Closed loop pumped storage hydropower

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Sites can be fully closed-loop, or they can use existing reservoirs along river systems. Supply curves are available for 8-, 10, and 12-hour storage durations, dam heights of 40-100 meters, head heights of 200-750 meters, and a maximum conveyance length between upper and lower reservoir of 12 times the head height (leading to a maximum horizontal distance between reservoirs of 8,250 meters for a 750-meter head height system). The dataset includes sites that use existing reservoirs to connect new off-river reservoirs with upper reservoirs and sites that repurpose open-pit mines for use as PSH reservoirs.

View the interactive tool

Resource potential is often assessed in terms of geographic (or resource), technical, and economic potential--each of which represents a succession of additional complexity and input assumptions that leverage similar data and a common analysis flow.

The closed-loop portion of the PSH resource assessment uses high-resolution digital elevation models (30-meter resolution) to identify potential upper and lower reservoirs within the technology parameters specified by the NREL adaptation of the ANU model. Design specifications include minimum head height of 200 meters and a maximum head height of 750-meters, dam heights of 40, 60, 80, and 100 meters, and a maximum conveyance length between upper and lower reservoir of 12 times the head height. This yields a large set of potential reservoirs with many overlaps.

Once the reservoirs are identified, technical potential criteria are applied to refine the development areas. The criteria eliminate any reservoirs that intersect existing water bodies and waterways; glaciers and ice-covered areas, protected federal lands; urban areas; critical habitat areas; or reservoirs within 1,000 feet of a wetland. Optional criteria can eliminate reservoirs intersecting roads or farmland or allow reservoirs intersecting ephemeral streams.

The HydroLAKES dataset of reservoir locations and characteristics is used to find potential sites that pair new off-river reservoirs with existing reservoirs that could be along river systems--to incorporate existing reservoirs into the full set of potential PSH reservoirs.

To find potential sites that use open-pit mines as reservoirs, NREL researchers search for pit features using 10-meter-resolution digital elevation models, removing any pits smaller than 10,000 square meters in area and shallower than 1 meter in depth. Pits are then identified by searching within 1 kilometer of mine locations in the U.S. Geological Survey mine symbol dataset and visually inspecting the results to remove errors.

Ultimately, this exercise results in a spatially resolved characterization of the technical potential quantity, quality, and cost of PSH resources, which can be sorted to represent a "supply curve" for a specific scenario. The figure below plots the supply curve of closed-loop PSH capital cost in dollars per kilowatt versus cumulative generating capacity in gigawatts for the contiguous United States for 8-, 10-, and 12-hour storage durations and the default assumptions for where to prohibit or exclude closed-loop PSH construction. This supply curve includes both closed-loop sites and sites that use existing reservoirs. Resource and cost data binned by cost ranges are also included in the NREL Annual Technology Baseline beginning in the 2022 data year.

The open-pit mine PSH site assessment, where pits are paired with potential off-river reservoirs, finds 15 candidate locations, as shown on the map below. These are mostly scattered throughout the western United States, with one site in Massachusetts. Many of these sites include active mining operations, so PSH development would compete with existing site use.