Western Electricity Market Update

Sacramento Municipal Utility District

Board Strategic Development Committee and
Special Board of Directors Meeting

June 9, 2026

Sacramento, California

Energy+Environmental Economics

Arne Olson, Senior Partner

Agenda

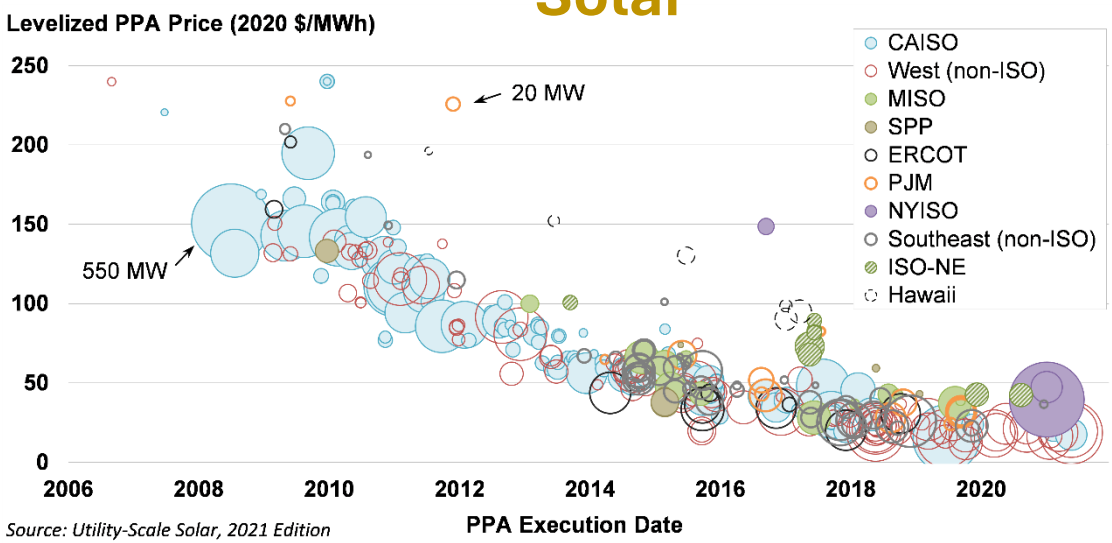
1. Current Hot Issue #1: Resource Costs and Affordability
2. Current Hot Issue #2: Resource Adequacy
3. Current Hot Issue #3: Clean Energy Accounting

Resource Costs and Market Conditions

Energy+Environmental Economics

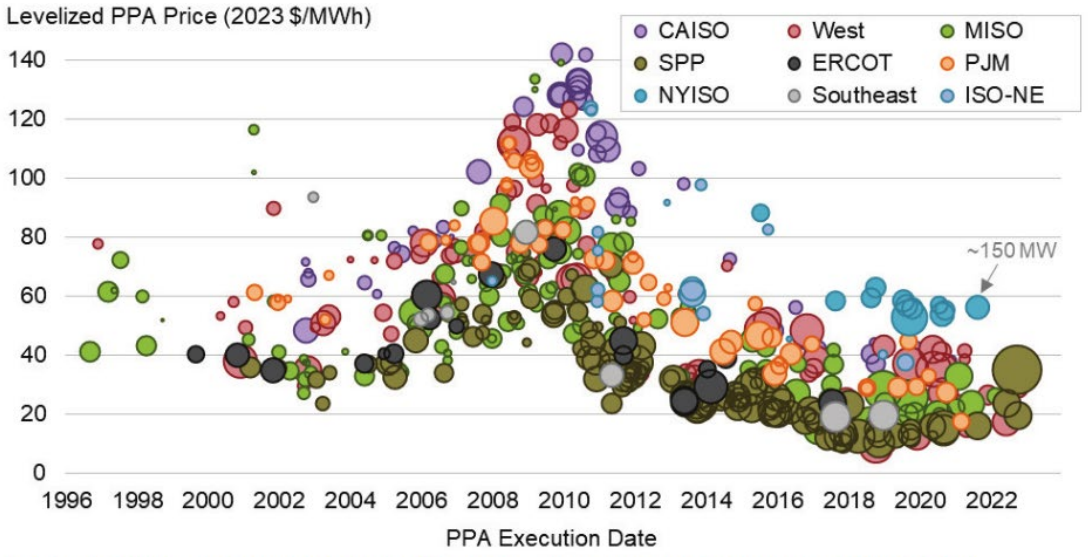
2010-2020 were an era of declining resource costs

Solar



Source: Utility-Scale Solar, 2021 Edition

Wind



Note: Smallest bubble sizes reflect smallest-volume PPAs (<5 MW), whereas largest reflect largest-volume PPAs (>500 MW)

Source: Berkeley Lab, FERC

Batteries

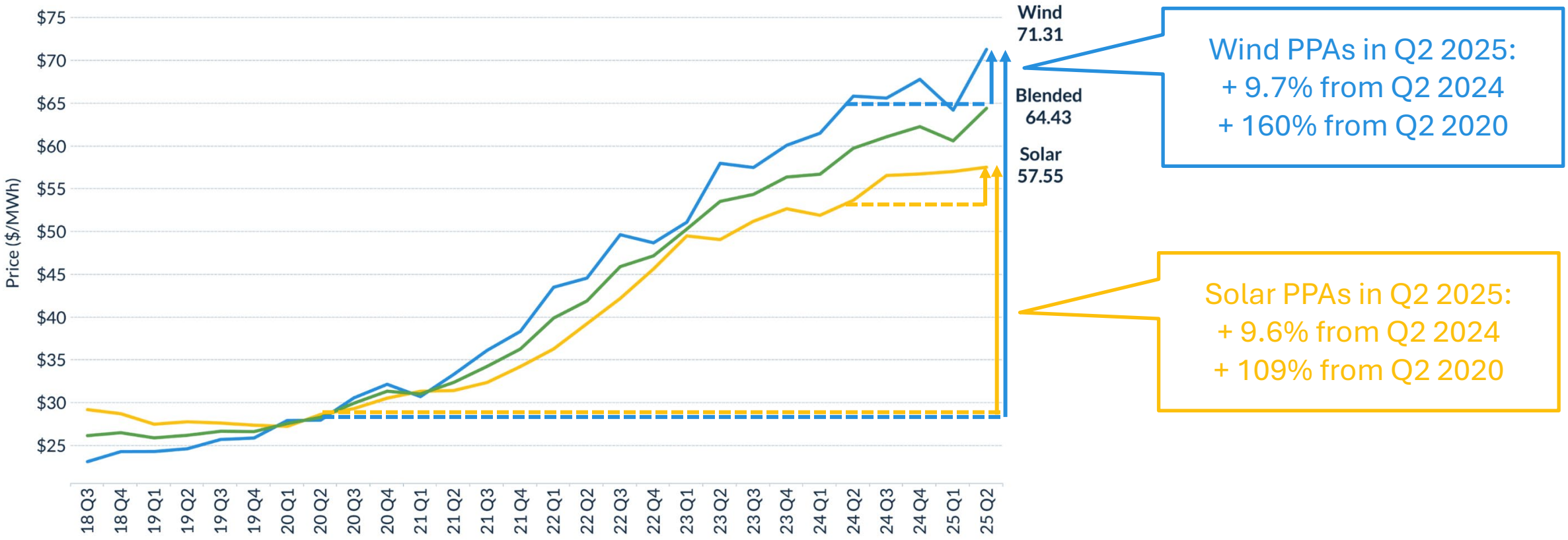
Source: BloombergNEF. Historical prices have been updated to reflect real 2023 dollars. Weighted average survey value includes 303 data points from passenger cars, buses, commercial vehicles, and stationary storage.

Key drivers included:

+ Technology "learning" and maturation
+ Low interest rates
+ Supportive federal tax and trade policy

Prices have "roared" in the '20s, and adverse federal policy impacts are not fully priced in yet

2025 Wind and Solar PPAs are more than double 2020 prices…without tariffs and tax credit phaseouts.



Wind PPAs in Q2 2025:
+ 9.7% from Q2 2024
+ 160% from Q2 2020

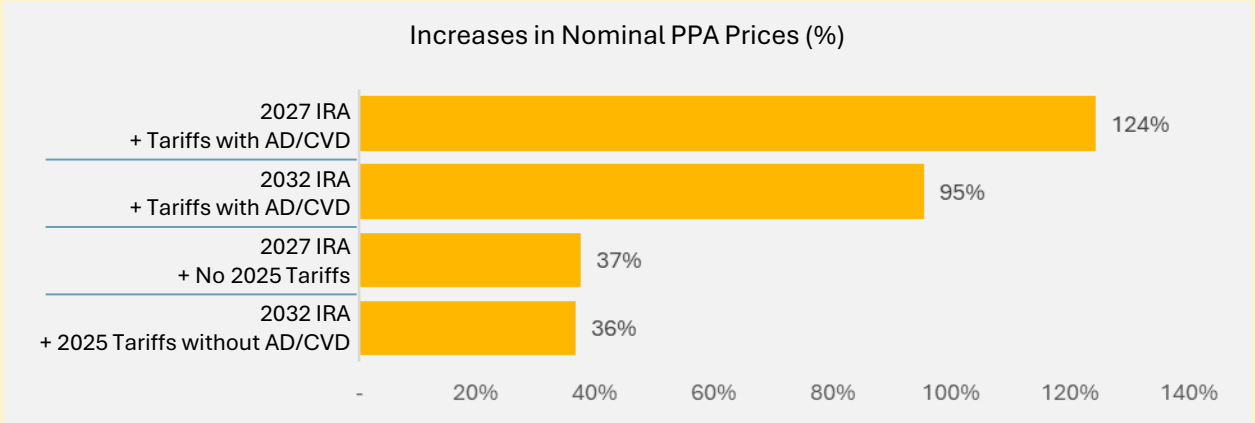
Solar PPAs in Q2 2025:
+ 9.6% from Q2 2024
+ 109% from Q2 2020

Source: LevelTen North American Continental PPA Price Index, Q2 2025.

Looking ahead, the "double whammy" of OBBBA and tariffs could raise PPA prices significantly through 2030

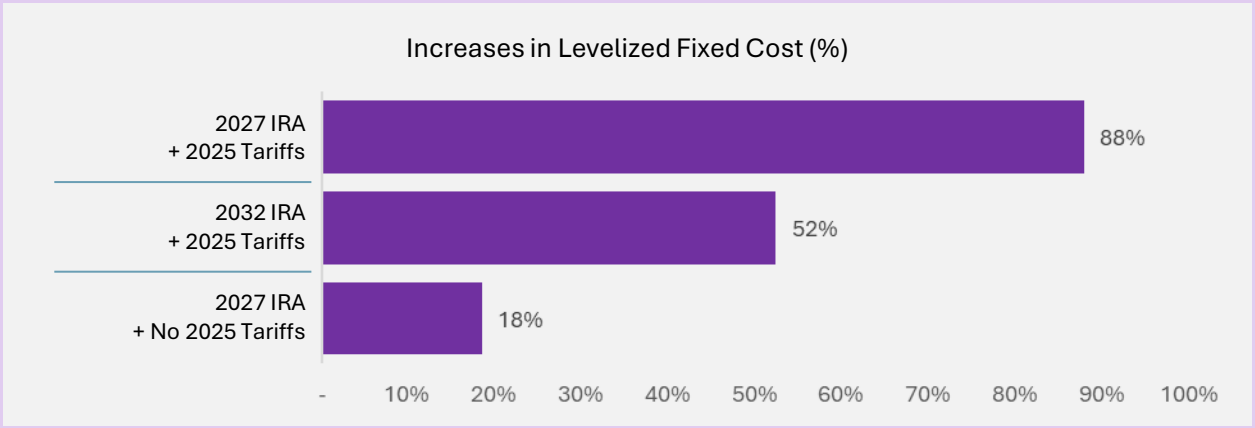
Using California as an example, nominal PPA prices (with flat pricing terms) could be 36% to 124% higher as a result of combined tariff and tax credit qualification impacts, under a "worst case" scenario.

Tariff impacts alone could drive PPA prices up by 36% to 95%.



Using California as an example, Levelized Fixed Costs (LFC), a proxy for tolling contract prices for BESS resources, could be 18% to 88% higher as a result of tariff and tax credit impacts.

Tariff impacts alone increase LFC by 52%.



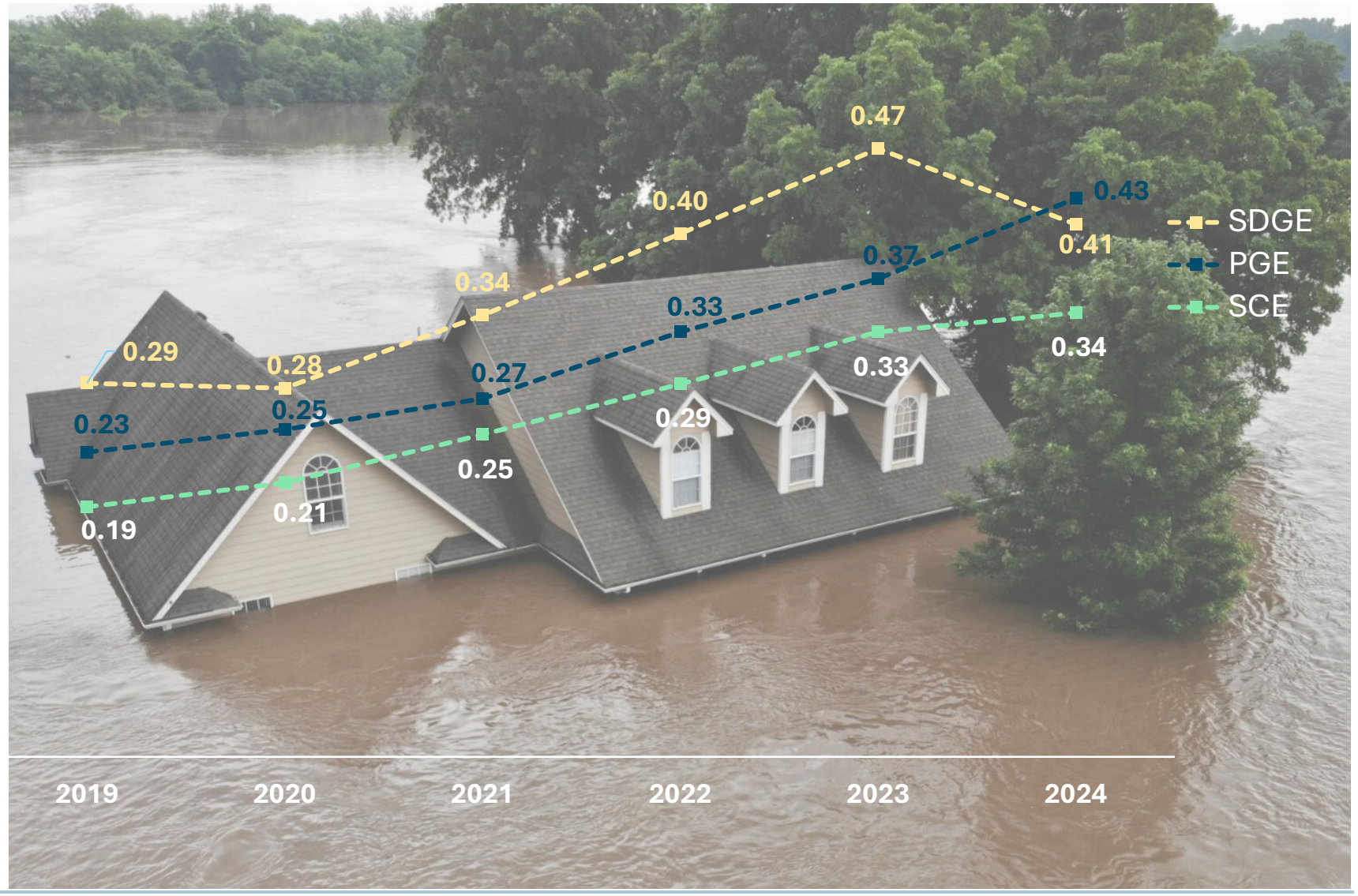
Customers of California IOUs are facing an Affordability crisis

Since 2019, residential rates have increased significantly:

+ PG&E: +87% (~11%/yr)
+ SCE: + 79% (~10%/yr)
+ SDG&E: + 41% (~6%/yr)

Customers are being flooded with higher costs…

+ Wildfire mitigation and damages
+ Cost of capital and other inflationary pressures
+ Net energy metering cost-shift



The California market will be trickier to navigate in the future due to solar and battery saturation

+ There were over 1000 hours of curtailment and negative prices in Southern California in 2024

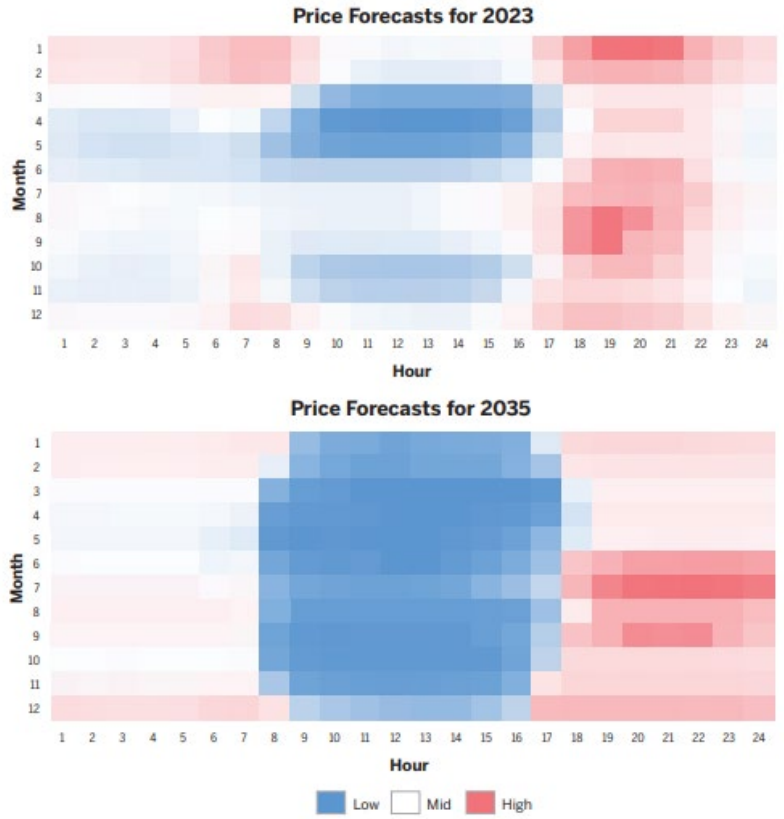
- Generators are paying up to -$67/MWh at for buyers to take their power

+ Battery development is helping to mitigate negative pricing a bit in 2025

- The extent of negative pricing in the future will depend on the push-pull between solar and battery development

Average prices in 2023 and forecast for 2035

CAISO SP15 zone

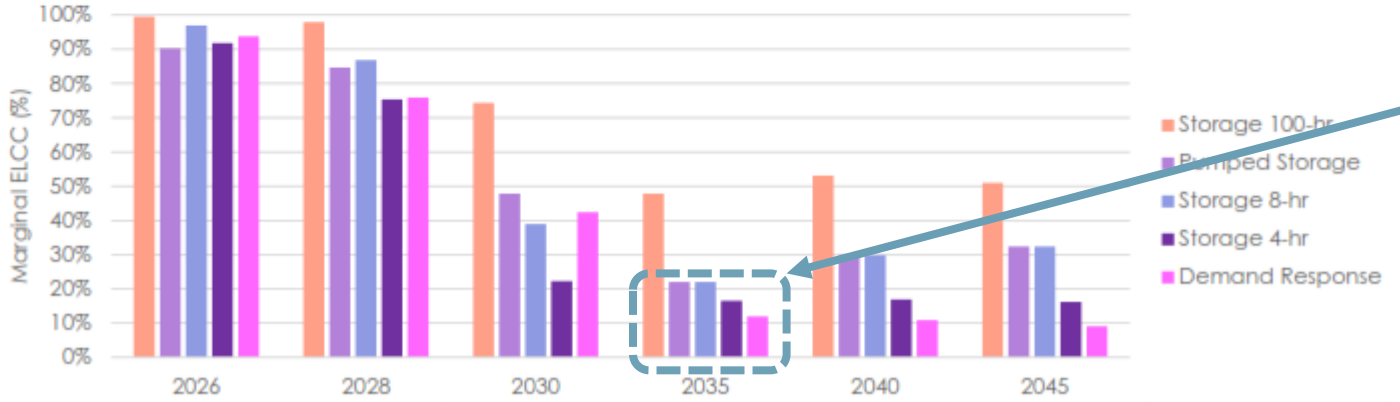


Saturation is leading to lower future capacity values for batteries in the CPUC IRP

Modeling Results

Storage and DR ELCCs Decline in Future Years

- Storage marginal ELCCs remain high in the near term amidst large solar additions but decline as storage saturates and critical hours spread out in an energy constrained system
  - Significant decrease in 2030 as large amount of solar and storage are added to meet GHG reduction requirements (making the system over-reliable)*
  - Long-term value post 2035 driven by continued solar and wind capacity additions, load shape changes, and increasing winter loss of load risk
  - Even 100-hr storage shows a significant decline in marginal ELCC in 2035 driven by multiple days of critical energy need, charging constraints, and low round-trip efficiency
- DR follows storage trends due to its energy duration limitations



2035 ELCC Values for diurnal storage are 10-20%

California Public Utilities Commission

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* This 2030 marginal ELCC is lower than an incremental ELCC study focused only on meeting RA needs would be (since this portfolio built more storage than needed for RA due to binding GHG constraints).

Resource Adequacy: Desert Southwest

https://www.ethree.com/ra-sw/

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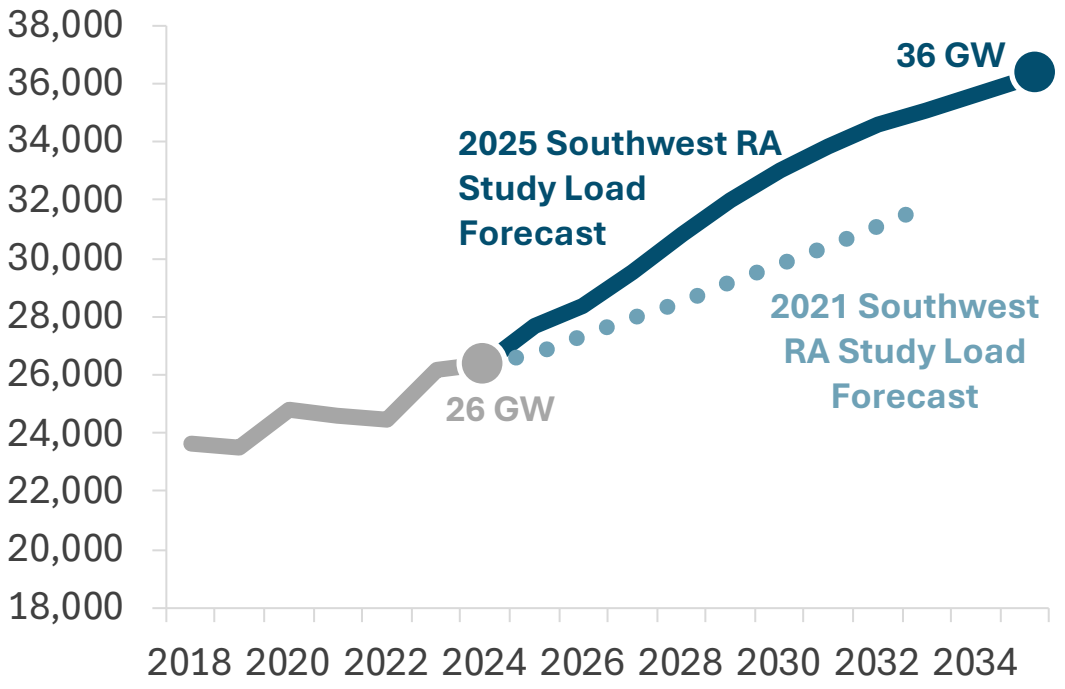
DSW: Rapid load growth and more extreme weather are leading to the need for more resources in the DSW region

1. **Load growth is accelerating mainly due to new large load customers**

2. **More extreme summer heat events require a higher planning reserve margin to maintain reliability**

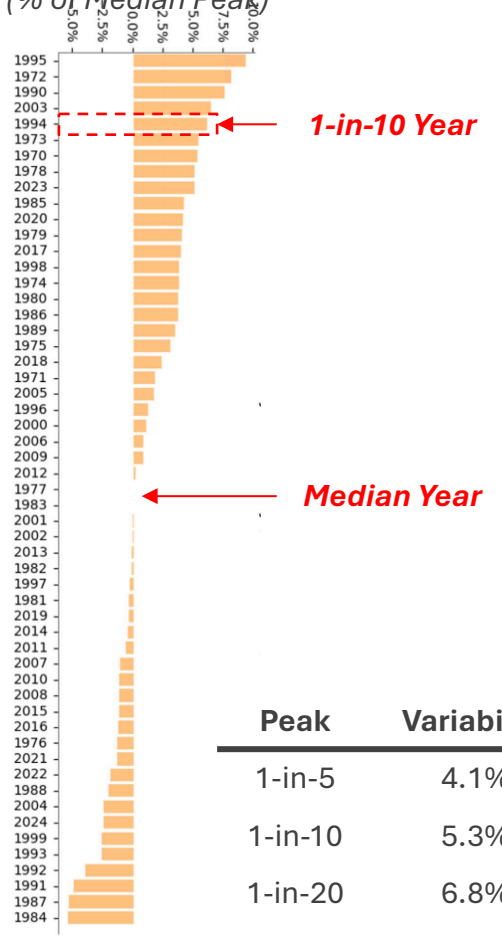
(1) Regional Coincident Peak Demand (MW)



Load forecast assumptions used in Phase 1 analysis are based on projections provided by utilities in 2025 Q1 and may no longer align with most recent utility forecasts. In general, utilities across the region have signaled expectations that updated forecasts will be higher than previous assumptions due to increased large customer growth.

(2) Weather Year Variability

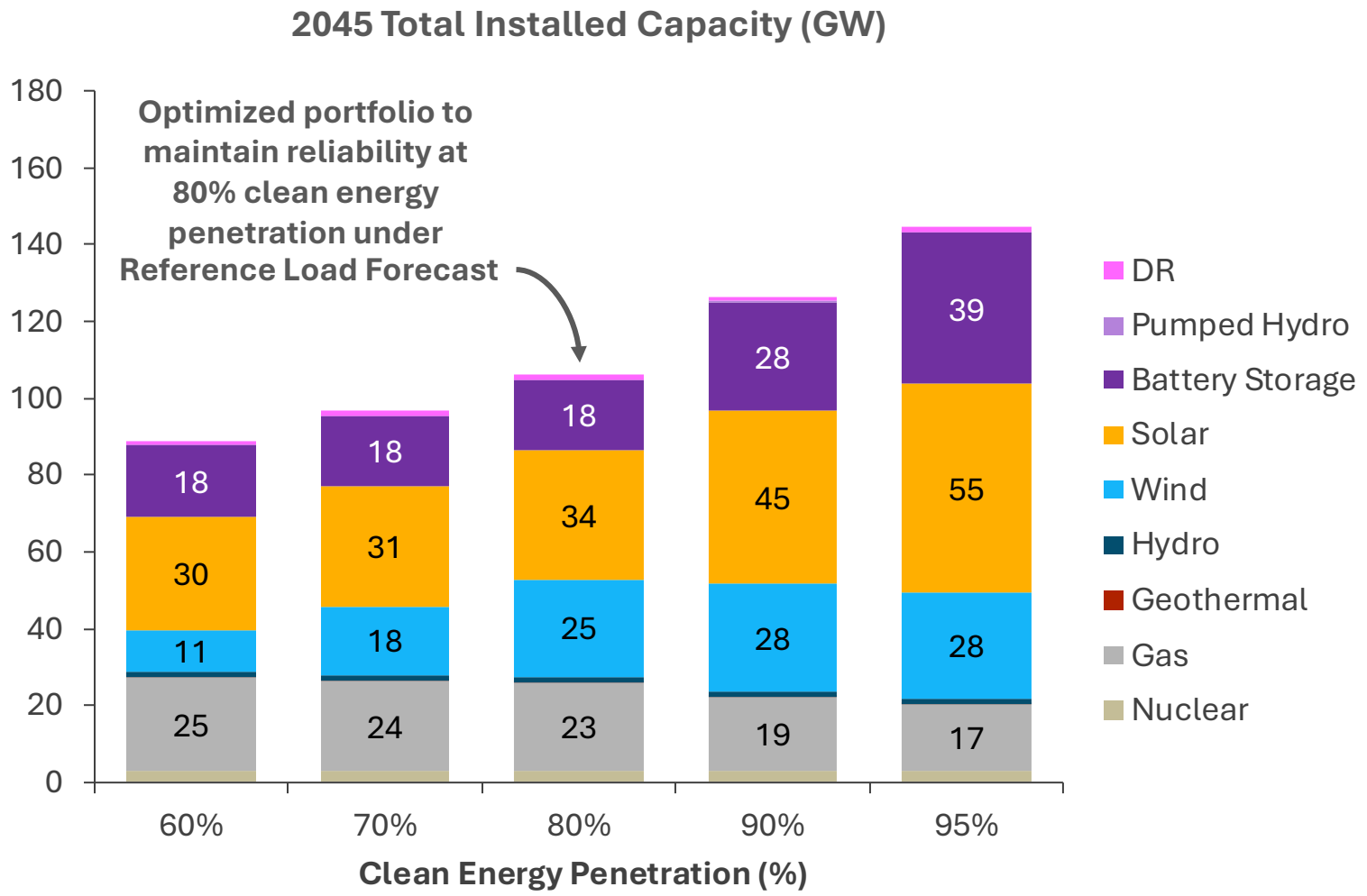
(% of Median Peak)



Peak	Variability
1-in-5	4.1%
1-in-10	5.3%
1-in-20	6.8%

DSW: Maintaining Resource Adequacy Requires a Diverse Portfolio of Renewables, Storage, and Firm Resources

- **Across all levels of clean energy studied, reliable portfolios in 2045 include a diverse mix of firm, renewable, and storage resources**
  - Wind and solar serve large portions of load when available
  - Storage shifts significant solar surplus from day to night
  - Natural gas and nuclear provide firm capacity around the clock



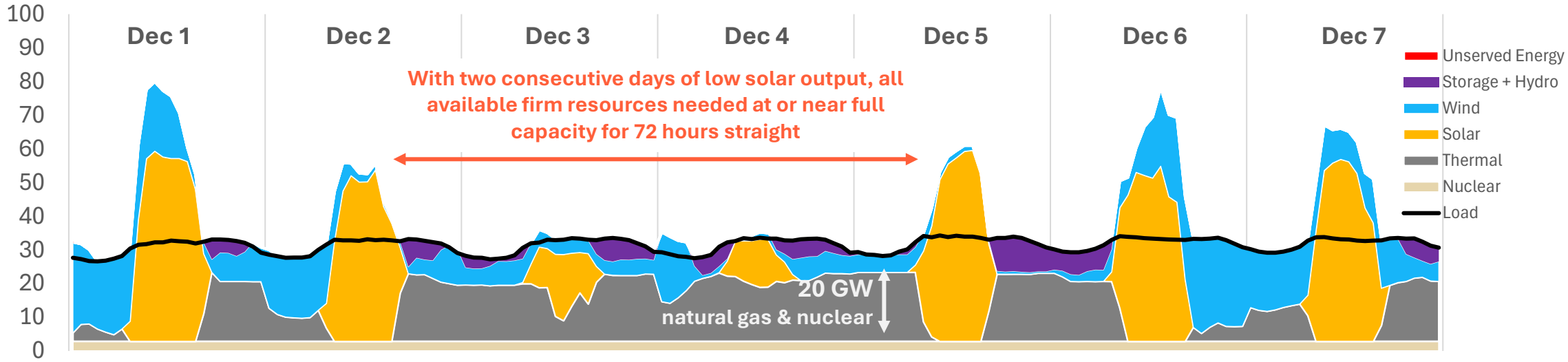
DSW: Firm Resources Essential to Reliability during Periods of Low Renewable Output

- Even at very high penetration of renewables and storage, there are extended periods during which they are not available
- During these extended periods – which may last days – firm resources that can operate at full capacity without limits on duration are essential to maintaining reliability

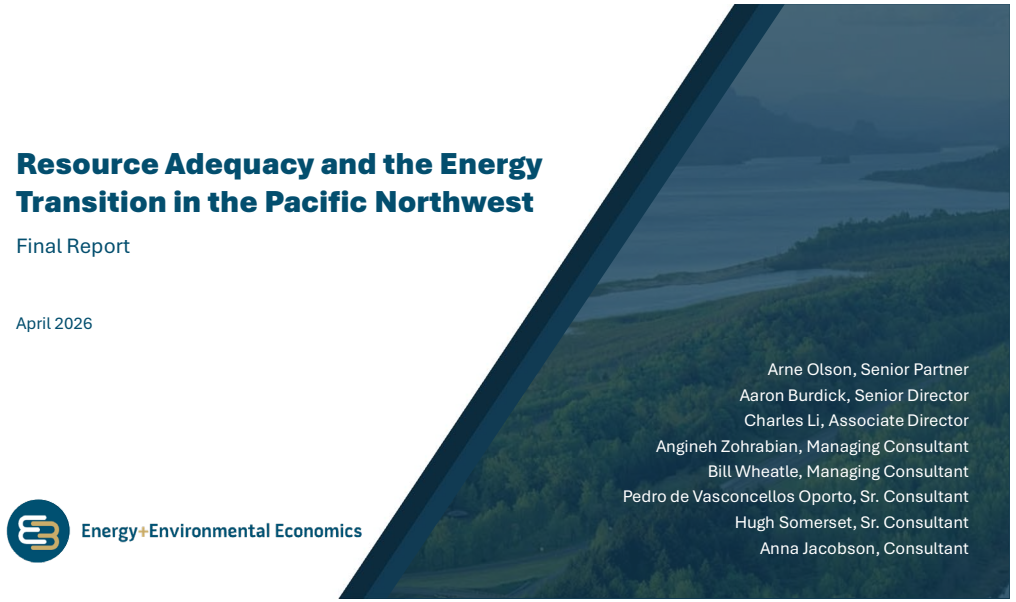
2045 Challenging Winter Week

95% Clean Energy Penetration, High Load

Dec 1 to Dec 7, 2011 Weather Conditions



Resource Adequacy: Pacific Northwest



https://www.ethree.com/ra-pnw/

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PNW: Greater Northwest region faces a resource shortfall of 9 GW in 2030 growing to 14-18 GW by 2035

Greater Northwest Load and Resource Balance

Effective Capacity (ELCC) MW

	2025	2026	2027	2028	2029	2030
Total Resource Need*	49,245	50,737	52,499	54,184	55,879	57,195
Existing Portfolio w/ Retirements	46,716	45,666	45,395	45,388	45,098	44,757
Firm Imports	3,750	3,750	3,750	3,750	3,750	3,750
Reliability Position Surplus (+) / Shortfall (-)	**+1,221**	**-1,321**	**-3,354**	**-5,046**	**-7,031**	**-8,689**
ELCC from "In-Development"** Firm Resources	-	296	407	580	770	1,114
ELCC from "In-Development" Wind, Solar and Battery projects	-	645	1,015	1,316	1,508	1,934

Available resources includes firm imports from other regions

The region faces a power supply shortfall starting in 2026 that grows to almost 9 GW by 2030

In development resources amount to only 3 GW of effective capacity, leaving 6 GW shortfall

** Total Resource Need includes median peak load + 9% PCAP planning reserve margin as well as obligation to serve the Columbia River Treaty Regime*

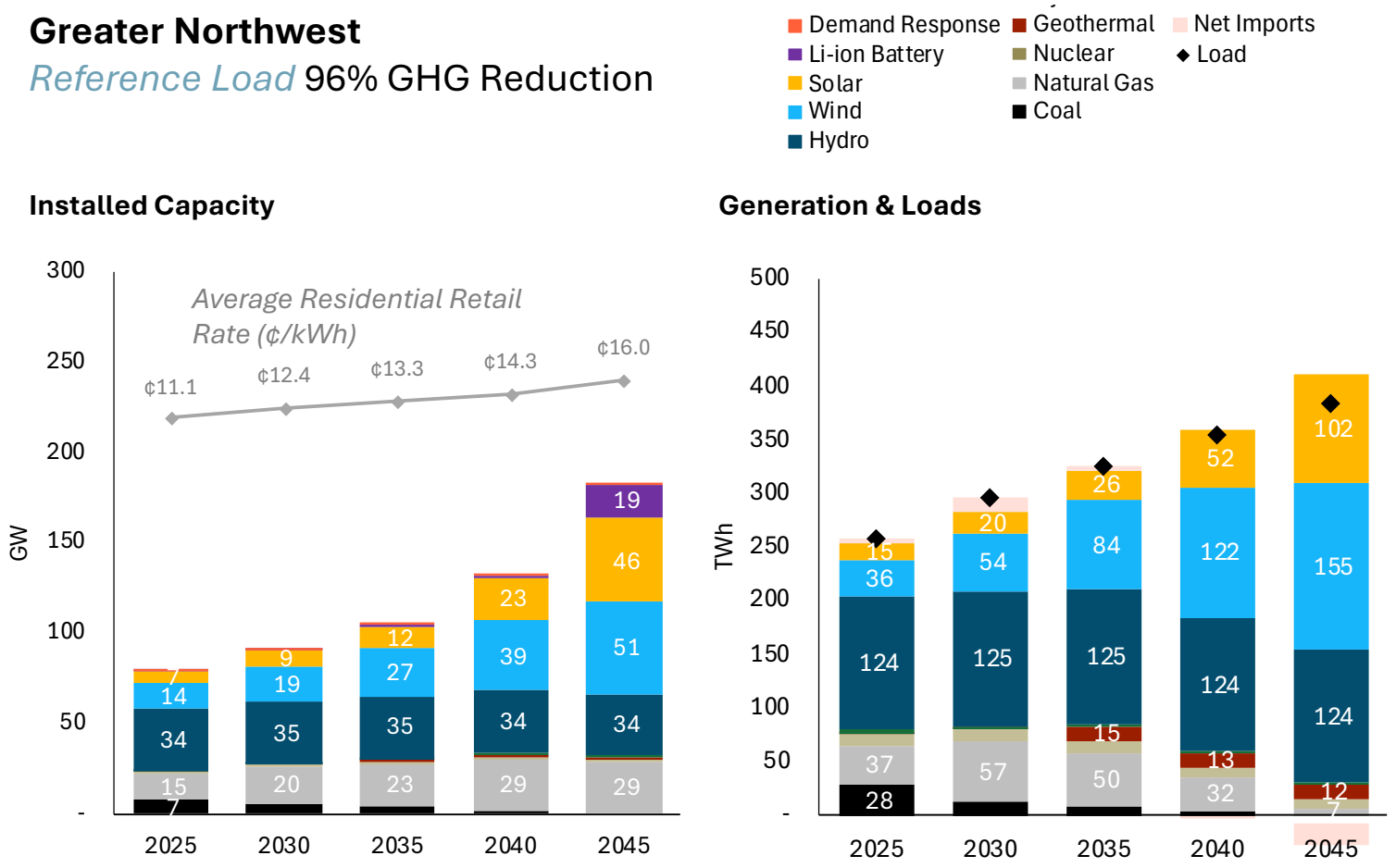
*** In-development resources are based on WECC ADS 2034 facilities with confirmed project location, project name, or can be verified online*

**** Centralia unit 2's repower from coal to gas was not in the WECC ADS data source and is not included here; it would bring down the shortfall by ~700 MW in 2029 and 2030*

PNW: Northwest can achieve deep carbon reductions by investing in a portfolio of energy efficiency, wind, solar, and natural gas

Greater Northwest

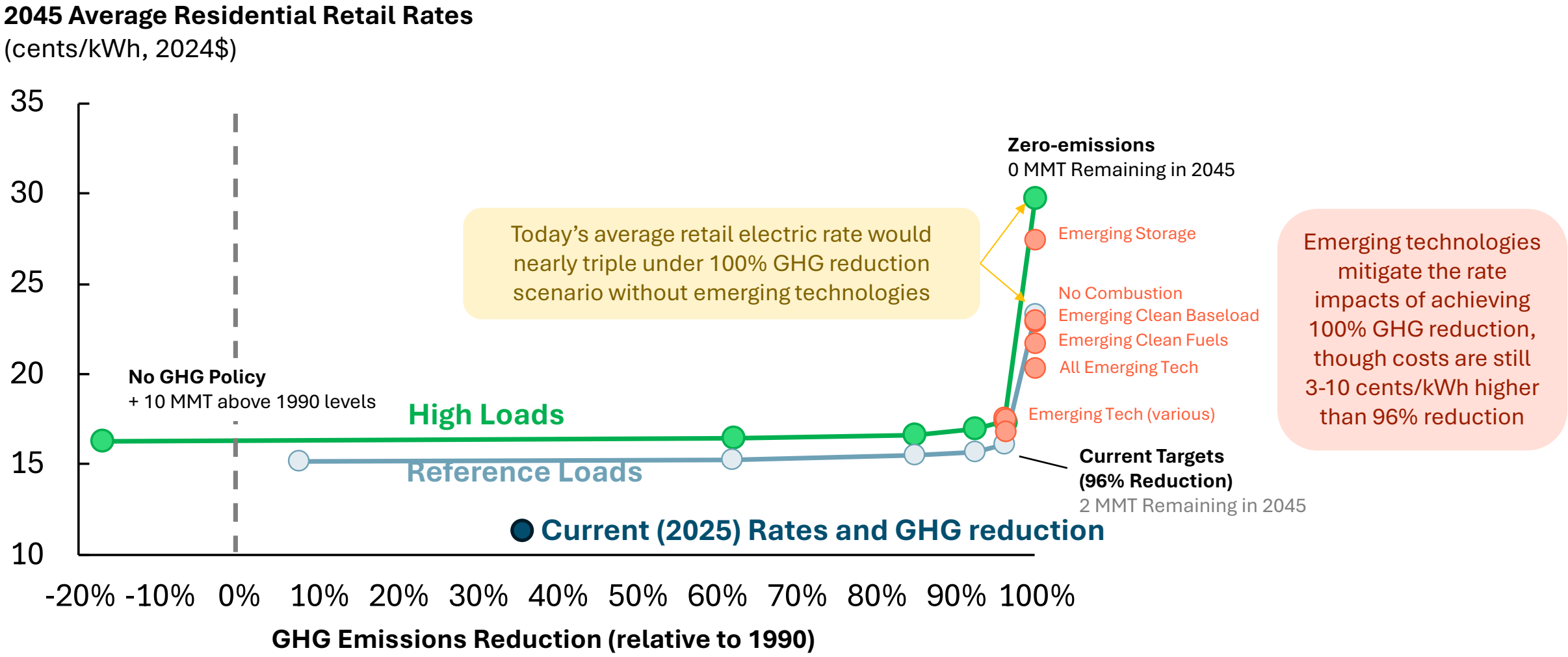
Reference Load 96% GHG Reduction



+ **Large increase in wind, solar, and gas is needed by 2035 to meet growing load and reduce emissions :**
  - 13+ GW Wind
  - 5+ GW Solar
  - 8+ GW Natural Gas
+ **Storage selected, but not until 2040's, when RA value and renewable integration values increase**
+ **Natural gas capacity is added as the reliability backstop, but additions of renewable generation reduce gas capacity factor over time**
+ **Costs increase to serve new loads, but costs to achieve 96% GHG reduction is only slightly higher than cases with uncapped emissions**

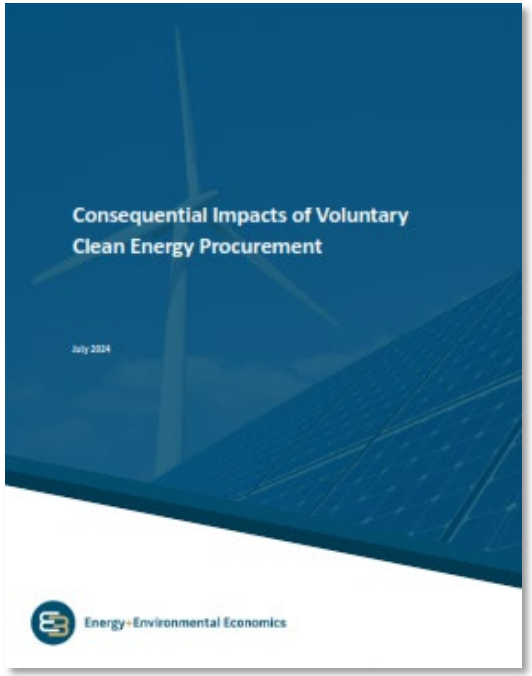
- Rate impacts shown in real 2024$ terms; some utilities may see significantly different impacts than these regional values
- Policies are modeled at least-cost, achieved on a regional basis
- Generation exceeds loads in years where the Greater Northwest is a net energy exporter

PNW: Achieving absolute zero carbon emissions is unaffordable without emerging clean firm technologies



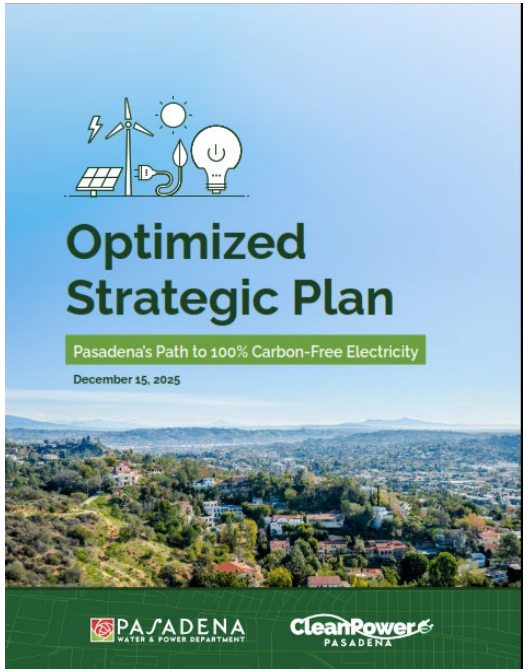
- Note: Emerging technologies are explored only in High Loads Scenario

GHG Protocol Scope 2 Accounting



24x7 Study partially funded by Meta:

https://www.ethree.com/meta-voluntary-clean-energy/



Pasadena Water & Power Optimized Strategic Plan:

https://www.ethree.com/pasadena-carbon-free/

The push for “24x7” clean energy accounting

- **The Greenhouse Gas Protocol is re-evaluating its methods for “Scope 2” clean energy and carbon accounting for corporate disclosure**
- **Some advocates, academics, and large tech companies such as Google and Microsoft have been pushing for mandatory hourly or “24x7” matching**
- **Multiple arguments are put forward:**
  - “Annual matching” does not achieve “consequential” carbon emissions reductions because there will be too many free RECs available in the market
  - 24x7 matching will help transform the market for “clean firm” technologies

Joule

CellPress

Available online 11 January 2024

In Press, Corrected Proof What's this?

Article

System-level impacts of voluntary carbon-free electricity procurement strategies

Qingyu Xu [1 2 4], Wilson Ricks [2 4], Aneesha Manocha [2], Neha Patankar [3], Jesse D. Jenkins [2 5]

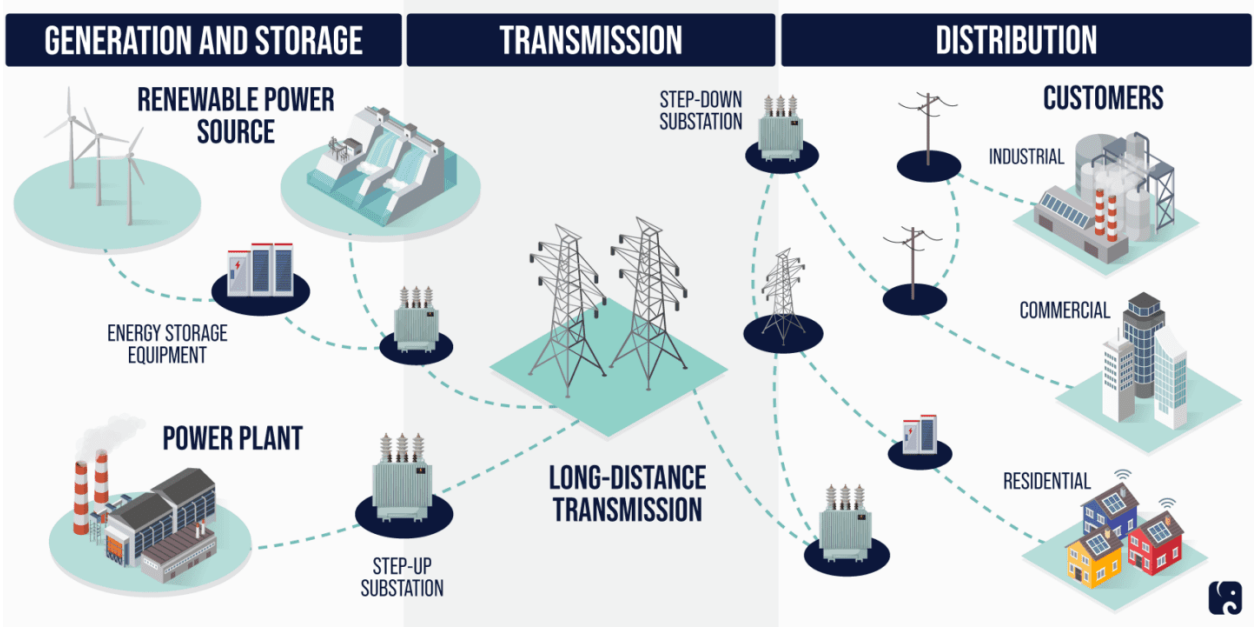
Specified energy purchases are a convenient fiction

+ Specified energy does not physically serve load on a networked power system

- Generators inject into the grid in one location, displacing other generators with higher operating costs
- Loads withdraw from the grid in another location, served by a mix of generators on the system

+ This fiction is important!

- Billions of dollars have been invested based on the notion that electric load can be served with specified clean energy supplies
- Since 1995, 243 GW of wind and solar capacity has been added to the U.S. grid(s), representing approximately $500 billion dollars of capital deployed



https://www.rpc.senate.gov/policy-papers/infrastructure-cybersecurity-the-us-electric-grid

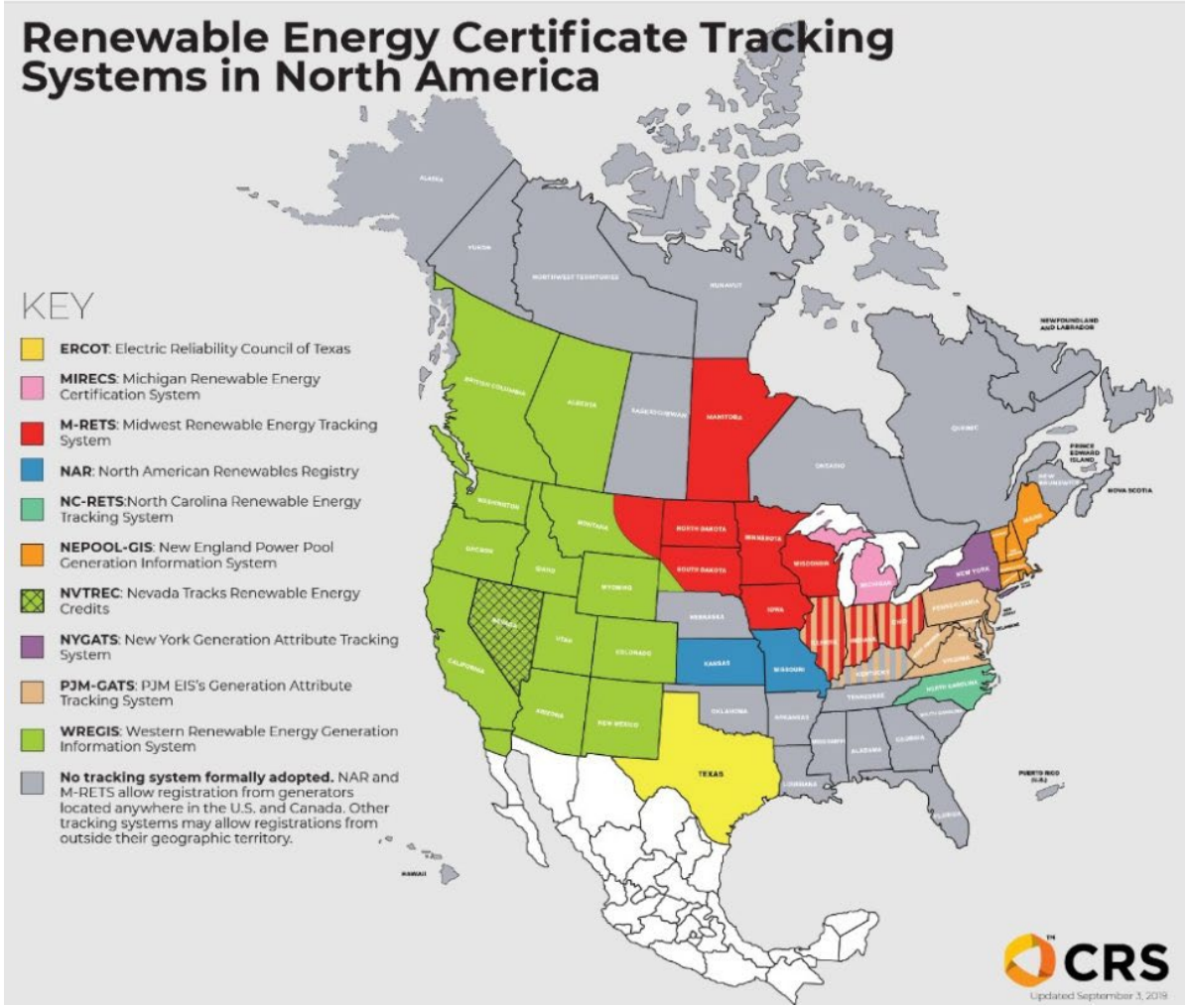
RECs are needed to implement demand-pull clean energy policies

Clean Energy Content Verification

- A mechanism is needed to verify the clean energy content of energy purchases
- The creation, trade, and retirement of RECs are verified and tracked by independent organizations to ensure no double-counting of renewable attributes across jurisdictions

Portfolio Balancing

- REC trading enhances efficiency by providing a tool for portfolio balancing and a visible price signal
- REC trading is an important tool for voluntary clean energy purchasers, who may not have the means to balance their load with their own supply

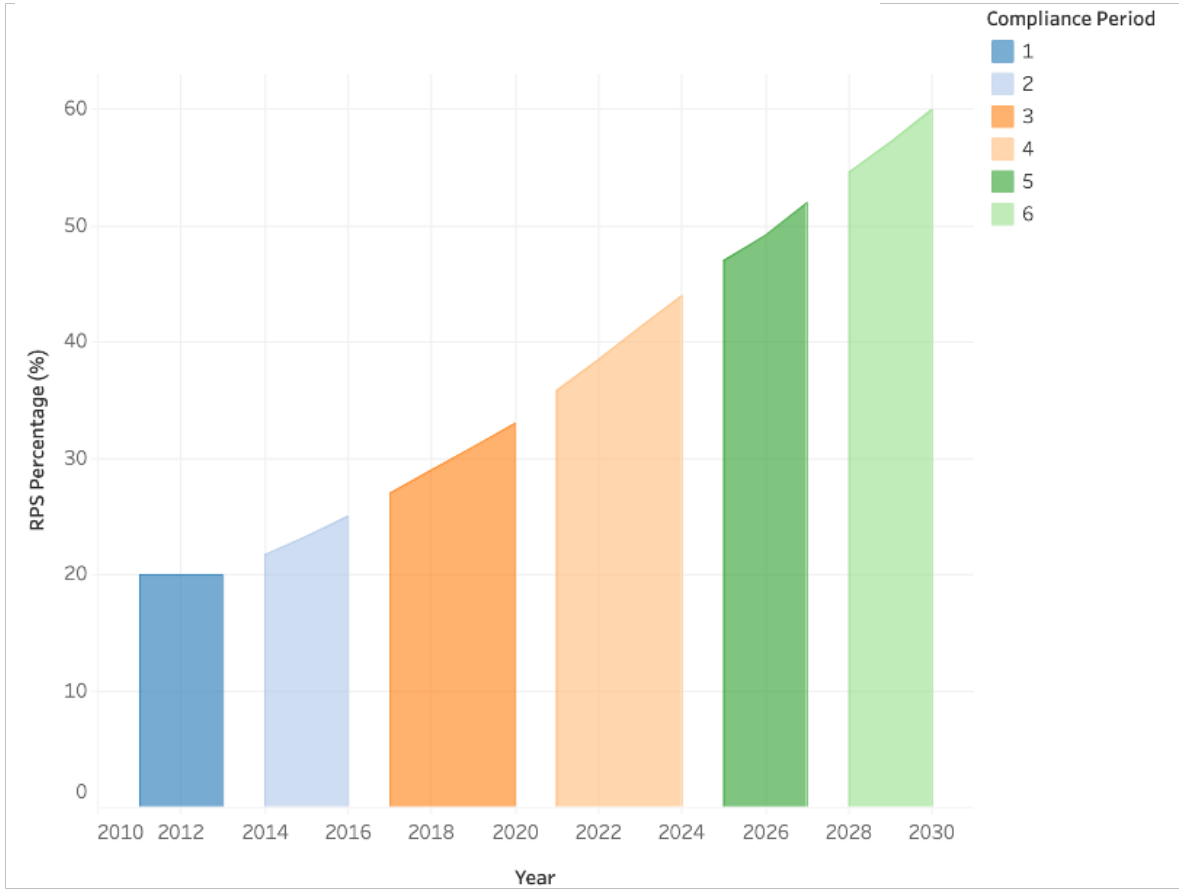


All state clean energy programs have annual or multi-year compliance periods

+ **Balancing over shorter time periods is very challenging**
  - Both load and clean energy production are uncertain and variable

+ **This flexibility reduces RPS compliance costs and is a feature of all RPS programs across US, including CA, ME, MD, IL, WA and others**

Multi-Year Compliance Periods in the California RPS Program



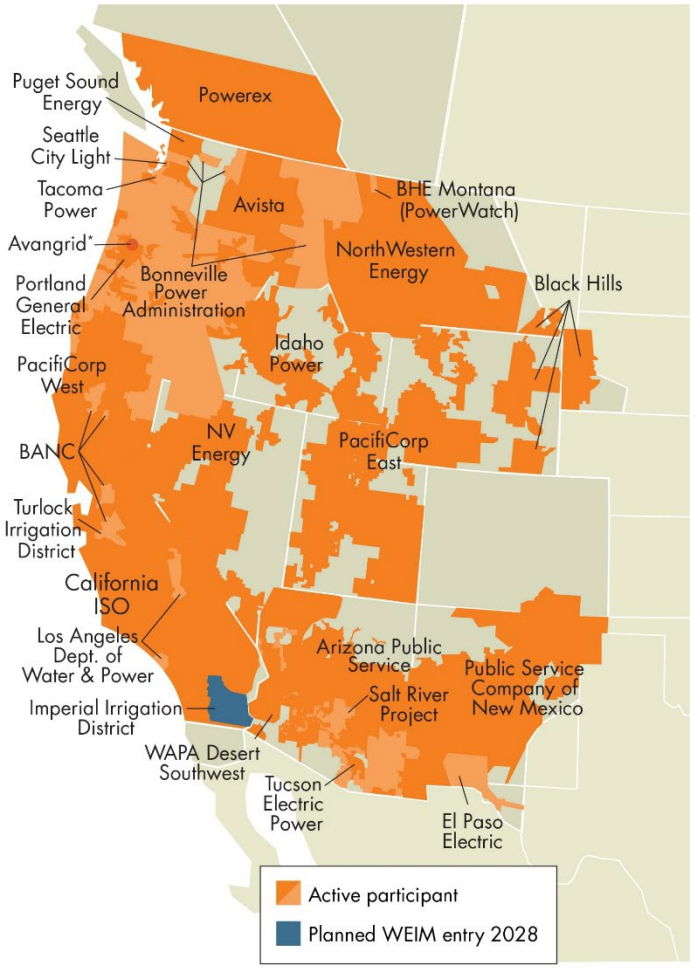
Source: California Public Utilities Commission

24x7 matching negates the benefits of organized wholesale electricity markets

+ Balancing on a market-wide basis creates efficiencies that benefit all market participants

+ Organized markets such as CAISO have facilitated low-cost integration of large quantities of clean energy

+ 24x7 matching in effect requires LSEs to become "electrical islands", forgoing the benefits of wholesale electricity markets



*Avangrid office; generation only BAA with distribution across multiple states.
Map boundaries are approximate and for illustrative purposes only.
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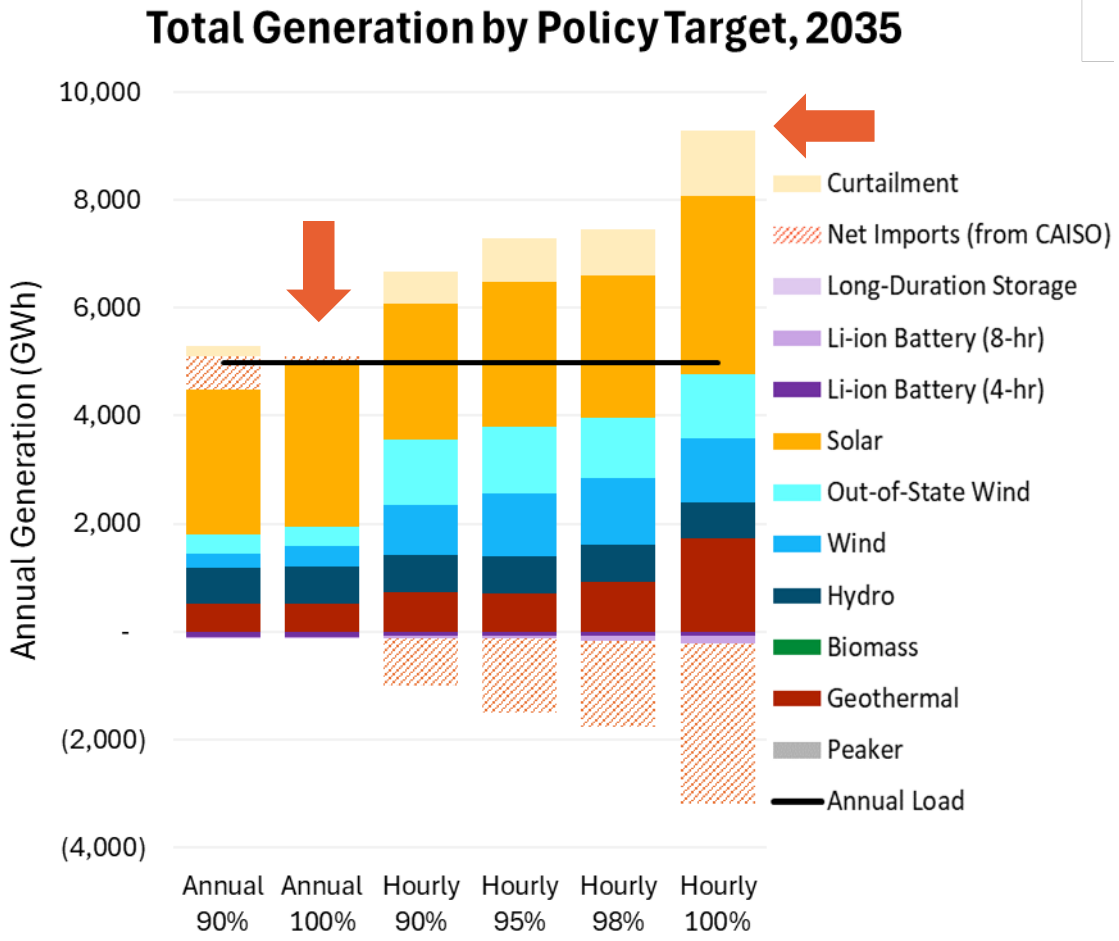
E3 study for SVCE demonstrates that 24x7 matching requires "over-procurement" of 181%

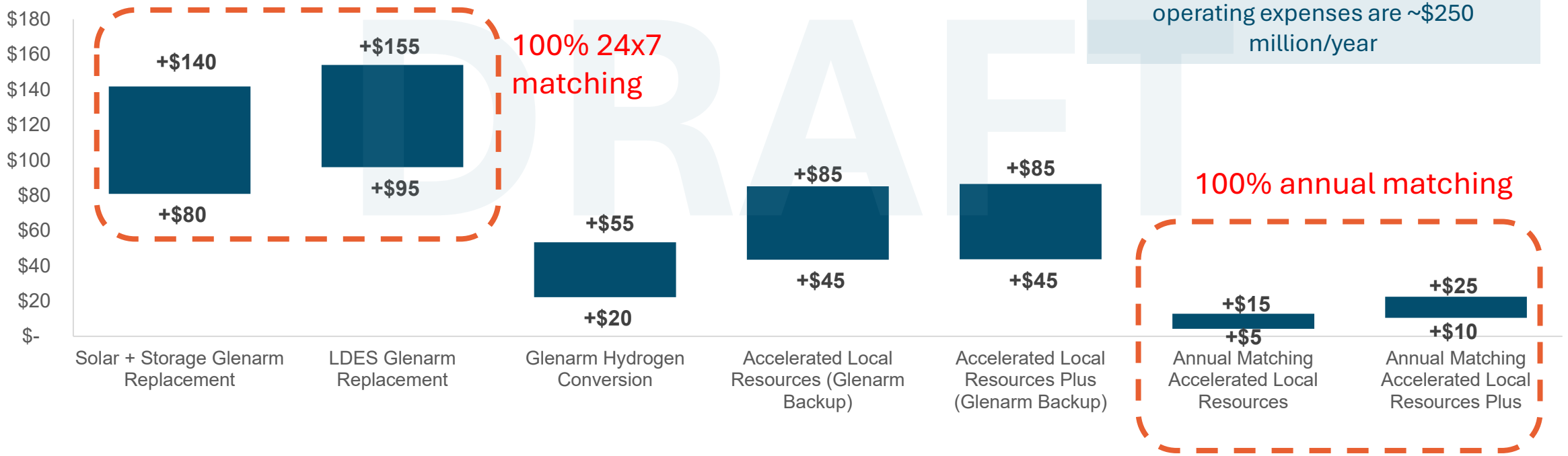
- Under "Net zero" or "100% annual matching", SVCE-contracted resources produce clean energy equal to 100% of annual need
- Under "Absolute zero" or "100% hourly matching", SVCE must procure energy equal to 181% of their annual need
- Annual and hourly matching achieve similar levels of carbon abatement



E3 study for Pasadena Water & Power found that 24x7 matching would increase electric rates by 30-60%

	Portfolios Designed to Meet 100% of *Hourly* Needs (Glenarm Replaced/Converted, No Market Purchases)			Portfolios Designed to Meet 100% of *Hourly* Needs (Glenarm Backup, No Market Purchases)		Portfolios Designed to Meet 100% of *Annual* Needs (Limited Glenarm Ops & Market Purchases)	
Metric 1	167%	183%	127%	170%	171%	108%	108%
Metric 2	100%	100%	100%	100%	100%	96%	96%
Metric 3	100%	100%	100%	100%	100%	94%	95%

2031 Relative Incremental Total System Cost
($ million per year)



Note: PWP's current power fund operating expenses are ~$250 million/year

DRAFT

Note: Incremental cost measured relative to a "least-cost" portfolio designed to meet 100% of Pasadena's annual energy needs with carbon-free resources

Thank you!

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