OPINION: How India can accelerate Pumped Hydro Storage for a clean energy future

Increasing the utilisation of closed-loop PHS, and initiating a differential pricing mechanism for PHS will make it more competitive, attracting more investment to the sector.

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New Delhi: India's clean energy transition is largely driven by the ambitious target of installing 450 gigawatts (GW) of renewable energy (RE) by 2030. While such huge RE deployment can pose several operational and technical challenges for the grid, energy storage can mitigate them.

Among the various energy storage technologies, pumped-hydro storage (PHS) and battery storage are emerging as the front-runners. PHS, the oldest and most mature large-scale storage technology, accounts for 96 per cent of installed global energy storage capacity. Around 169 GW of pumped storage capacity is installed worldwide, with China leading with 32.1 GW, followed by Japan with 28.5 GW, and United States with 24.2 GW.

PHS is a type of hydroelectric energy storage which uses a two-reservoir system (upper and lower) to store energy and generate electricity. It is of two types: 'open loop', which has an associated natural-water source (like a river) for one or both the reservoirs; and 'closed loop' (or off-river PHS), which does not have a connected natural-water source and the same water is cycled between the two reservoirs for pumping and generation.

Unlike battery storage technology that uses expensive and critical materials such as lithium, nickel, and cobalt (lithium-based), or polluting materials such as lead (lead acid), PHS uses the potential energy of water as the storage medium. Also, batteries have a much shorter lifespan, making their replacement and disposal a hassle. Thus, PHS is best suited for complementing India's storage needs. The recent draft National Electricity Policy (NEP) 2021 also underpins the need for large-scale adoption of PHS for supporting the electricity grid.

Multiple advantages

PHS can generate power continuously for 6-10 hours, depending on the storage capacity of the reservoir. It has a lifetime of over 40 years, with an efficiency of 70-80 per cent. Also, as compared to the conventional thermal generator, PHS has a higher ramping capability (ability of quick start-stop).

These features enable PHS to provide multiple services to the power grid. The high ramping capability helps it deal with the sudden bursts of load in the power system (peak-load shaving). Similarly, it can smoothen the sudden fluctuations in RE generation (RE smoothing), and can also support frequency and voltage deviations in the grid (ancillary services). In addition to these short-term grid services, PHS can cater to the seasonal mismatches in RE and load due to its bulk storage capability.

But there are challenges too, including a high initial investment (USD 600-2000/kW), topographical requirements like the range for elevation (20-1000 m) between the two reservoirs, proximity to a large water body, and environmental impacts like loss of wildlife habitats and issues of resettlement and rehabilitation of human population.

Accelerating the growth of PHS in India

Although PHS dominates the global storage-capacity scene, its growth in India has been tepid. The Central Electricity Authority of India has estimated a PHS potential of 96 GW, but only 3.3 GW is currently operational in India. This slow pace can be attributed to the high cost associated with the commissioning of PHS plants, the long gestation period due to delays in obtaining environmental clearances, and the low recovery from the existing pricing mechanism of PHS.

The high cost and environmental clearance issues can be resolved using a closed-loop PHS system that utilises less water, has a low gestation period, and minimal impact on the environment. A 2019 study by Australian National University (ANU) estimates that there are 16,000 closed-loop PHS sites in India, with a combined energy storage capacity of 56,000 gigawatt-hours.

To resolve the issue of low recovery from the existing pricing mechanism, a differential pricing mechanism can be employed. The present mechanism comprises a two-part tariff with fixed and variable costs. While the fixed component recovers the annual capital cost incurred, such as cost of plant and machinery, and manpower, the variable component takes care of the operational cost. The variable cost does not take into account the variation in prices during different periods of PHS operation, leading to low recovery. Additionally, the conventional tariff-determination method does not account for the multiple services (RE smoothing, peak-load shaving, and ancillary services) provided by PHS to the grid. A differential pricing mechanism—with separate pumping (off-peak) and generation (peak) prices—will help PHS earn a profit over and above the recovery of variable cost. This profit will help in recovering a certain percentage of the fixed cost as well. The price differential will be based on the multiple services PHS can provide to the grid.

Thus, increasing the utilisation of closed-loop PHS, and initiating a differential pricing mechanism for PHS will make it more competitive, attracting more investment to the sector. The increase in large-scale adoption of PHS will provide stability to the grid, while enabling India’s smooth transition towards an RE-dominant future.

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