Our Energy Future Series

Session 6: Pump Storage Hydro

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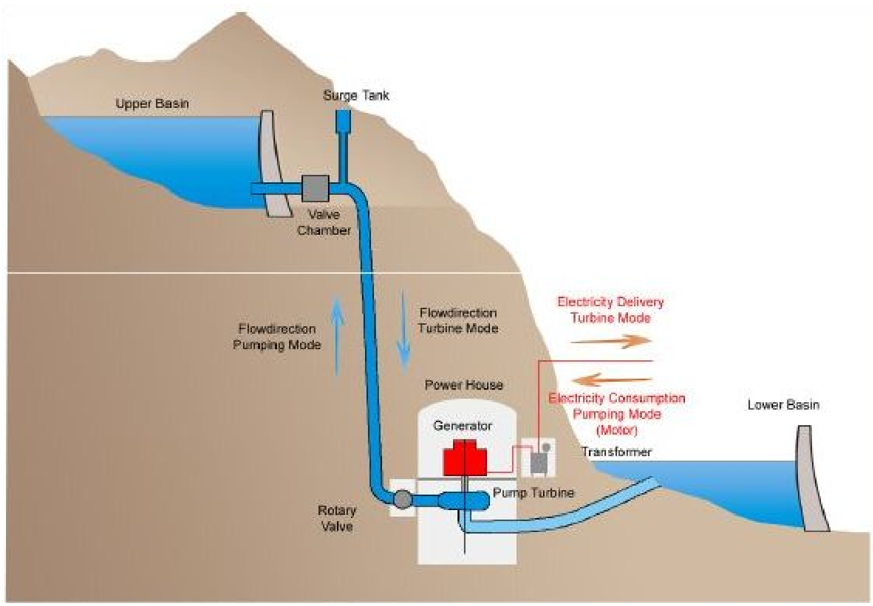
What is pump storage hydro?

Section 1

Section 1: What is Pump Storage Hydro?

Pump Storage Hydro (PSH) is a type of hydroelectric energy storage used by electric power systems for load balancing. The method stores energy in the form of gravitational potential energy of water, pumped from a lower elevation reservoir to a higher elevation.



P/G efficiency:

$$\frac{\text{Generation energy } (downhill)}{\text{Pumping energy } (uphill)} = \sim 80\%$$

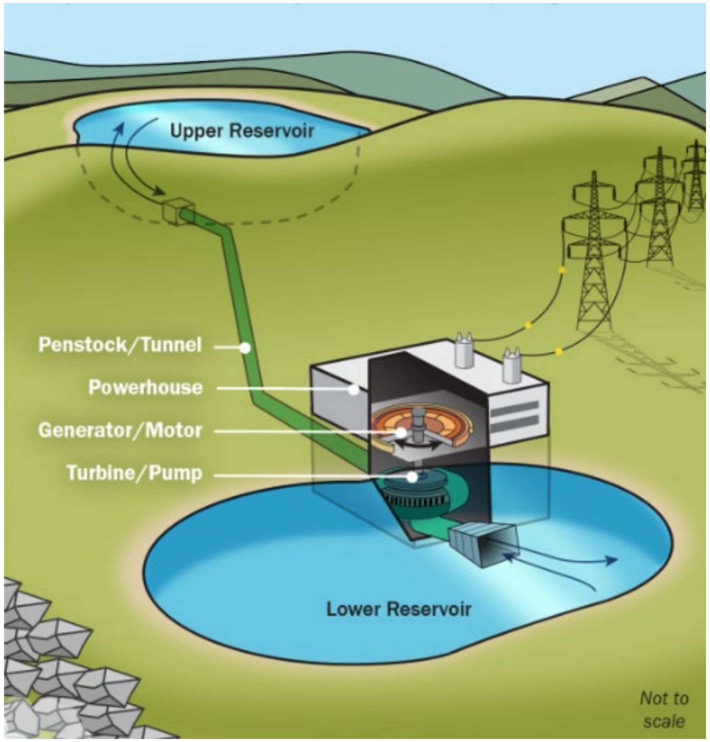
Requirements:

- ✓ Topology – elevation between upper & lower basins
- ✓ Power lines – Access to transmission grid
- ✓ Water Supply

Pumped-storage hydroelectricity (PSH) is a type of hydroelectric energy storage used by electric power systems for load balancing. The method stores energy in the form of gravitational potential energy of water, pumped from a lower elevation reservoir to a higher elevation.

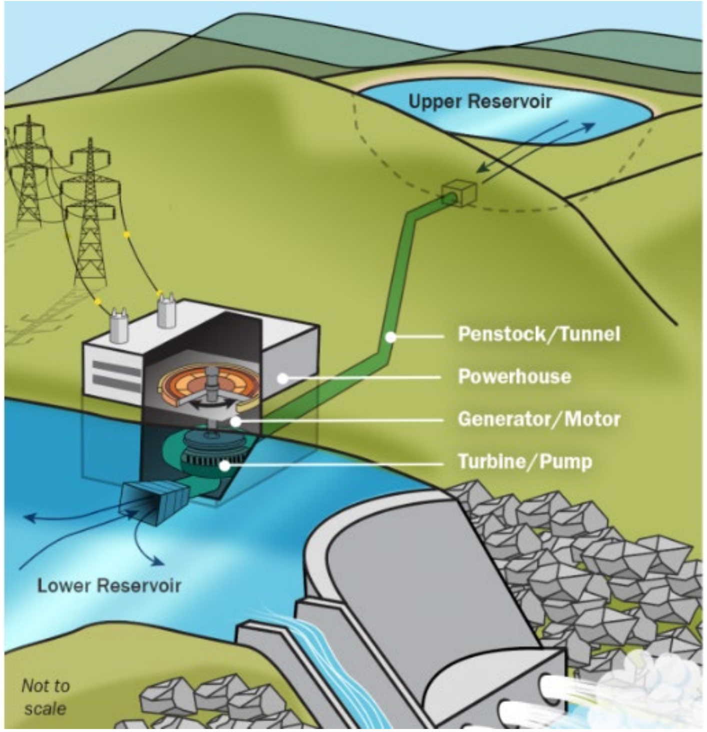
Section 1: What is Pump Storage Hydro?

Types of PSH



Closed – Loop

- ✓ Disconnected from any existing waterway
- ✓ Fewer environmental impacts
- ✓ Makeup water constraints



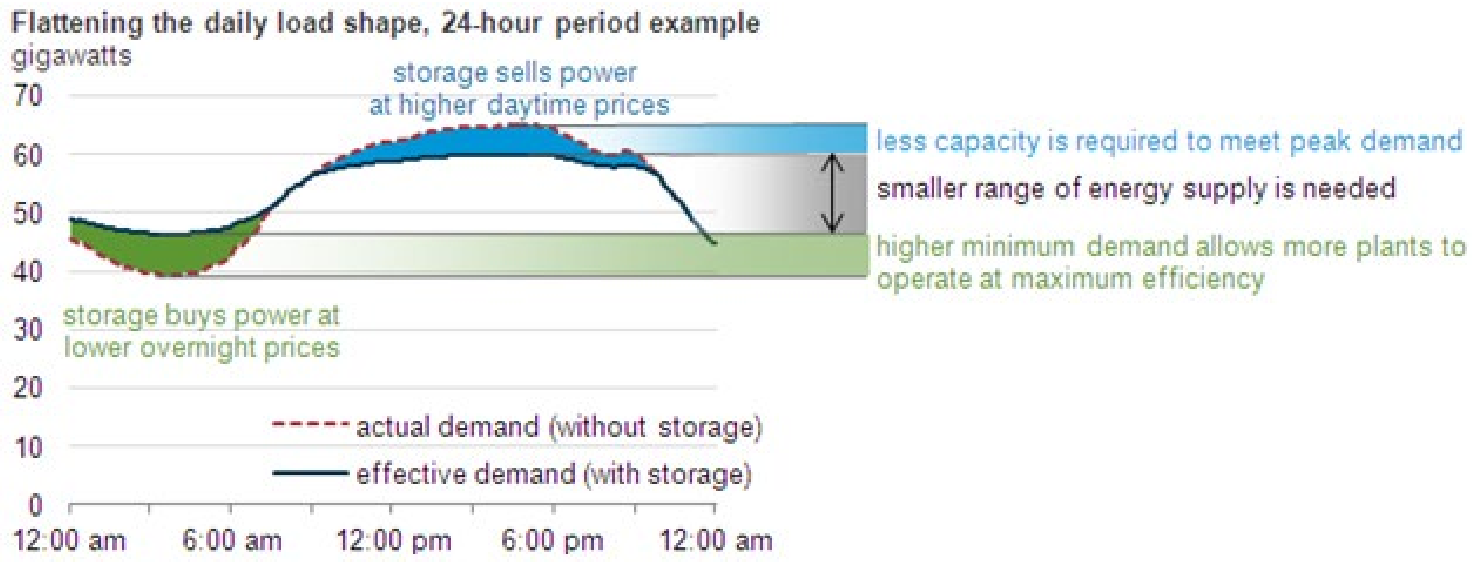
Open – Loop

- ✓ Connected to existing waterway
- ✓ Ready water supply
- ✓ Additional environmental impacts

How does it work?

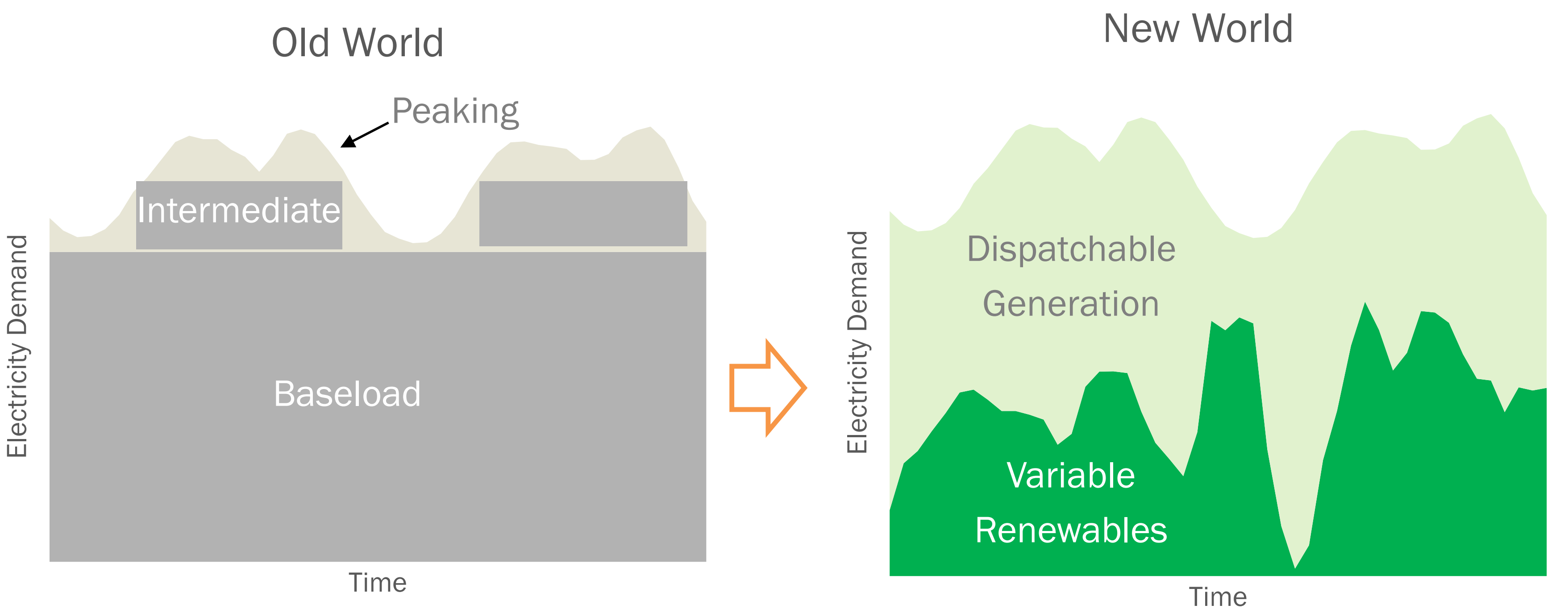
Section 2

Traditional purpose



- ✓ Existing PSH fleet constructed mid- to late-1970s
- ✓ Load Shaping and Peak Shaving
- ✓ Energy Arbitrage, Peak/Off-Peak

New PSH interests



- ✓ Increase penetration of variable renewable energy resources
- ✓ Electricity Market Designs: Energy, Capacity and Ancillary Services
- ✓ New Technology – Variable Speed Pumps/Generators

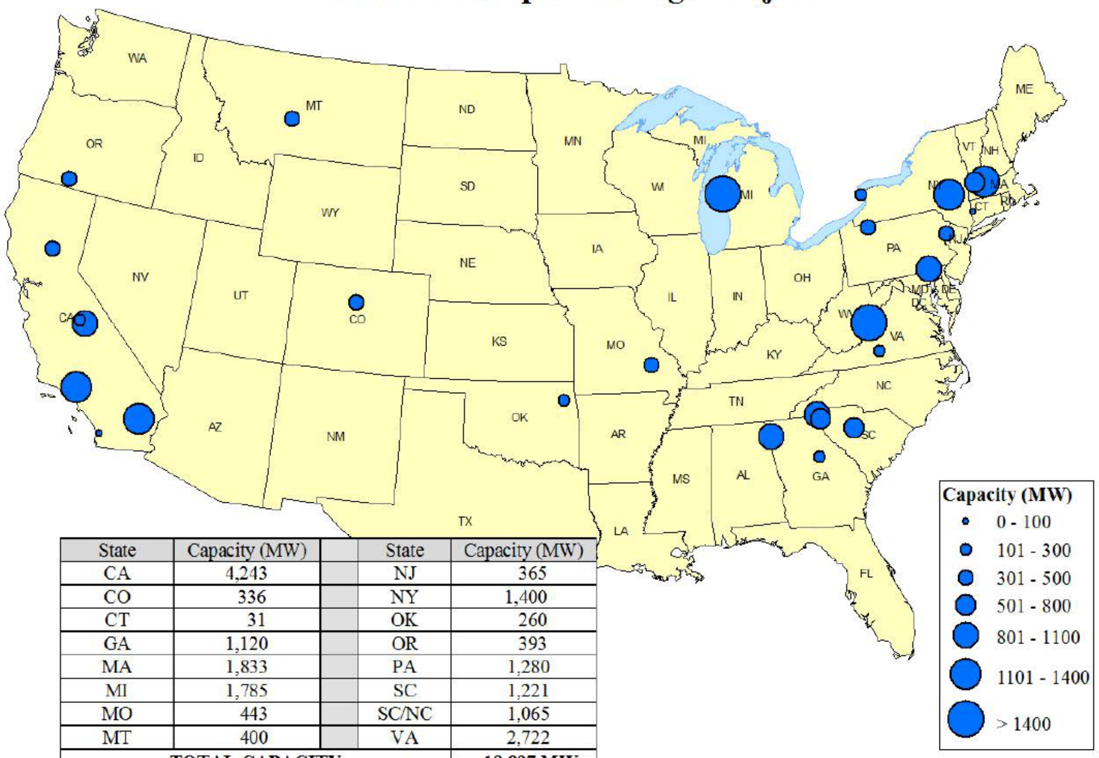
Existing and future projects

Section 3

Section 3: Existing PSH projects

Where in the US?

Licensed Pumped Storage Projects



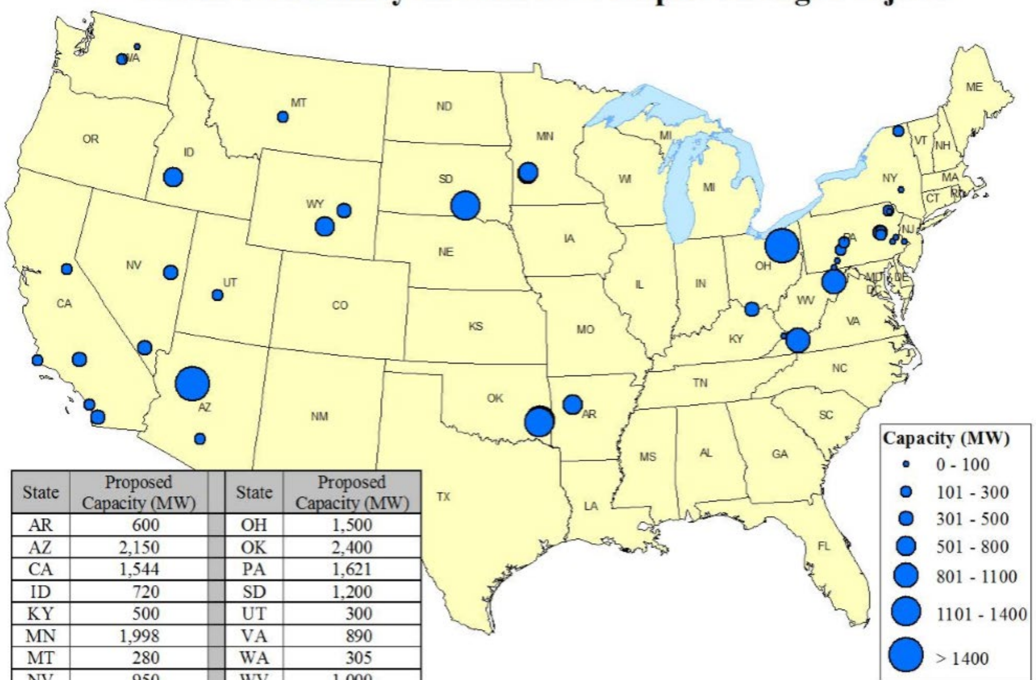
State	Capacity (MW)		State	Capacity (MW)
CA	4,243		NJ	365
CO	336		NY	1,400
CT	31		OK	260
GA	1,120		OR	393
MA	1,833		PA	1,280
MI	1,785		SC	1,221
MO	443		SC/NC	1,065
MT	400		VA	2,722
TOTAL CAPACITY				18,897 MW

Source: FERC Staff, September 1, 2019

Section 3: Proposed PSH Projects

Where in the US?

Issued Preliminary Permits for Pumped Storage Projects



State	Proposed Capacity (MW)	State	Proposed Capacity (MW)
AR	600	OH	1,500
AZ	2,150	OK	2,400
CA	1,544	PA	1,621
ID	720	SD	1,200
KY	500	UT	300
MN	1,998	VA	890
MT	280	WA	305
NV	950	WV	1,000
NY	289	WY	1,100
TOTAL CAPACITY			19,347 MW

Source: FERC Staff, September 1, 2019

Pump Storage Hydro at Cowlitz?

Pump Storage at Cowlitz

Opportunities

- ✓ Existing project/reservoirs
- ✓ Open 3rd pump/generator bay at Mossyrock
- ✓ Promising economics

Challenges

- ✓ Environmental impacts
- ✓ Additional upper reservoir
- ✓ Re-opens FERC licensing process
- ✓ Transmission: located near critical flowgate
- ✓ Scale (250 – 300 MW)
- ✓ Co-operations

Benefits and challenges

Section 4

Advantages of Pump Storage Hydro:

Flexible and reliable

- ✓ Reacts to network fluctuations
- ✓ Contingency outages
- ✓ Load following
- ✓ Absorbs excess generation
- ✓ Reserve output at low wind or lack of sunshine

Concepts

- ✓ Hybrid – Combining pumped storage with wind and/or solar generation
- ✓ Symbiotic – Renewable Resource used to integrate Renewable Energy with clean hydropower
- ✓ "Green" battery – Currently the most viable utility-scale energy storage technology

Reservoir management and flood control

Exceptional lifetime of more than 80 years

Challenges of Pump Storage Hydro

Projects are Capital Intensive

- ✓ Development ($millions)
- ✓ Construction ($billions)

Regulatory

- ✓ FERC Licensing and permitting

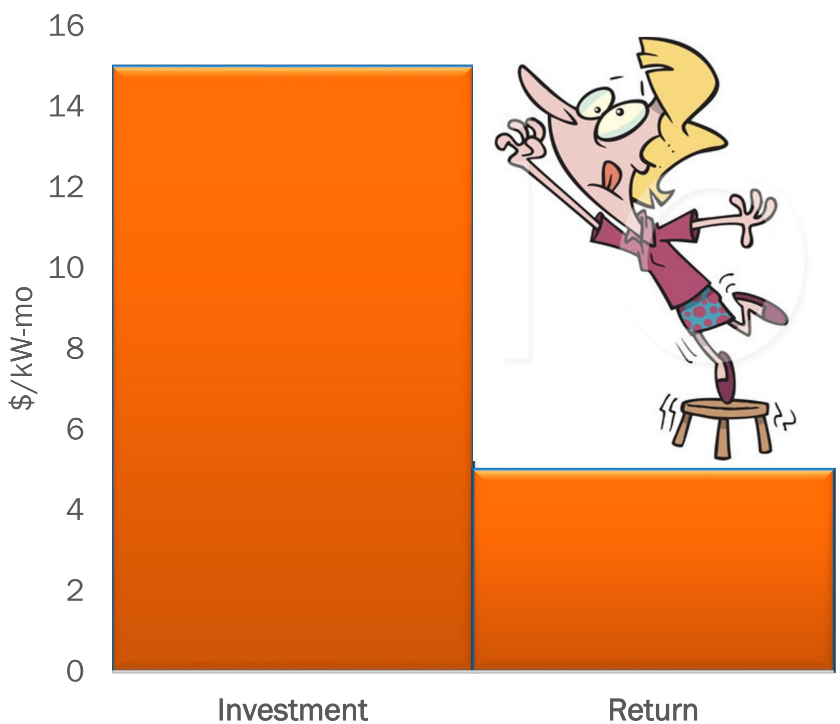
Scale

- ✓ Capitalization – Equity vs. PPA, Governance vs. Operations, etc.
- ✓ Joint operations – Shared costs/benefits, project optimization

Market Limitations

- ✓ Missing revenue streams – deriving value from Energy & Ancillary Services (AS).
- ✓ Market Design – lack of market structure for monetizing value clean dispatchable generation resources.

Missing Money



Market prices do not fully reflect the value of investment necessary to meet load

- Insufficient Resource Adequacy standards undervalue existing clean dispatchable generation such as hydro
- Inadequate incentives to invest in new forms of dispatchable generation like Pump Storage Hydro

* Environment costs, taxes, etc.

Summary

Section 5

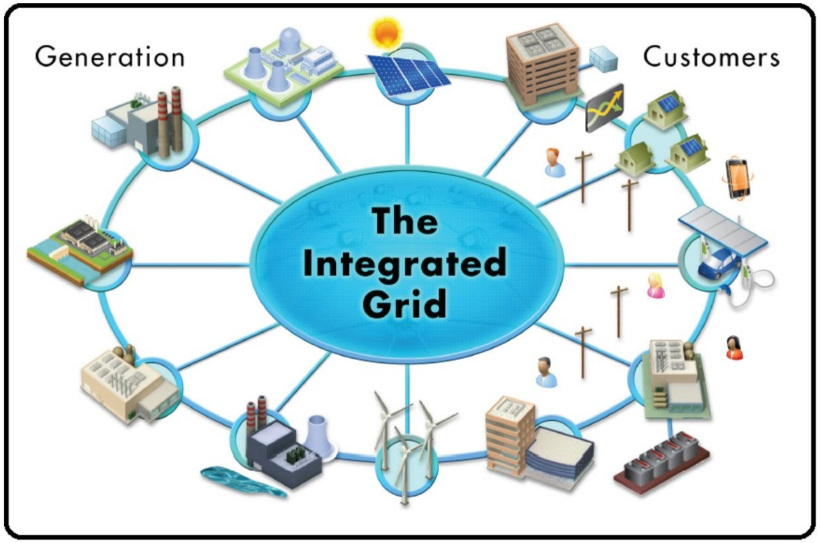
Future State: Pump Storage Hydro part of a well-integrated grid

Benefits

- Complements Renewable Energy Resources
- Very Flexible Resource
- Improves Reliability
- Longevity

Challenges

- Long-term Economics
- Development costs
- Construction time
- Scale
- Market Design



IRP Update

Section 6

Stakeholder Input Process

Working Group Workshops

- Smaller group selected by utility with goals of ensuring committed participation and balance of perspectives
- Responsibility for reviewing materials and providing feedback on assumptions, analysis, etc.

Input Opportunities for Other Community Members

- Observe & comment during open comment time
- Written comment on workshop materials
- Online contact form for general comments

General Information Sharing

- Email distribution list to interested parties
- All materials to be posted on website

Workshop 1 (February 24)
- Introduction to process & key issues

Workshop 2 (March 11)
- Key inputs

Workshop 3 (April 27)
- Analysis framework

Workshop 4 (June 11)
- Analysis results

Working Group Membership

Selected with goals of ensuring **committed participation** and **balance of perspectives**

Customer Classes

- Residential (1 to 2 representatives)
- Small business (1 to 2 representatives)
- Large commercial (1 to 2 representatives)
- Industrial (1 to 2 representatives)
- JBLM (1 representative)
- Puyallup Tribe of Indians (1 representative)

Environment & Sustainability

- Regional organizations (1 to 2 representatives)
- Local organizations (1 to 2 representatives)

Other Expertise

- NW Power & Conservation Council (1 representative)
- Academic (1 representative)

Anticipated 2020 Study Session Schedule

	Topic	Date
1	Resource planning 101	August 28 (complete)
2	Resource adequacy	October 9 (complete)
3	Our current portfolio & resource options	October 23 (complete)
4	Small nuclear reactors	November 13 (complete)
5	Energy storage	December 4 (complete)
6	Pump storage hydro	January 7 (today)
7	Key inputs: Load & price forecasts, Preliminary metrics, resource options & scenarios	March 25
8	Final metrics, analysis of uncertainty, current resource need and final resource options & scenarios to model	May 13
9	Analysis results & recommendations	July 8
10	(If needed) Revised Results & Recommendations	July 22
11	Approve IRP (BOARD MEETING)	August 12

IRP Schedule

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			2020											
	Activities	Aniticpated Completion	1	2	3	4	5	6	7	8	9	10	11	12
MODEL & ANALYSIS	Draft base case system model results (current portfolio)	20-Mar-20	■	■	■									
	Final portfolio performance metrics selected	15-May-20	■	■	■	■	■							
	Final resources & scenarios selected for evaluation	15-May-20	■	■	■	■	■							
	Full draft analysis results	1-Jun-20			■	■	■	■						
	Final draft IRP document complete	31-Jul-20							■					
	Submit IRP	14-Aug-20								■				
	Publish IRP & communicate findings externally	31-Dec-20									■	■	■	■
INPUT	Stakeholder Workshops	11-Jun-20		■	■	■		■						
	PUB Study Sessions	22-Jul-20	■		■		■		■					
	PUB Approval of IRP	12-Aug-20								■				