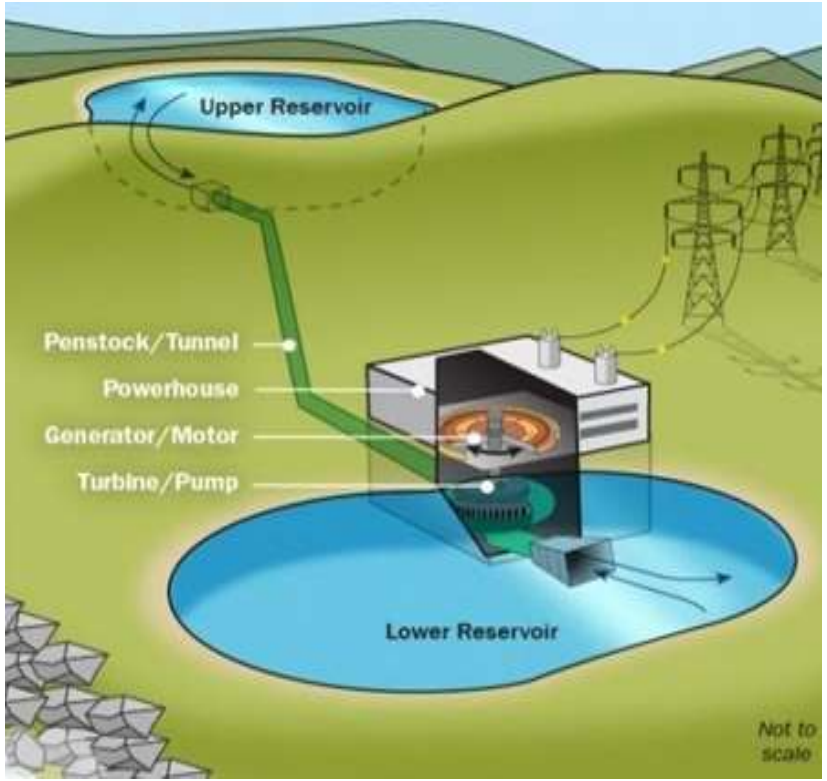
Off-River PSPs – NHPC Study

Favorable Site Conditions for PSP

- The minimum practical head for pumped storage project is generally around 100 m, with higher heads being preferred. However, very little technical know-how is available in the world for handling a project having high head more than 800m. Therefore, range of head between 100 m to less than 800m is practicable.

- Other favorable site requirements of PSP are better accessibility requiring less lengths of new roads, Suitable topography like natural depressions and valley shape for creating reservoirs , better Geology, sites with less environmental concerns, proximity to RE power centers and proximity to water source.

Off-River Pumped Storage Projects Advantages



- Reservoirs are located in areas physically separated from existing river systems. Generally the project shall not require flood mitigation arrangements, Silt management arrangements and Diversion arrangement during construction and hence project cost as well as construction period shall be optimized.

- The construction cost & time of off -river PSP schemes are more predictable as there is less uncertainties such as flash floods etc.

- Environmental costs required in river system for the provision of Fish ladder, longitudinal connectivity, E-flows shall be avoided in off-river PSPs.

PSPs in Himalayan Region – Prospects & Challenges

Large number of Hydroelectric projects (HEPs) are located in Himalayan region and many others are being planned & constructed.

Some of the constraints for converting existing Projects into PSPs and Developing new PSPs in Himalayan region are below.

Reservoir Capacity & Type of Scheme

- In pure Run of River schemes (ROR) no additional storage is available to be used for PSP.
- In ROR schemes with Pondage, the available storage is sufficient only for fulfilling peaking requirement of that project.

- The projects reservoirs in Himalayan region are kept at lower levels/MDDL during the monsoon to manage flood and silt, as such no storage is available during monsoon period for PSP functioning.
- Some multi purpose reservoirs have very large capacity are planned such that all the silt get settled in the reservoir and provide silt free water to the downstream. The PSPs can be planned in such projects. But there are very few big storage reservoirs. Tehri dam is an example of such project with a very big reservoir.
- For establishing new PSPs there will be requirement to create lower and upper reservoirs. In Himalayan region these reservoirs will also have lot of silt in flow during the monsoon season and have issues related to reduction in storage capacity.

Himalayan Region & PSPs - Prospects & Challenges

Cascade Hydro power project Development

- Most of the projects in Himalayan region have been developed/proposed in cascade pattern on the rivers for exploiting maximum available head and hence, any additional storage for using it as lower and upper reservoir for PSP may affect the performance of upstream and downstream projects.

Sedimentation and Flood management

- Most of the Himalayan region projects are located in heavily sediment prone areas. It is estimated that more than 80% of average annual sediment comes during the monsoon season i.e. from June to September along with high flood discharge.
- Flood and silt being important issues in Himalayan region, the cost of silt and flood management arrangements such as spillways, energy dissipation arrangements, silt

- All on-river reservoirs need to have proper silt and flood management arrangements and the cost of these arrangements is very significant as the spillways, sluices, energy dissipation arrangements, silt exclusion systems and desilting basins are planned from safety and operation aspects.

Natural disasters & Accessibility

- Himalayan ranges are vulnerable to heavy rains, landslides, cloud burst and other natural disasters. Many probable PSP sites are situated in inaccessible region so construction of new roads & bridges to various components of PSP including upper & lower reservoirs, penstocks & other water conductor system and power house would require large investments. These expenditures will make the scheme unviable in many cases.

Himalayan Region & PSPs - Prospects & Challenges

Geological Aspects

- Himalayas are the youngest folded mountains having complex tectonic and geological setup, prone to land slide hazards and cloud bursts. Most of the projects in Himalayan terrain are dotted with various geological weaknesses, shear zones, folds, faults and lineaments.
- The complex geological conditions in the Himalayas and frequent occurring shear zones, folds & faults, possibility of encountering adverse geological conditions during construction of underground/surface project components may have high cost implications.

- In Himalayas, topography is generally rugged and steep and flat terraces/areas are scarce and generally of small dimensions. Wherever flat areas exist they are generally inhabited and cultivated. Moreover, flat terraces /areas in Himalayas are generally associated with faults/ thrusts/ buried channels or other geological anomalies.

Proximity to RE power centers

- There is less probability of developing large solar & wind power projects in Himalayas. It will be preferable to have PSPs near large wind power and solar power centers.

Non-Himalayan Region & PSPs - Prospects & Challenges

1. Land Submergence

Generally in peninsular India the land terrain is flatter and hence there will be large land submergence even for less reservoir capacity. In Madhya Pradesh and Maharashtra various off river good PSP sites are available but terrain and topography of the site are such that Large forest land, some agricultural land and some residential land area submergence shall occur.

2. Rehabilitation and Resettlement issues

In non-Himalayan region, the settlement of habitats in plain area are sparse but in many dense clusters. As such construction of lower and upper reservoir will require more rehabilitation and resettlement.

3. Water rights of the area

The water rights of the stream and pond is the important factor required to be looked into before finalizing the PSP scheme in the area. Generally rain water during monsoon is used to be stored by check dams to be used for agriculture and domestic purpose for the rest of the year. The catchment area of upper and lower reservoir may be common with the existing ponds and the same may be point of concern.

4. Rainfall Dependency & Proximity to Water Source

The peninsular India, which is favorable for development of PSP plants have rainfall in the monsoon season only. The paucity of water in this region may discourages construction of PSP plants however it is worked out that reservoirs shall be filled in one or more years by rain water. Reservoir volume and project capacity may be adjusted according to rainfall.

The availability of water source in the nearby area is preferable.

Off-River Pump Storage Plants–(Australian National University Atlas)

- In Off-River (Closed Loop) PHES scheme, the reservoirs are located in areas physically separated from existing river systems. Development of a off-River system requires identification of a water source to provide the initial charge and after the initial filling of reservoirs, the only additional water requirement is the minimal operational make-up water required to offset evaporation or seepage losses.

- The *Australian National University (ANU)* has found about 16,000 off-river sites in India with various storage capacities with many of them located in Himalayan and Non-Himalayan region.
- Recently in November 2021, MOP has directed all CPSUs to explore the possibility of new PSP in the vicinity of all their existing projects (completed & ongoing) based on the data provided by Australian National University (ANU).

Brief Summary of NHPC Study on Off-River Potential

States	Operational Issues
• Sites Studied (In Himalayan Region)	• 33 nos. off river PSP schemes in the vicinity of NHPC Projects • Locations near Narmada River region in MP appeared suitable
•Criteria (For Detailed Study)	• Head nearly 300 m or more • Separation upto 3 km • Height & Length of the Dam required for creating Reservoirs.
• Shortlisted/Probable Sites	• 6 Sites in Narmada River Region in MP state
***Presently one no. site (Tekwa-II) is selected for pre-feasibility studies.	

Study by NHPC for Conversion of its Existing Hydro Power Plants/Projects to PSP

- As most of the projects in NHPC are ROR with limited pondage, the sufficient reservoir capacity is not available round the year to support the Pump Storage Plant (PSP).
- Projects are generally developed in cascade pattern. Hence any additional storage for using it as a lower reservoir or upper reservoir may affect the performance of upstream and downstream projects.

- Most of the NHPC projects in Himalayan region have long underground water conductor systems making L/H ratio unfavorable for pumped storage. Some of the projects have quite low head and not suitable for PSP.
- If the machines of the existing power plants are replaced as PSP machines there will be requirement of huge modification/replacements of many electro-mechanical components and also complicated civil works.

Conclusion

- On comparing the merits and demerits of the PSP schemes in Himalayan and non-Himalayan region, part of peninsular India with desired topography and geological conditions comprising of Deccan trap Basalts seems a better suited area for locating pumped storage projects.
- Due to various limitations existing power stations / projects cannot be converted into PSP schemes.
- As per ANU study there are many sites in India to develop off river PSPs. The arrangements like spillway, energy dissipation arrangements, silt excluders arrangements are nor required for off river reservoirs.

NHPC Initiatives for developing PSPs:

- NHPC has been interacting proactively with the different state governments/ agencies to accelerate the development of PSPs.
- NHPC is interacting with Odisha government for developing in JV mode 3 PSP schemes of 1420MW, Govt. of Andhra Pradesh for 7 PSP schemes totally 6600 MW, Jharkhand Govt. for one scheme of 1500MW.
- PFR for one PSP using Indirasagar PS & Omkareshwar PS reservoirs.
- Detailed study for one off river PSP(near Tekwa water fall) in Narmada river region in MP.

- NHPC has carried out due diligence for 4 prospective PSPs in Kerala totaling 1400MW and 5 prospective PSPs in Tamilnadu totaling 2550MW. NHPC has shown interest in these PSP schemes.
- Recently MOP/CEA has allotted 10 nos. PSP totaling 15850MW (Six in Maharashtra, one in J&K, one in Odisha, one in Mizoram and one in Andhra Pradesh) and the sites assessment is in the progress.

THANK YOU