Pumped storage: long-duration bulk storage

400-MW “closed-loop” Swan Lake Pumped Storage Project in southern Oregon

1200-MW “closed-loop” Goldendale Energy Storage Project in eastern Washington
Pumped storage is a “sure thing”

- **Pumped storage** is the only proven, cost-effective storage at scale.
- Consists of pumping or generating by moving energy in the form of water through a powerhouse between an upper and lower reservoir.
- **Pumped storage is prolific** in the US – there are 39 pumped storage plants in operation with a total installed capacity of about 22,000 MW; however, over 2 decades since last built in US.
- **Globally**, there is nearly 131,000 MW of pumped storage capacity currently in operation; **currently building all over world but US**.
- **Batteries** still very expensive, uncertainty viability in replacing thermal plants, don’t last nearly as long and come with mining/toxic waste issues.
Over 6 GWs of spinning mass/inertia slated for retirement & very difficult (if not impossible) to build new gas-fired plants.
CA 100% modeling selects mostly solar and storage to meet decarbonization goals

- 100%+ RPS achieved by 2050 in both scenarios
- RESOLVE utilizes a Planning Reserve Margin constraint but does not examine resource adequacy in detail

**High Biogas Scenario**

**High Electrification Scenario**

**Solar and storage build driven by decarbonization targets**

![Graph showing solar and storage capacity growth from 2020 to 2050 in both scenarios.]

- Energy Efficiency
- Pumped Storage
- Battery Storage
- Customer Solar
- Solar
- Wind_Offshore
- Wind
- Geothermal
- Biomass
- Hydro (Small)
- Hydro
- Gas Peaker
- Gas CCGT

6-hr duration:
- 9 GW (2020)
- 9 GW (2025)
- 10 GW (2030)
- 43 GW (2040)
- 51 GW (2050)

6-hr duration:
- 9 GW (2020)
- 9 GW (2025)
- 10 GW (2030)
- 57 GW (2040)
- 74 GW (2050)
Pumped storage strategically located in grid for new carbon-free flexible capacity

- Viable, constructible “closed-loop” projects interconnecting into existing high-voltage transmission that leverages major import/export path to California (i.e. AC & DC Interties)
- Proven storage solution strategically located in grid to support regional decarbonization goals affordably and reliably
- Projects support continued history of beneficial regional bulk power exchanges between California and the Pacific Northwest evolving from seasonal to daily
- Hundreds of millions of dollars in annual potential cost-saving/revenue regionally to grid based on E3 modeling; over 6000 jobs during multi-year construction period

- California Oregon Transmission Project (COTP)
- Pacific AC Intertie (PACI)
- Pacific DC Interties (PDCI)
Barriers to building new pumped storage

- Carbon-free flexibility/storage will be critical for higher penetrations of renewables and reliability
- However, benefits of storage difficult to value in fragmented, deregulated markets and IRP processes (i.e. the Balkans)
- Also, IRPs do not expressly model or **address market prices that can result from a tight capacity market** (WUTC’s concern on PSE’s 2017 IRP in acknowledgement letter)
  - Game of “capacity chicken” going on in PNW with building new capacity
  - Everybody knows there is a potential problem but nobody wants to own it
- Bottom-line, **need adequate economic modeling tools** at the granular level necessary to show full value of storage both as generation and transmission for regulatory approval/cost-recovery to procure/commercialize
- Lastly, **regulators need to encourage/incentivize** utilities for building new **carbon-free flexible capacity/storage** in a orderly, planned fashion taking into execution/resourcing/capital deployment on a reasonable guidepath to decarbonize