JULY 2026

Pacific Northwest Storage Roadmap

The Pacific Northwest grid is entering a period of rising stress. Storage could help manage the challenge, but market and planning frameworks fail to capture its full value, thereby limiting its deployment. Reforms drawn by example from other regions could unlock storage's potential and support grid transition in the PNW.

Prepared for
Renewable Northwest

Prepared by
Aurora Energy Research

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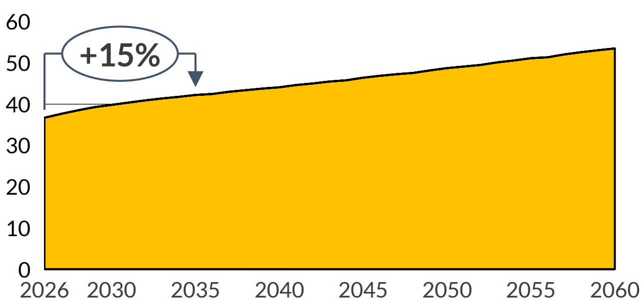
ENERGY RESEARCH

PNW grid introduction

Load growth, thermal retirements, and transmission constraints are increasing stress on the PNW grid

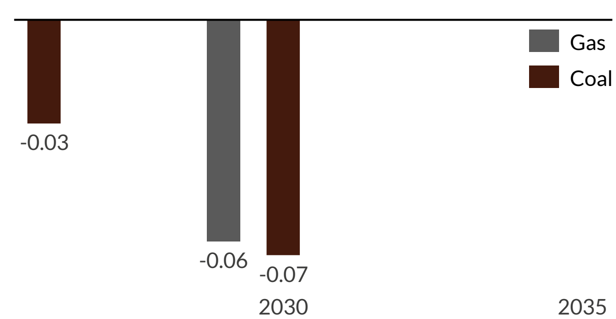
Load growth

PNW forecasted load growth
GW



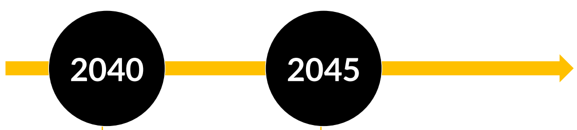
Shrinking thermal fleet

PNW announced thermal retirements
GW



Renewable deployment

PNW clean energy standards

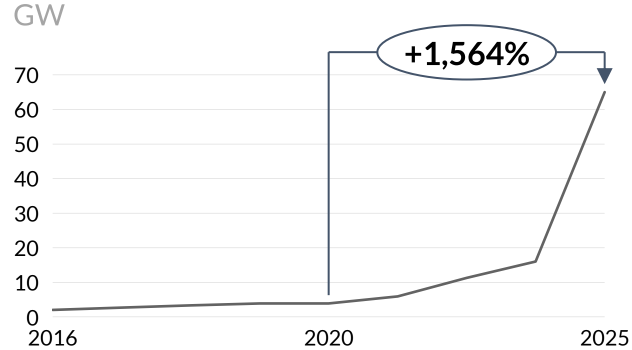


HB2021
Requires OR utilities to achieve 100% emissions reduction by 2040

CETA
Requires WA utilities to achieve 100% non-emitting electricity by 2045

Transmission constraints

BPA IXQ by study year
GW



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PNW grid stressors increase the need for core services that storage provides: capacity, energy shifting, and ancillary services

Storage core services

1 • Capacity
Storage provides dispatchable capacity to meet peak demand and resource adequacy needs

2 • Energy shifting
Storage stores surplus low-cost generation (e.g. midday renewables) and discharges during high demand periods

3 • Ancillary services
Storage provides fast-acting balancing energy and maintains operational grid requirements

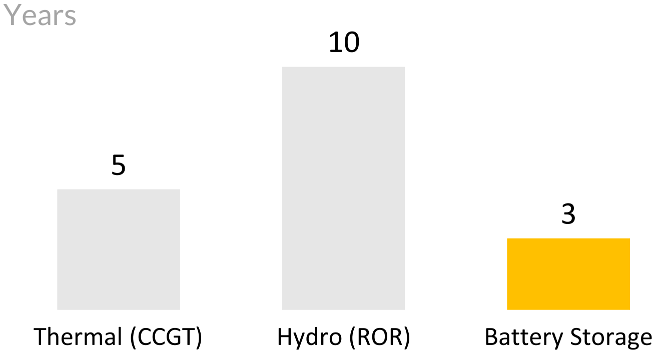
Impact of PNW grid stressors on need for storage services

	Capacity	Energy shifting	Ancillary services
Load growth	**Increased need for firm capacity** given load growth's impact on peak load	**Increased need to shift energy from off-peak to peak periods** as load shapes evolve	**Increased procurement** of ancillary services is necessary as the grid scales, exacerbated by volatile loads like data centers for AI training
Shrinking thermal fleet	**Reduces supply of firm capacity**	**Increases need for flexible resources** to replace lost load-following capabilities	**Reduces supply of ancillary services** from thermal units, increasing need for alternative providers
Renewable deployment	**Diminished security of supply** despite rise in nameplate capacity addition	**Increased need to shift energy** from periods of excess renewable generation to periods of low output	**Increased need for ramping support and frequency regulation** driven by variable generation
Transmission constraints	**Reduction in firm capacity** due IXQ delays slowing pace of new additions to replace retirements	**Increases need to shift energy across** constrained periods to mitigate congestion and curtailment	**Limits access to system-wide balancing resources,** increasing need for local ancillary services

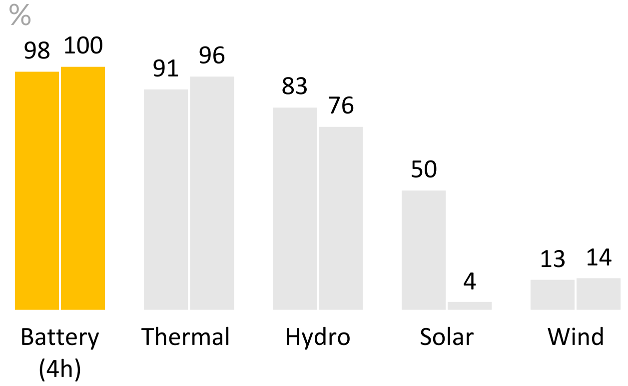
Faster to deploy than thermal or hydro, storage is well-suited to contribute to PNW's near-term capacity needs

As load grows and thermal generators retire, there's an increased need for capacity in the PNW. Storage is well-suited to provide that capacity given relatively fast construction and declining CAPEX

Average construction time
Years



WRAP ELCC
%



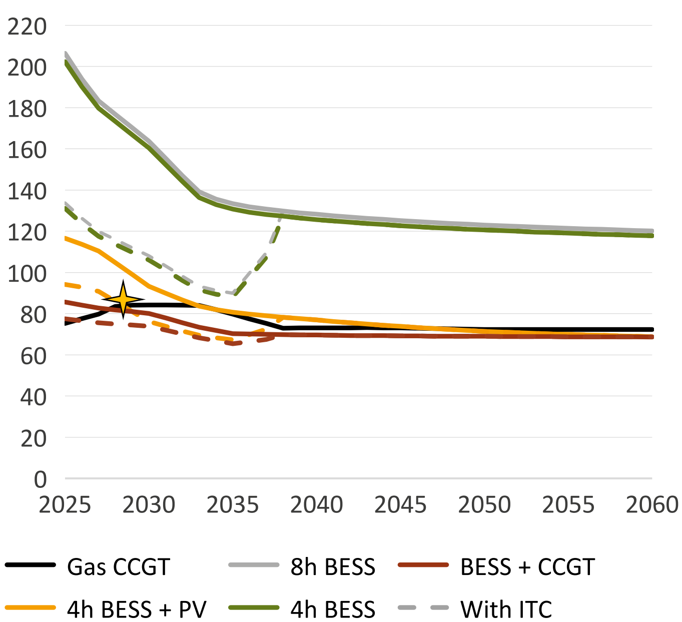
Storage is faster to deploy than thermal or hydro

Storage projects are modular, require less infrastructure, face fewer permitting hurdles, and have shorter construction timelines, making it well-suited to address the PNW's near-term capacity gap

Storage provides dispatchable green capacity

Storage provides emissions-free dispatchable capacity, enabling it to support both reliability and clean energy goals in the PNW

LCOE forecast, PNW
$/MWh, real 2024



Storage is increasingly cost-competitive

BESS costs have declined dramatically in recent years due to falling cell prices, and are expected to continue declining

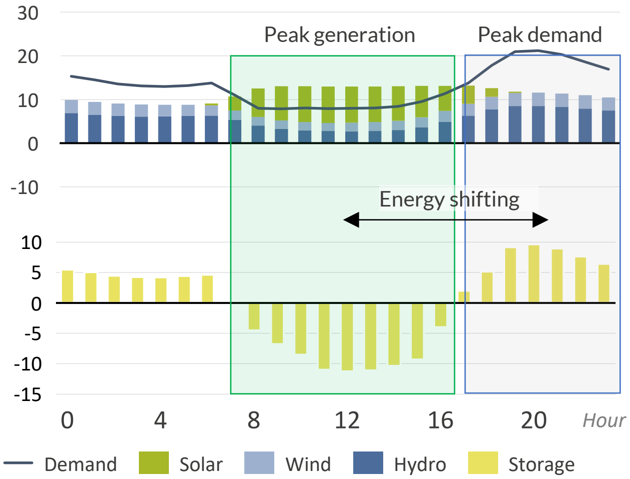
Storage continues to be eligible for the Investment Tax Credit through the 2030s

Lead times for new CCGT plants have jumped from 3.5 years in 2023 to 5 years in 2025 due to increasing demand and turbine shortages

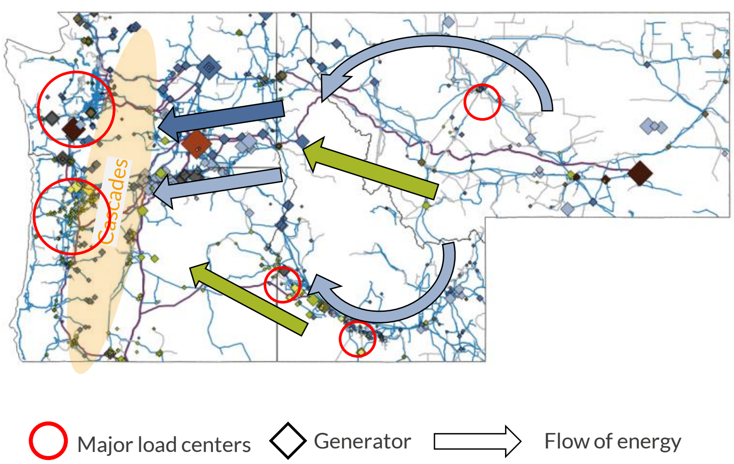
Storage provides critical energy shifting and grid-stabilizing ancillary services

> Storage supports a cleaner, more cost-effective grid by shifting low marginal cost renewable energy production to align with demand, while also providing ancillary services that stabilize grid operations

Illustrative demand and generation
GW



PNW network



Storage enables renewable integration

Renewable sources generate at times that don't always align with demand. Storage shifts that energy to hours when peak demand occurs, enabling customers to benefit from low marginal cost renewable power

Storage eases transmission congestion

Cascades transmission constraints limit low-cost eastern solar and wind generation from reaching western load centers. Storage sited near these constraints could absorb excess generation or serve local load, reducing congestion across the bottleneck

Ancillary services provided by technology

Ancillary service	Li-ion ★	Pumped	Reciproc. engine	CCGT
Frequency response	✓	✓	~	~
Inertia / stability	~	✓	✓	✓
Energy balancing (reserve)	✓	✓	✓	✓
Congestion resolution	✓	~	~	~
Voltage support	✓	✓	✓	✓
Restoration	✓	✓	✓	~

✓ Well suited ~ Partial _ Limited

Storage provides cheap ancillary services

Compared to other ancillary service providers such as CCGTs, storage can provide a majority of the ancillary services at a much lower cost, higher efficiency, and faster response time

Emerging use cases for storage extend storage's value beyond its core services

1 · Long-duration storage

Technologies such as iron-air and A-CAES storage systems are maturing and are well-positioned as firm capacity to address PNW winter reliability concerns

***2026, Colorado:** Google and Xcel Energy signed an agreement for 1,600MW of clean generation and a 300MW iron-air LDES asset, which will provide "similar benefits to a natural gas peaking plant"*

2 · Storage as a transmission asset

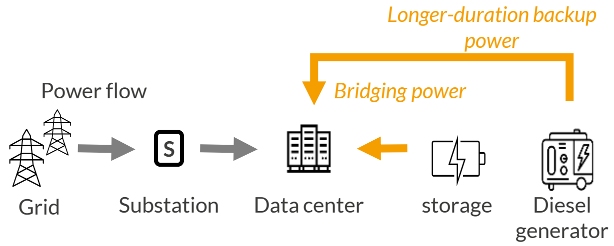
Storage operated as part of the transmission system can defer costly upgrades and enable new projects to come online without the lengthy and costly interconnection upgrades

***2019, Massachusetts:** 6MW/48MWh storage deployed to defer transmission upgrade by 13 years. Deferral valued at $122M in present value; total benefits of $158M against $94M cost, making a 1.68x return on investment*

3 · Co-location with data centers

Behind-the-meter storage cuts peak demand on the substation, deferring upgrades and speeding interconnection. Front-of-meter storage absorbs load spikes and provides grid stability, reducing ancillary procurement

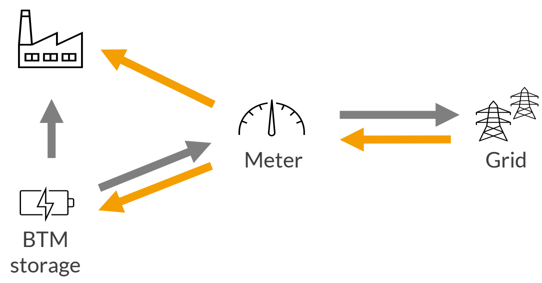
Example BTM +thermal data center configuration



4 · Behind-the-meter programs

BTM storage charges off-peak and discharges during peak events. BTM can be installed in weeks-to-months, bypassing queue bottlenecks

BTM configuration schematic



Planning and market frameworks that undervalue storage are the primary barriers to deployment

Limited monetization of storage value

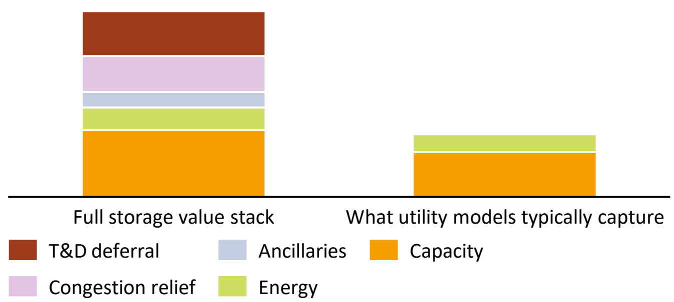
EDAM and Markets+ don't include ancillary-service markets, leaving a major portion of storage value unquantified

	Pre-regionalization	*Regionalized Day-ahead Markets*	
Energy products	**Non-ISO**	**EDAM**	**Markets+**
Energy	Bundled PPA	Day-ahead & real-time market	Day-ahead & real-time market
Capacity	Bundled PPA	Voluntary RA program[1]	WRAP
Ancillary services[2]	No ancillary service market	**No ancillary service market**	**No ancillary service market**

Capacity-based procurement & cost-of-service regulation

Capacity-based planning obscures full value-stack of storage. Cost-of-service regulation can bias investment toward capital-intensive assets

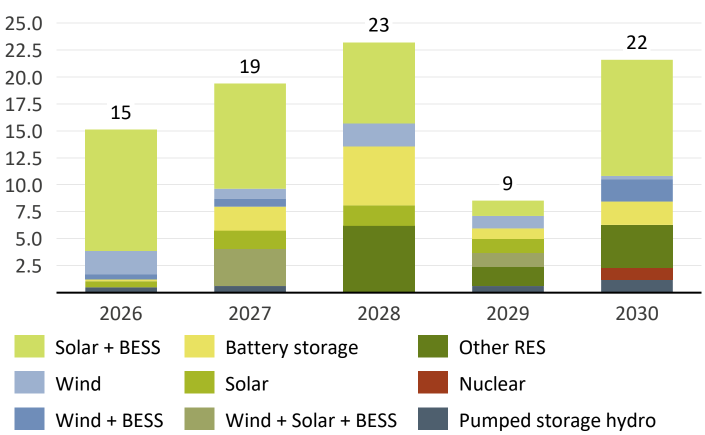
Storage value stack (illustrative)



Significant delays in BPA IXQ

BPA owns about 75% of the transmission in the PNW, and its outdated planning framework (currently under reform) has not kept up with the volume of solar and renewables currently in its queue

BPA IXQ by in-service date
GW



Frameworks that exclude clean-energy goals

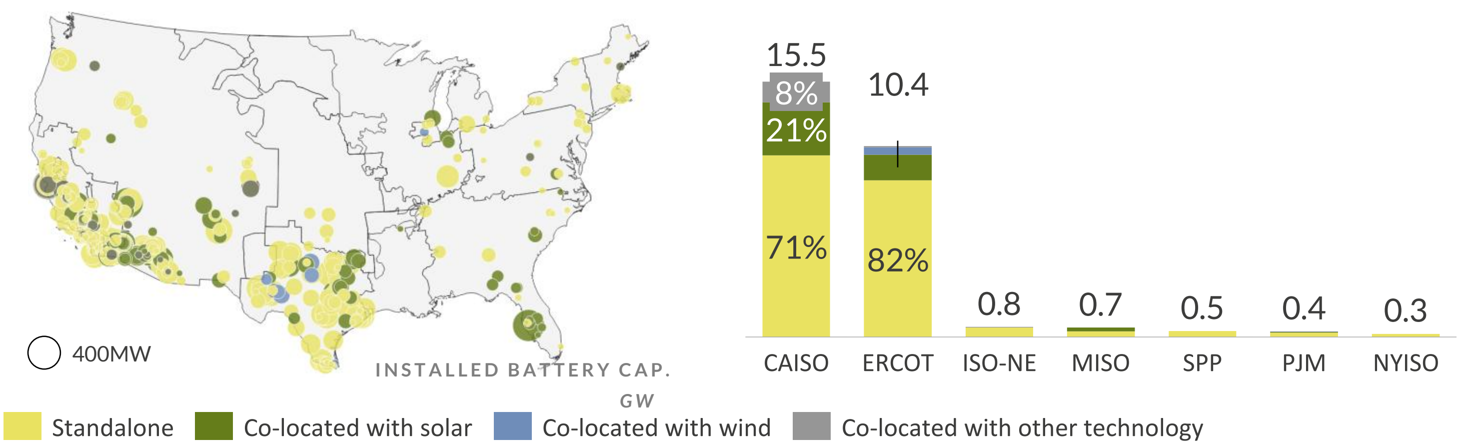
Load growth and IXQ delays put pressure on utilities on near-term reliability, and they are increasingly turning to thermal assets despite clean-energy goals

Near-term PNW thermal capacity additions

Name	COD	State	Size (MW)
South Hills Power Plant	Mid-2029	ID	222
Peregrine Power Plant	Mid-2030	ID	430
Centralia Unit 2 coal-to-gas conversion	Late-2028	WA	700
PSE peaker turbines (IRP planned)	2026-2030	WA	237

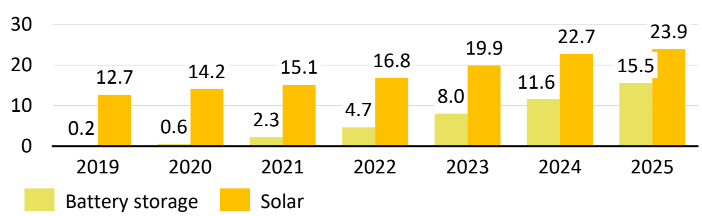
US storage deployment is led by CAISO (15.5 GW) and ERCOT (10.4 GW)

Installed battery capacity in US, 2025



CAISO

INSTALLED CAPACITY
GW



Drastic solar buildout encourages storage deployment

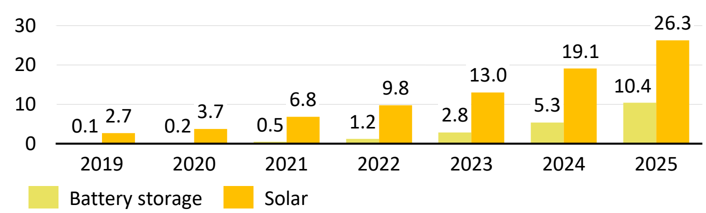
Between 2016 and 2025, grid-scale solar capacity doubled and led to drastic storage deployment to harness the mid-day solar energy

State-led procurement further strengthens signal for storage deployment

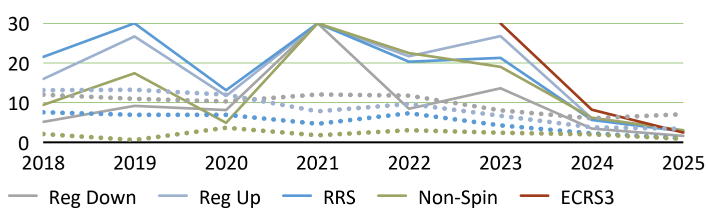
CPUC's procurement mandates require LSEs to procure firm, clean, flexible capacity, directly driving large-scale storage deployment

ERCOT

INSTALLED CAPACITY
GW



HISTORICAL ANCILLARY SERVICE PRICES
$/MW/h



Storage deployment is driven by load growth, renewables penetration, and market design

A combination of demand and renewable growth coupled with energy-only design with high price ceiling and volatile prices drive large-scale storage deployment across the state

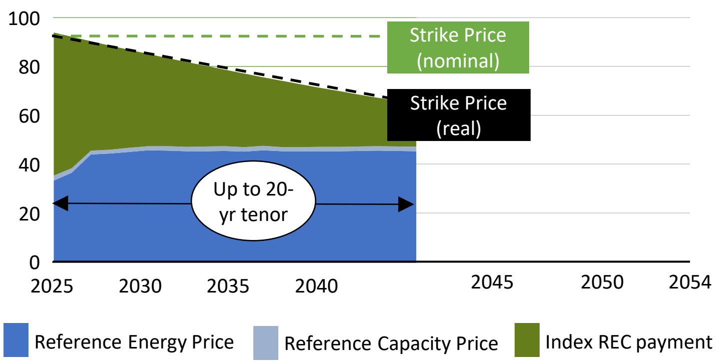
Examples in NYISO, SPP, and abroad point to beneficial policies and mechanisms to support storage deployment

NYISO

Index Storage Credit

A contract for difference on a strike price sets a revenue floor that reduces developer risk, while ratepayer costs track market outcomes rather than fixed subsidies

NYSERDA Index REC contracting structure, 2025 entry year

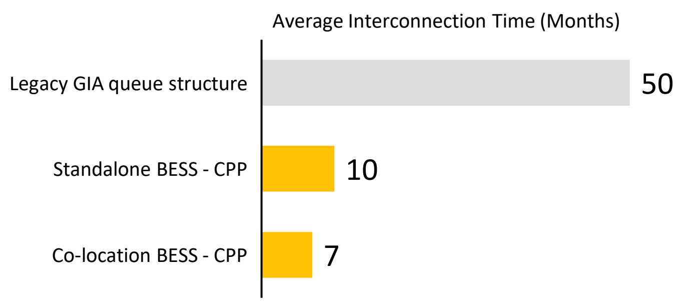


SPP

Consolidated Planning Process

Integrates transmission planning and generator interconnection into one coordinated framework that results in much faster interconnection timeline

SPP interconnection time



Brazil

BESS procurement in hydro-dom. system

Like PNW, Brazil is a hydro-dominant system without a robust ancillary service market. Rising renewable deployment drove curtailment and led to first storage auction, with a target of 2GW by 2028

CA/MA/NY

State-level incentive programs for LDES

CA's SB122/AB102 enables $380M for >8-hour, non-lithium LDES; MA mandates 1.5 GW of 10-24h + >24h storage by 2030; NY's ROSI program funds 12-hour-plus resources

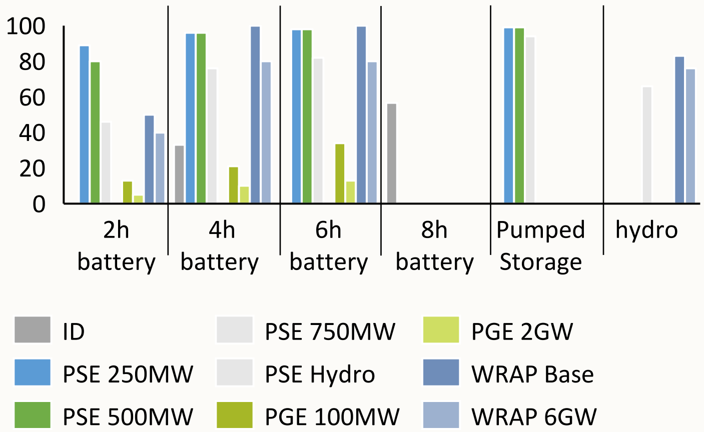
Storage ELCC is sensitive to the underlying modeling assumptions

What ELCC measures

Effective Load Carrying Capability measures how much additional load a resource can reliably serve while holding system reliability constant. A base case is run without the new technology, then capacity is added back in tiers and the additional load it supports is measured

STORAGE ELCC RATINGS ACROSS PNW

%



Drivers that move storage accreditation

Hydro operating assumptions	Low hydro-flexibility spreads stress across the day, while high flexibility concentrates it at morning and evening peaks where storage is better positioned to contribute
Reliability metric	The choice of accreditation metric affects how much credit storage receives for its contribution during shortfalls
Renewable buildout	Higher renewable penetration changes the timing and shape of net load, creating more opportunities for storage to charge and discharge during high-risk periods

How ELCC is calculated - example

STEP 1
Base case
90 GW
System without the new tech; find the peak load hitting target loss-of-load expectation — 55 GW

→

STEP 2
Change case
+30 GW
Add the tech back in tiers (→120 GW). Peak load reaching the same LOLE rises to 60 GW

→

STEP 3
Accredited
5 GW
The 5 GW gain in supportable peak load is the accredited capacity for the 30 GW added

→

STEP 4
Derating
16.67%
Accredited ÷ added (5 ÷ 30) — the gap between nameplate and accredited capacity

Recommendations to accelerate storage adoption

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Reforms that better recognize and compensate storage's value, and reduce development barriers, are critical to accelerating deployment

Main storage deployment barriers

Utility Planning Framework

Current utility planning frameworks fail to capture storage's full value stack across capacity, energy, and ancillary services, resulting in low storage procurement

Limited Revenue Streams

No regional ancillary service market and fragmented capacity frameworks mean storage cannot reliably monetize its revenue streams, thus producing a weak investment signal for utilities and private developers alike

Developmental bottlenecks

Even when there is desire to build storage projects, the interconnection queue delays along with PTP transmission rights and complex siting permits result in delayed storage build-out in the region

Recommendations to address barriers

- *Reform procurement planning frameworks*
- *Develop ancillary services markets*
- *Prioritize interconnection queue reform*
- *Adopt performance-based ratemaking*
- *Establish capacity markets or regional RA frameworks*
- *Remove PTP transmission right requirement*
- *Revise ELCC methodology*
- *Policies for emerging battery technologies and configurations*
- *Streamline siting and permitting*