Northwest **Power** and **Conservation** Council

December 3, 2019

MEMORANDUM

TO: **Power Committee**

FROM: **Gillian Charles**

SUBJECT: **Pumped Storage Reference Plant for draft 2021 Power Plan**

BACKGROUND:

Presenter: Gillian Charles

Summary: As part of the development of inputs for the draft 2021 Power Plan, staff develops generating resource reference plants as resource options – along with energy efficiency and demand response – for the Council's power system models to select to fulfill future resource needs. A generating resource reference plant is a collection of characteristics that describe a realistic and likely implementation of a given technology within the region. It includes estimates of costs, operating and performance specifications, and developmental potential.

Staff presents reference plants for review and discussion with the Generating Resources Advisory Committee (GRAC) and incorporates feedback (when necessary) before bringing the reference plant to the Council for review.

At the December Council Meeting, staff will present the reference plant for pumped storage

Relevance: Development of inputs for the 2021 Power Plan

Workplan: A.4.1 Develop generating resource reference plants for 2021 Power Plan

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Pumped Storage Reference Plant for the 2021 Plan

December 10, 2019 Power Committee

Gillian Charles

THE 2021
NORTHWEST
POWER PLAN
FOR A SECURE & AFFORDABLE
ENERGY FUTURE

Reminder: Council Input on Reference Plants

Staff develops candidate reference plants → Staff engages GRAC to solidify draft reference plants → Staff brings draft plants to Council → Reference plants are incorporated into models

Two important points:

- Most reference plant details are "just the facts" and are presented to the Council as background
- Some characteristics are a matter of judgement and are presented to the Council for discussion and direction taking

Proposed Resources for 2021 Plan: What you've seen so far and what's next

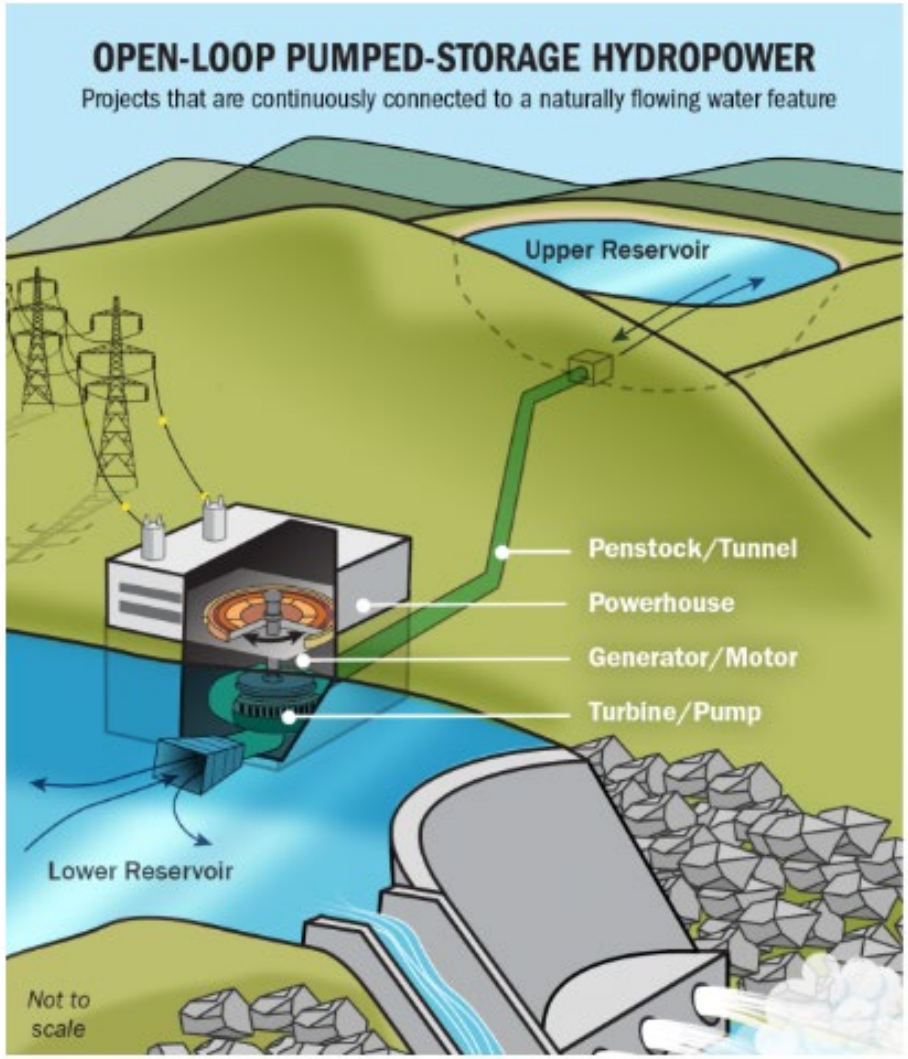
February P4

	Primary	Secondary	Emerging/Long-term
October P4 ✓	Solar PV ⚙	Conv. Geothermal ⚙	Enhanced Geothermal Systems
November P4 ✓	Onshore Wind ⚙	Offshore Wind	Small Modular Reactors
Jan/Feb P4	Gas CCCT ⚙	Distributed Generation*	Carbon Capture & Sequestration
	Gas SCCT – Frame ⚙	Biomass	Hydrogen Gas Turbine
October P4 ✓	Battery storage (Li-ion) ⚙	Hydro Upgrades	Allam Cycle Gas
October P4 ✓	Solar + Storage ⚙	Biogas	Wave, Tidal
Today! P4	Pumped Storage ⚙	Power-to-Gas	
Jan/Feb P4	Reciprocating Engine	Small Hydro	
	Gas SCCT - Aeroderivative	Combined Heat and Power	

⚙ = reference plant

* DG will also be included in the load forecast
Omitted: Advanced nuclear, coal, large hydro, CAES

Pumped Storage



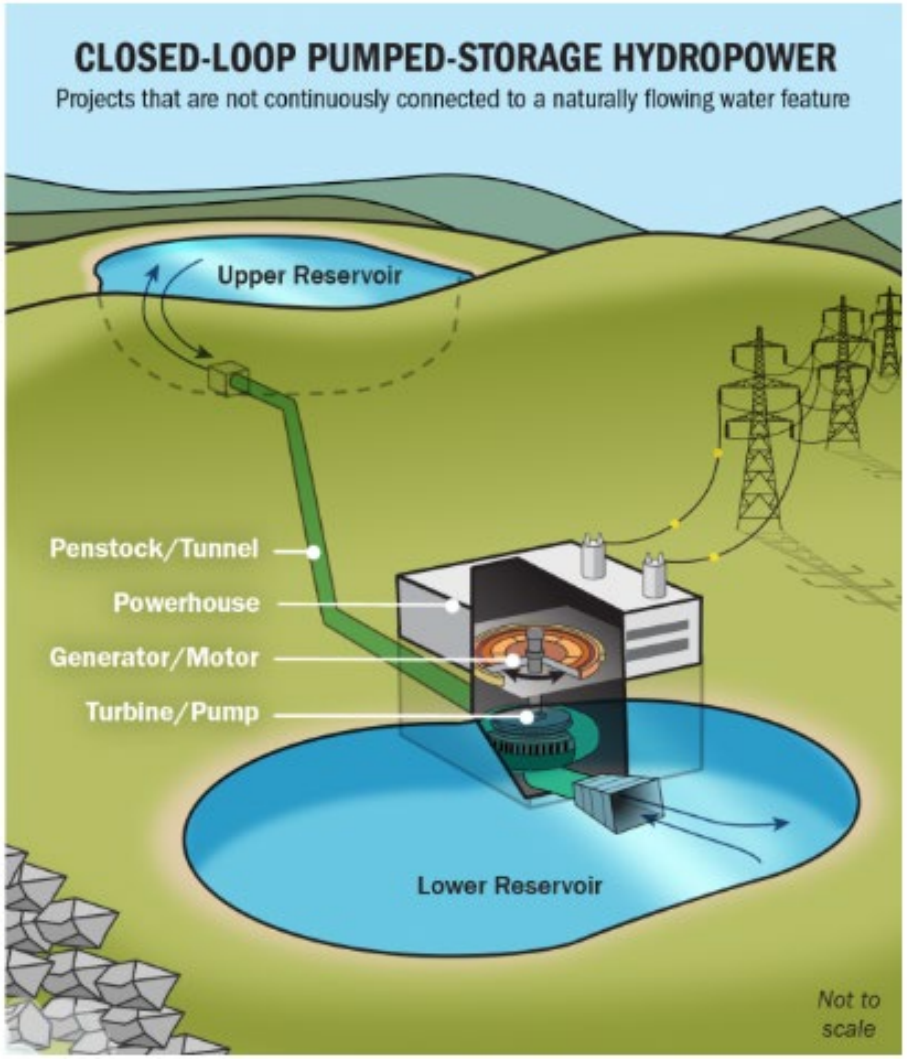


Image source: https://www.energy.gov/eere/water/pumped-storage-hydropower

Treatment in the Seventh Power Plan

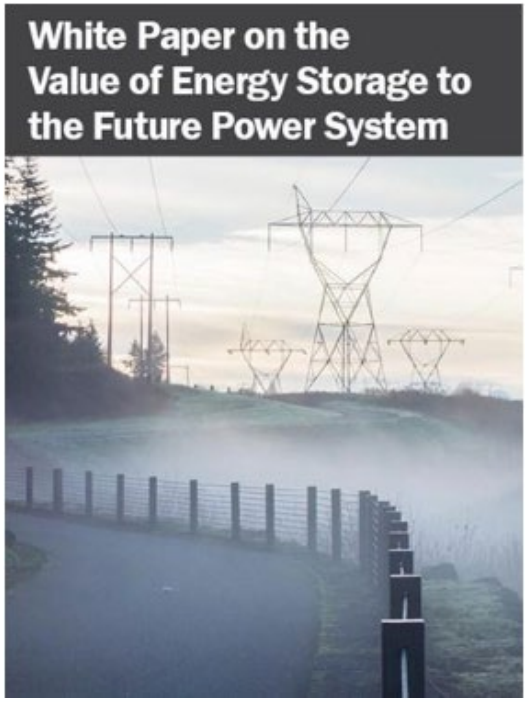
- Analyzed qualitatively as an **emerging technology** and recognized in the **action plan** through two specific action items
  - ANLYS-14, ANLYS-16
- Council considered pumped storage as emerging, despite it being an established and commercially mature technology, because

> "… new advances in technology have expanded its role from primarily shifting energy to providing ancillary services and capabilities that are beneficial in today's power system…"

  - E.g. Adjustable speed vs. traditional fixed speed pumping units

ANLYS-16 Research and develop a white paper on the value of energy storage to the future power system. [Council, Generating Resources Advisory Committee] The Council should convene a subgroup of subject matter experts from its Generating Resources Advisory Committee to assist in the research and development of a Council white paper on the full value stream of energy storage and its role in the power system, including transmission, distribution, and generation. In addition, the white paper should investigate the existing need for frequency and voltage regulation and balancing reserves in the regional power system. The Council should author the white paper with help from industry experts, or lead a request for proposals and select a consultant to write the paper. The white paper should be completed in advance of the Eighth Plan.

One of the potential constraints to extensive storage development is the ability of the developer and/or investor to capture and aggregate the full value of the storage system's services in a non-organized market and transform interest and overall system need into revenue streams and project funding. Many of the benefits of large scale storage are the portfolio effects for an optimized regional system, not just solely to a specific power purchaser, utility or end-user, and therefore it can be difficult to raise funds and seek cost-recovery for storage projects if the purchaser is not directly benefiting from all of the services, or is paying for a service that benefits others who are not also contributing funds. The white paper should clearly identify the issues and barriers and provide useful information that would be beneficial to the region's decision makers, power planning entities and integrated resource planning processes.



Pumped Storage in the Seventh Power Plan

ANLYS-14 Monitor and track progress on the emerging technologies that hold potential in the future Pacific Northwest power system. [Council, Generating Resources Advisory Committee] The Council should continue to monitor on an ongoing basis the emerging technologies identified in the Seventh Plan as potential resources of the future regional power system. There are several emerging technologies which could play an important role in the operation of the future power system, including:

- Distributed power with and without storage (Solar PV, CHP)
- Utility Scale Solar PV with battery storage
- Enhanced geothermal systems (EGS)
- Offshore wind
- Wave and tidal energy
- Small modular reactors (SMR)
- Energy Storage
  - Pumped storage with variable speed technology[5]
  - Battery storage
  - Other

Benefits of Pumped Storage

- Large scale, carbon-free resource in a region with clean policy standards and goals
- Ability to provide flexible capacity and energy balancing to the grid
- Augment renewable generation and reduce renewable curtailment
- Energy arbitrage and ancillary services such as reserves and frequency control
- Longer duration energy discharge (as compared to short(er)-term battery storage)

Challenges of Pumped Storage: Barriers to New Development

- Capital-intensive, challenges to long-term financing, and regulatory risk
- Long permitting, construction, and lead time
- Monetary valuation of benefits that don't yet provide direct compensation/revenue streams

America's Water Infrastructure Act of 2018*

1. **Extends the preliminary permit terms and start of construction deadlines for new construction projects**
2. Promotes new, small conduit hydropower facilities
3. Promotes hydropower development at existing non-powered dams
4. **Promotes development of closed-loop pumped storage projects**
5. Incentives investments and modernization projects at existing hydropower facilities

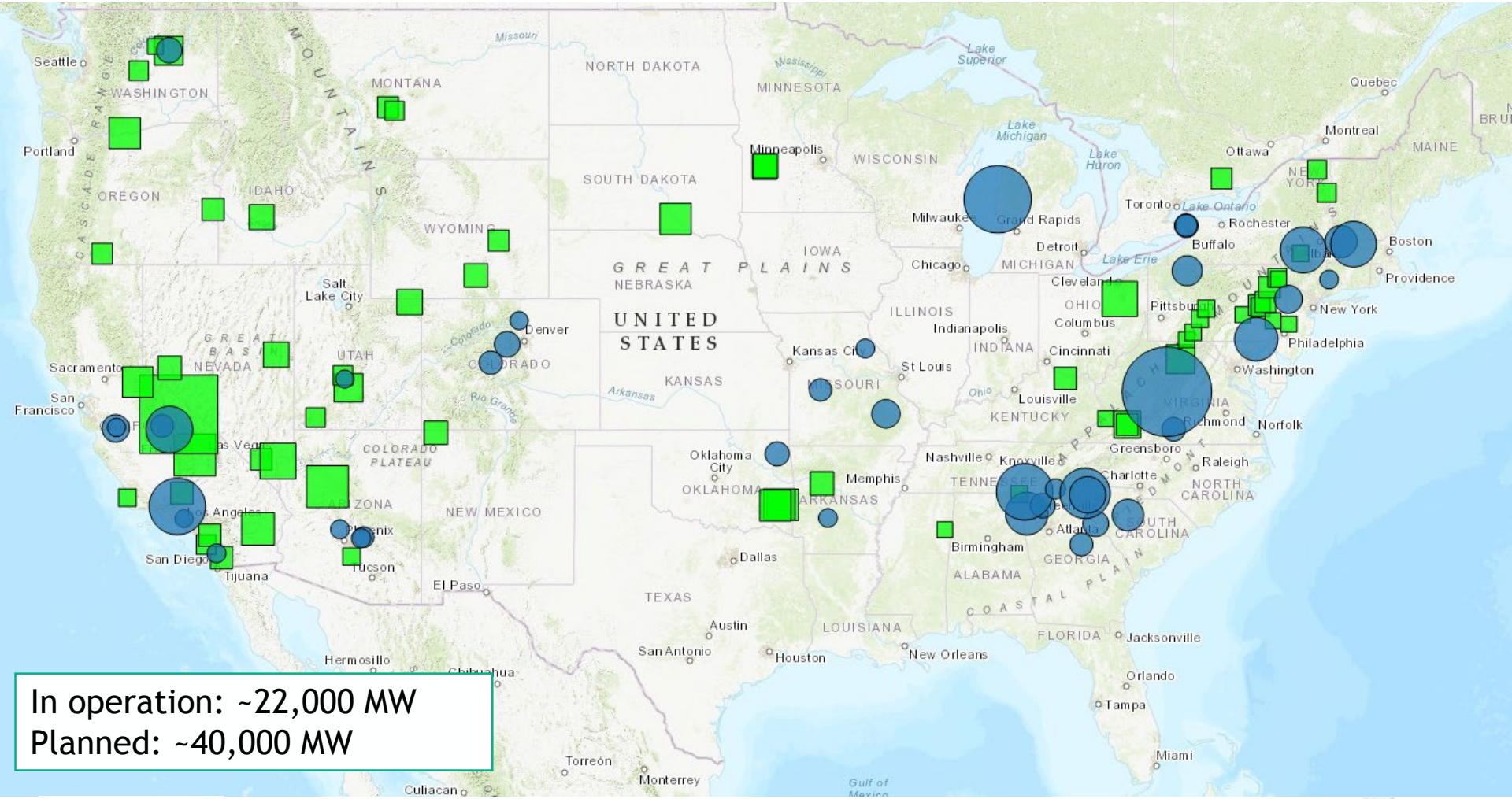
* Signed into law on October 23, 2018

DOE EERE Techno-Economic Study of Pumped Storage

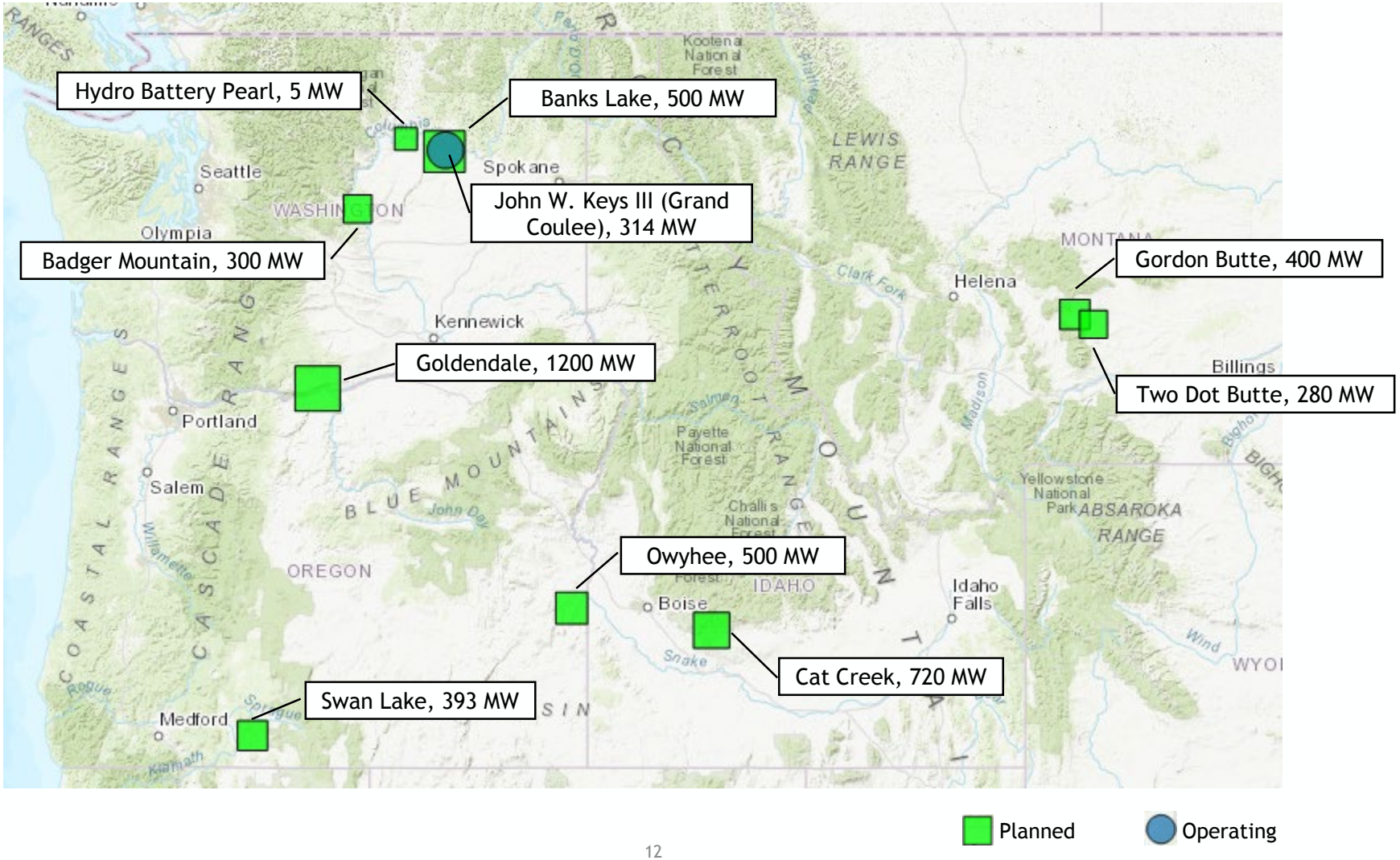
- Water Power Technologies Office issued a NOTA (Spring 2018) to perform techno-economic studies to evaluate the long-term value of two pumped storage projects
  - Goal to provide developers the ability to estimate the long-term value of proposed projects, guidance on financial revenue streams under current market conditions, and additional system benefits (e.g. transmission, portfolio effects)
- Council wrote letter of support for selection of a site located in the Pacific Northwest, stating that

  "understanding and capitalizing on the potential revenue streams from a specific pumped storage hydropower project within the regional market and existing portfolio of resources could go a long way towards making pumped storage cost-effective and competitive… in addition, information produced by the DOE's analysis could help regional modeling and analysis of large-scale storage opportunities and unite interested parties and service providers to consider strategic investments in long-term storage solutions like pumped storage hydropower"
- December 2018 – DOE selected two projects as case studies
  - Goldendale (1200 MW, National Grid) and Banner Mountain (400 MW, Absaroka Energy)

Operating and Planned Pumped Storage Projects in the U.S.



Operating and Planned Pumped Storage Projects in the Region



Proposed Projects in the Region

Project-specific information received from developers, Fall 2019 (thank you!)

	Swan Lake	Goldendale	Gordon Butte	Banks Lake	Badger Mountain	Owyhee	Seminoe	White Pine
Capacity/ Storage	393MW/ 9hr	1200MW/ 12hr	400MW/ 8.5hr	500MW/ 6.5hr	300MW/ 8hr	600MW/ 8hr	750MW/ 10hr	750MW/ 8hr
Est. Earliest COD	2025	2028	2025	2026	2025	2026	2026	2026
Configuration	Closed-loop	Closed-loop	Closed-loop	Open-loop	Closed-loop	Open-loop	Closed-loop	Closed-loop
Location	Klamath Cty, OR	Klickitat Cty, WA	Meagher Cty, MT	Grant Cty, WA	Douglas Cty, WA	Malheur Cty, OR	Carbon Cty, WY	White Pine Cty, NV
FERC Status	FERC Permit	FERC Prelim Permit	FERC Permit	FERC Prelim Permit	FERC Prelim Permit	Application for FERC Prelim Permit	FERC Prelim Permit	FERC Prelim Permit
Cost Estimate*	$866M	$2.14B	$975M	$1.44B	$675M	$1.2B	$1.6B	$1.5B
Capital Cost Estimate*	$2,203/kW	$1,783/kW	$2,437/kW	$2,880/kW	$2,250/kW	$2,000/kW	$2,133/kW	$2,000
Source (Developer)	National Grid/Rye	National Grid/Rye	Absaroka	Kleinschmidt Associates	GridFlex	GridFlex	GridFlex	GridFlex

* Assume nominal 2019 dollars

Integrated Resource Plan – Round-up (1)

- PacifiCorp considered pumped storage in IRP, not selected in preferred portfolio, but in some other portfolios (such as no new gas)
- NorthWestern Energy's draft 2019 IRP identifies peaking capacity needs and plans to solicit competitive proposals from variety of sources (including pumped storage) starting in 2022 in increments of 200 MW capacity/year
- Idaho Power modeled pumped hydro but did not select it in preferred portfolio (near-term action is solar PPAs)
- Avista's draft IRP identifies 150 MW pumped storage in 2026, around the time the Lancaster PPA expires and following the exit from Colstrip 3, 4
- Puget Sound Energy included pumped storage in resource options; draft 2019 IRP yet to be released
- Snohomish PUD exploring pumped storage in its resource plan as well

Integrated Resource Plan – Round-up (2)

Portland General Electric, 2019 IRP (filed July 2019)

- Identified need for near-term dispatchable capacity resources over range of future conditions
- Preferred portfolio includes both pumped storage and battery storage in the action plan period (through 2025)
- Capacity procurement actions could allow for numerous outcomes to support future capacity needs – this could result in selection of existing capacity resources or new non-emitting capacity resources (including pumped storage and batteries)
- Oregon PUC staff has raised some concerns about the timing of PGE's planned procurement process and its potential misalignment with the permitting and construction process for a longer-lead time resource like pumped storage

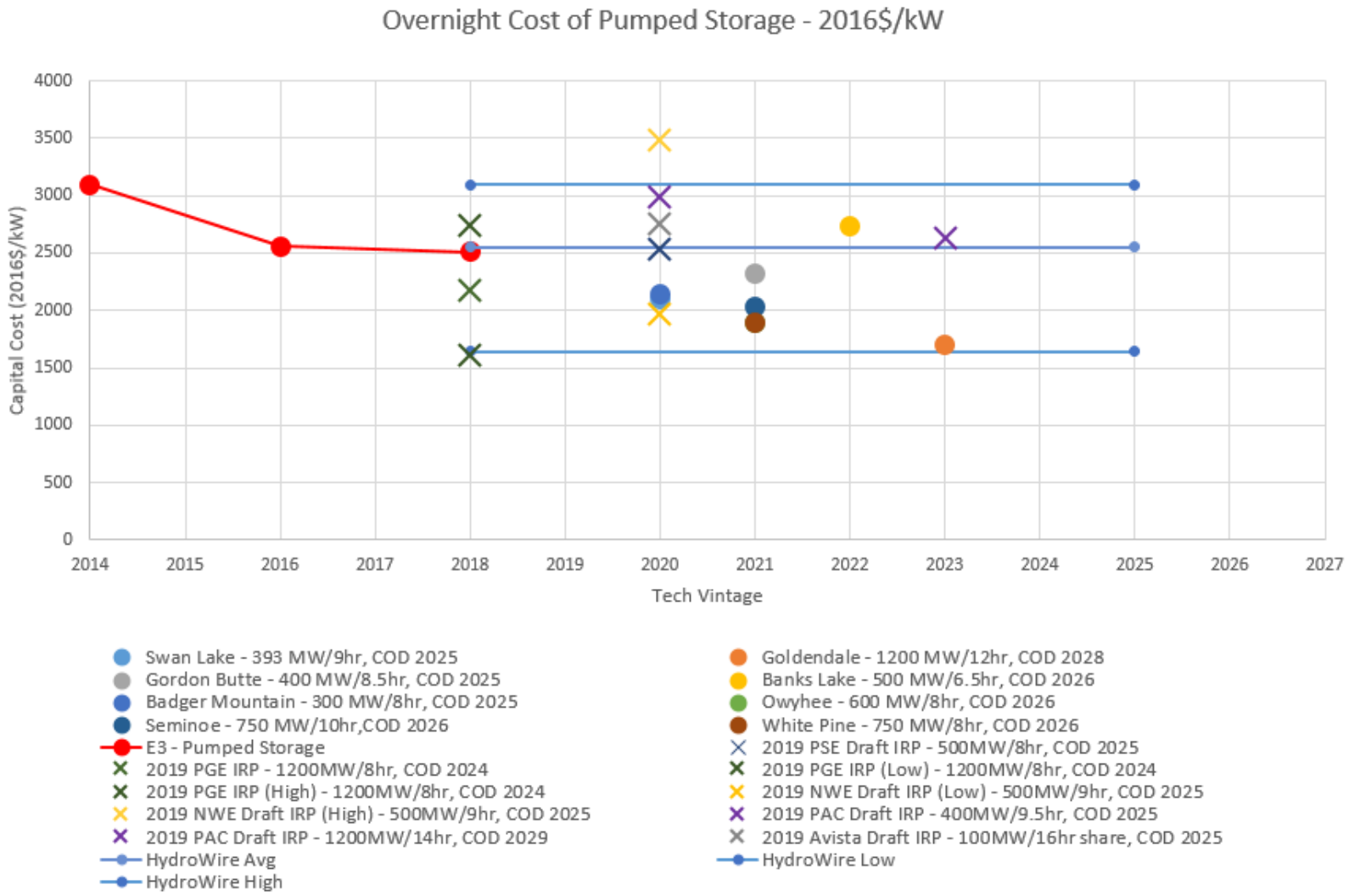
Pumped storage capital costs are very site specific

- Open-loop vs. closed loop
- Man-made reservoir vs. natural reservoir
- Access to water source, availability of existing infrastructure and transmission
- Site geology, environmental considerations
- Various technology options to select from, w/ varying equipment costs (e.g. configuration, single vs. variable speed, etc.)
- Project size, head and capacity

Generating Resources Advisory Committee Discussion and Feedback

- **September 25**
  - Regional project developers provided status updates on projects
    - Swan Lake & Goldendale, National Grid and Rye Development
    - Gordon Butte, Absaroka
    - Banks Lake, Kleinschmidt Associates
- **October 29**
  - Staff presented status and background of pumped storage technology and a draft pumped storage reference plant
  - Discussion on size, duration of storage (hours), overnight capital cost

Capital Cost Estimates for Pumped Storage



2021 Plan Reference Plant: Pumped Storage

	Pumped Storage
Configuration & Technology	400 MW, 8hr, Variable Speed Pump, Closed-loop System
Capacity (MW)	400
Energy (MWh)	3,200
Round Trip Efficiency	80%
Financial Sponsor	IOU
Economic Life (years)	50
Overnight Capital Cost ($/kW)	$2,300/kW
Fixed O&M Cost ($/kW-yr)	$14/kw-yr
Earliest Commercial Online Date	2025
Development Time	4 years
Construction Time	5 years
Potential	4,000 MW (equiv. 10 reference plants); staggered availability and development time over planning period

Next Up

- January/February P4: Natural gas reference plants
- February P4: Geothermal reference plant
- Timing TBD: Emerging technology analysis