

Supply and Demand in the Western Interconnection: The Impact of Climate and Climate Policy

Law Seminars International
Electric Power in the West
Seattle, Washington
January 26, 2023



Energy+Environmental Economics

Arne Olson, Senior Partner



Agenda

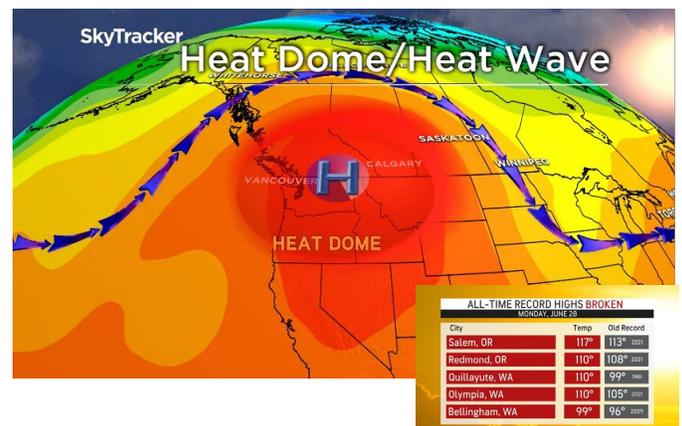
- 1. A changing climate and related policy are driving significant increases in the need for energy infrastructure**
- 2. Supply-demand balance is precarious throughout the West**
- 3. Maintaining reliability during the transition will require some difficult decisions**

1. A changing climate and related policy are driving significant increases in the need for energy infrastructure



Extreme heat events are causing much higher summer loads

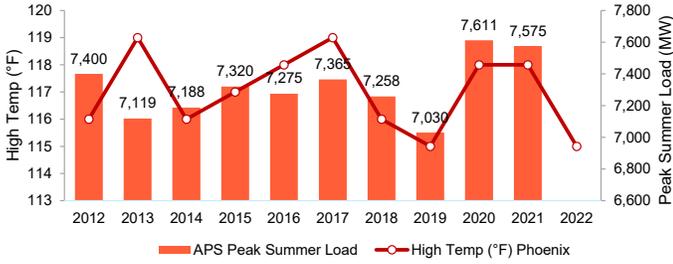
- Many utilities in the Northwest set new summertime **PEAK DEMAND RECORDS** during heat dome event on June 29-30, 2021
- Summertime peaks are now approaching or **EXCEEDING WINTER PEAKS** across the region
- Higher summer peaks **CREATE CHALLENGES** across generation, transmission and distribution systems



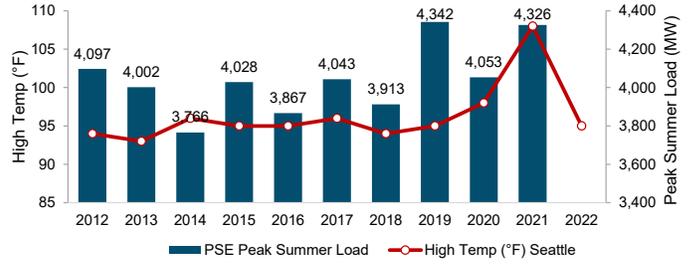


Summer High Temp and Peak Load by Service Territory Selected WECC Utilities

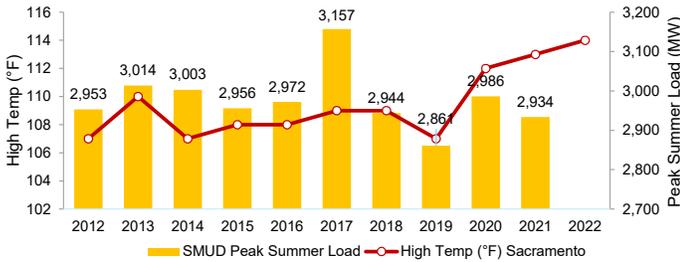
Phoenix (Arizona Public Service)



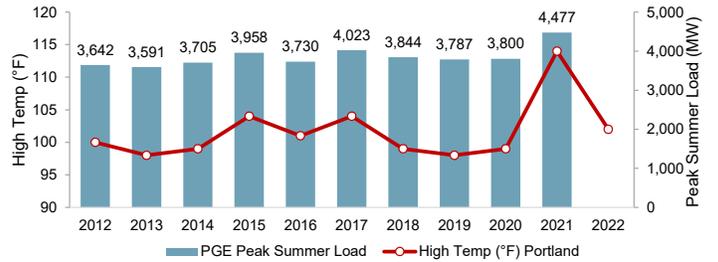
Seattle (Puget Sound Energy)



Sacramento (SMUD)



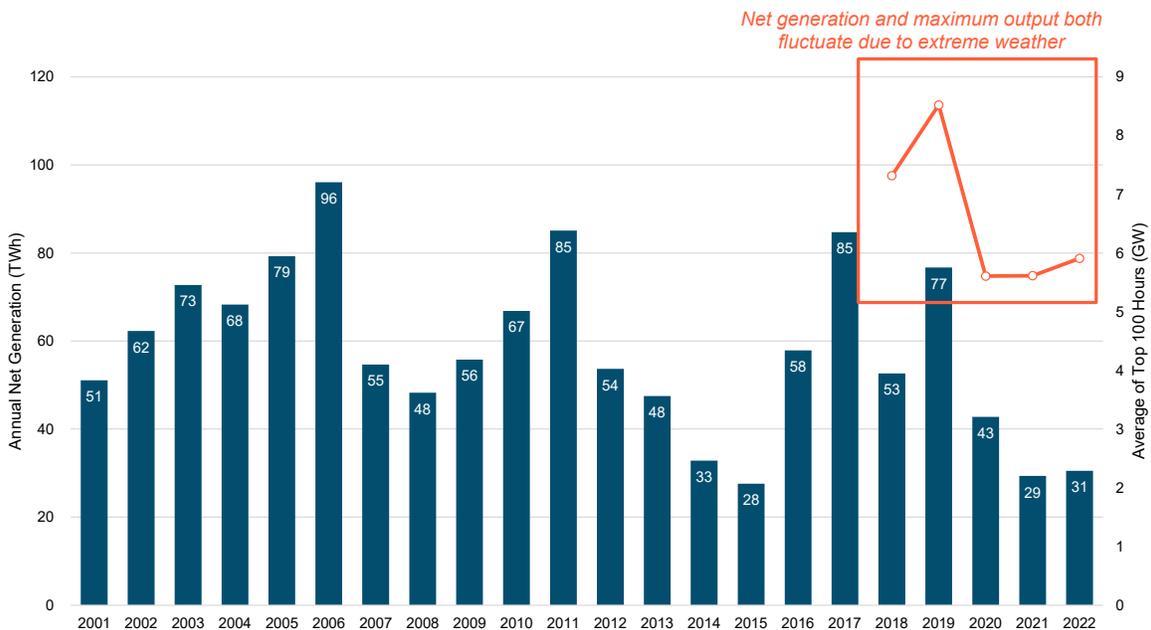
Portland (Portland General Electric)



Source: Temperature data: NOAA. Peak load: SNL (S&P Market Intelligence).



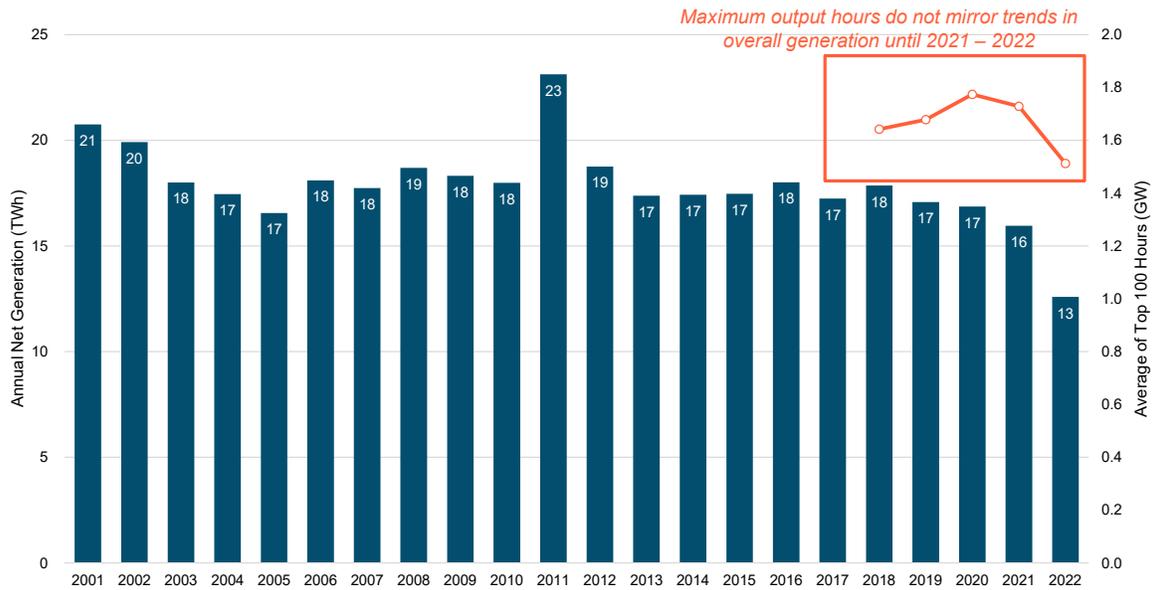
Hydro Production California



Source: EIA. [Link here](#) for hourly data and [here](#) for annual data.



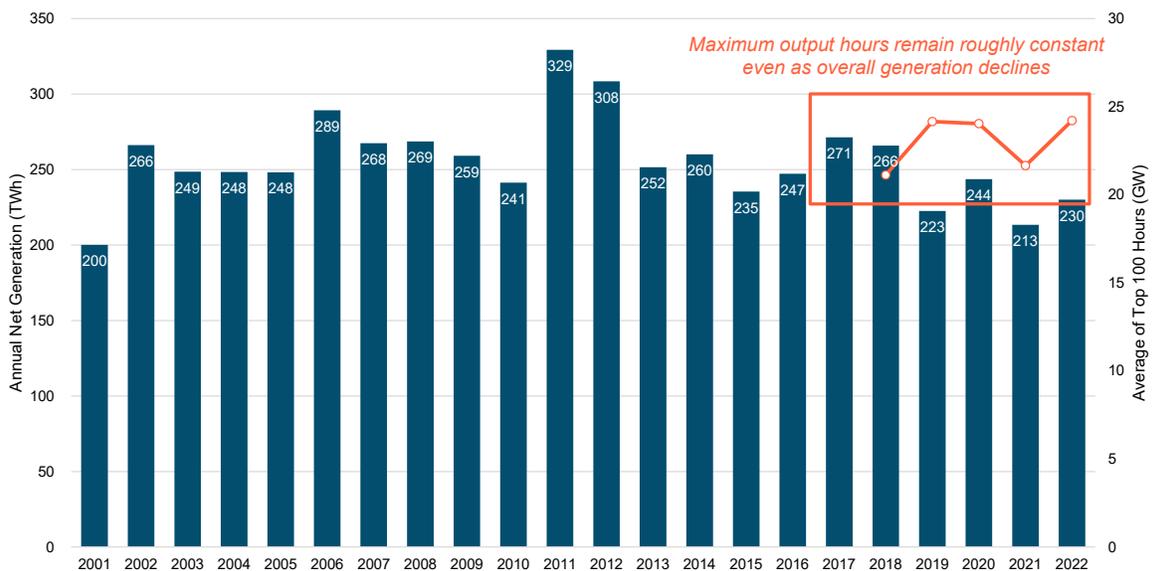
Hydro Production Southwest



Source: EIA. [Link here](#) for hourly data and [here](#) for annual data.



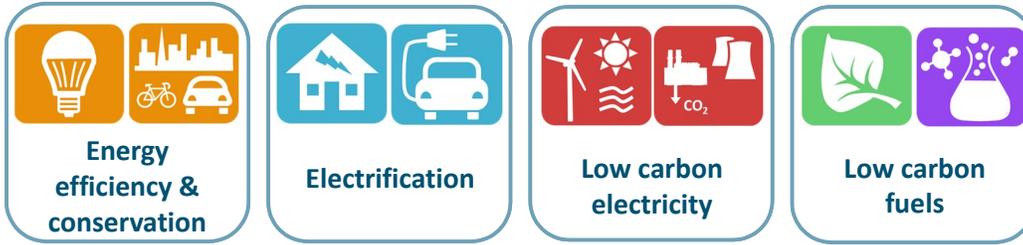
Hydro Production U.S. Northwest



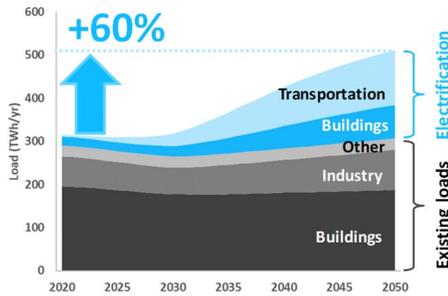
Source: EIA. [Link here](#) for hourly data and [here](#) for annual data.



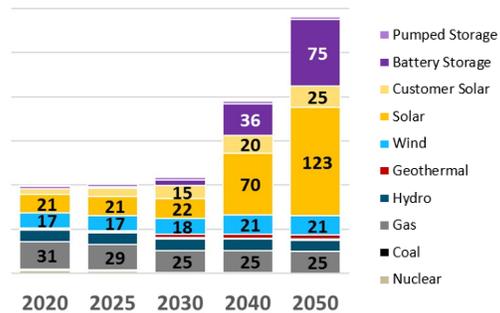
“Four Pillars” of decarbonization point to the crucial role of the electricity sector



California Electric Loads under Deep Carbon Reductions



California Electric Resources under Deep Carbon Reductions



Clean electricity displaces fossil fuels as the main source of primary energy

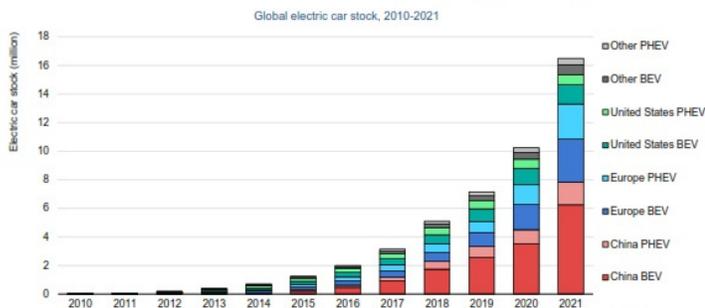


Adoption of light duty electric vehicles is accelerating rapidly

- Vehicle charging load will become noticeable in the **NEXT FEW YEARS**
- Initial adoption likely to be concentrated in certain locations creating **DISTRIBUTION CHALLENGES**
- Utilities will need to be ready for **SMART CHARGING** rates, panel installations, charging stations, etc.



Over 16.5 million electric cars were on the road in 2021, a tripling in just three years

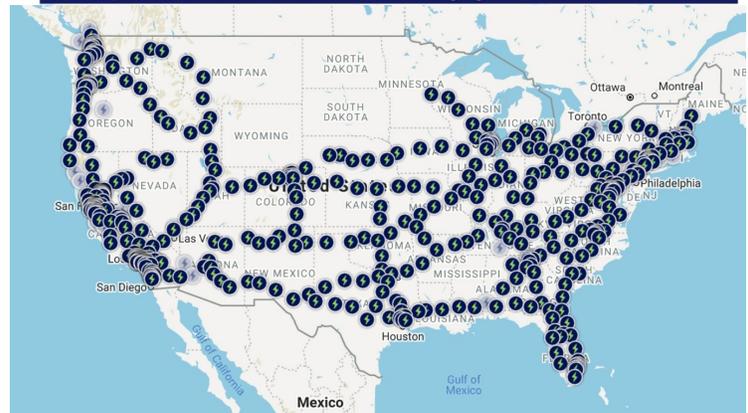


Notes: BEV = battery electric vehicle; PHEV = plug-in hybrid electric vehicle. Electric car stock in this figure refers to passenger light-duty vehicles. "Other" includes Australia, Brazil, Canada, Chile, India, Japan, Korea, Malaysia, Mexico, New Zealand, South Africa and Thailand. Europe in this figure includes the EU27, Norway, Iceland, Switzerland and United Kingdom.

Sources: IEA analysis based on country submissions, complemented by ACEA, CAAM, EAPO, EVVehicles, Marklines

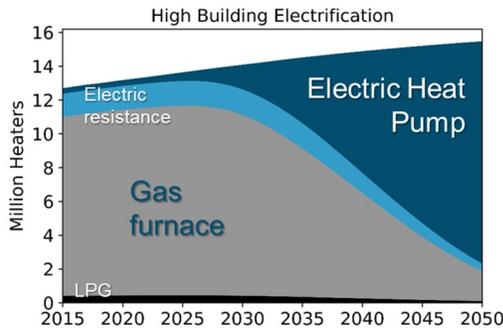
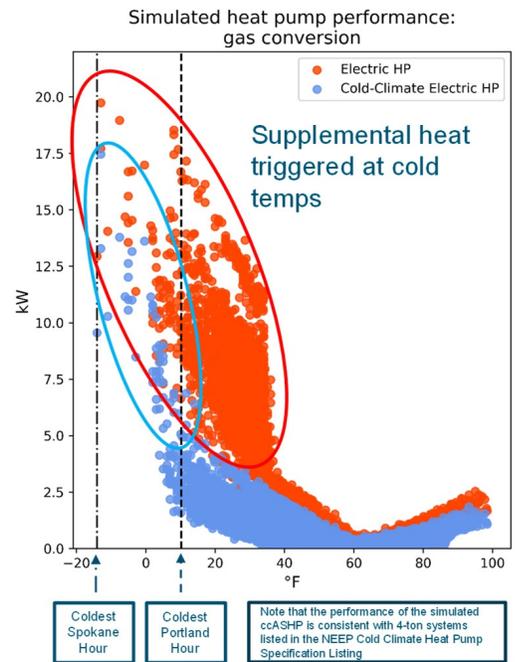
IEA. All rights reserved.

Electrify America – Nationwide DC Fast Charging Network



E3 Electric heat pumps will add significant electric load and will likely increase the need for gas during wintertime peaks

- Á State policy just beginning to encourage adoption of **ELECTRIC HEAT PUMP** technologies for residential and small commercial buildings
- Á Peak load may increase **AS MUCH AS 100%** in some areas due to heat pumps replacing gas or oil
- Á Most regions will need to meet electric peaks with **NEW GAS PEAKERS**, increasing peak day gas demand



E3 How to meet this new demand? COMMON FINDINGS FROM E3'S LONG-TERM PLANNING STUDIES

E3's work with utilities and regulators to develop long-term resource plans support three general findings:

1. Technologies available today can enable significant progress towards ambitious state and utility clean energy objectives
2. A technology-neutral approach to planning and procurement will enable utilities to meet reliability and clean energy goals most affordably
3. Some form of firm capacity is needed for reliability even under a deeply decarbonized grid

These findings are supported by a growing body of literature, including recent studies by the National Renewable Energy Laboratory (NREL), Princeton University, the Electric Power Research Institute (EPRI), and the Massachusetts Institute of Technology (MIT)

Blueprint for a Low Carbon Grid



Scalable Low-Cost Clean Energy Resources

Today: wind, solar
Future: nuclear SMR, CCS



Balancing Resources

Today: batteries, pumped storage, hydro, demand response
Future: advanced flexible loads, other storage technologies



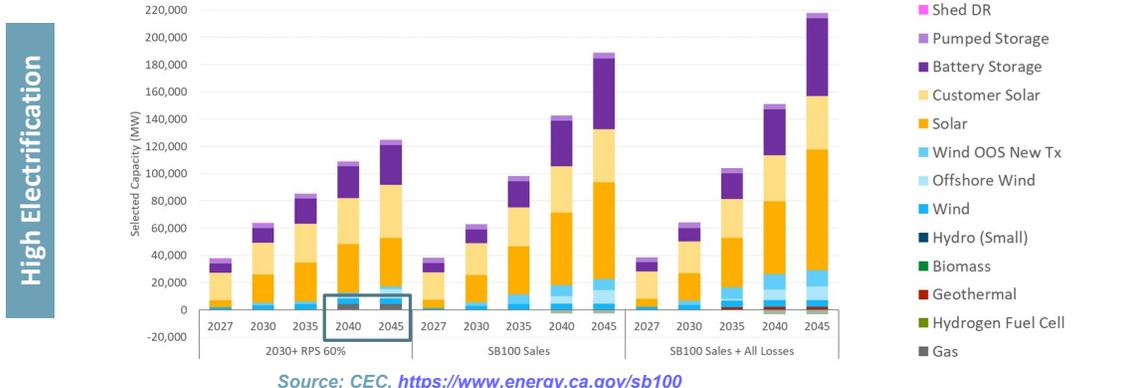
Firm Resources

Today: nuclear, natural gas, geothermal
Future: hydrogen, long-duration storage, nuclear SMR, CCS



California's SB 100 study calls for hundreds of GW of new wind, solar and batteries

- ^ **The primary scalable resource for meeting California's clean energy goals is solar power**
 - Requires supplementation with a significant quantity of battery storage
- ^ **Wind and geothermal help provide portfolio diversity but are limited in quantity**
 - Largest scalable wind resources are offshore and out-of-state
 - Enhanced geothermal is a promising emerging technology



Massive increases in clean resources will be needed to meet clean energy goals in the Pacific Northwest

- ^ **Utilities will need to procure wind and solar resources at an UNPRECEDENTED PACE**
- ^ **BATTERY STORAGE may be helpful for integration and resource adequacy**
- ^ **Retaining existing NUCLEAR and HYDRO reduces costs**

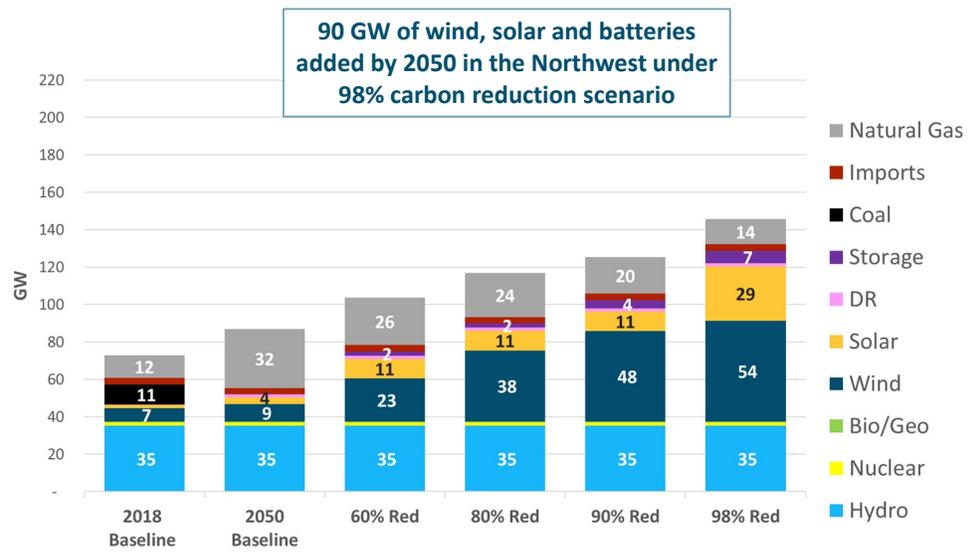


Image source: [Resource Adequacy in the Pacific Northwest](#) (Various utilities, 2019)

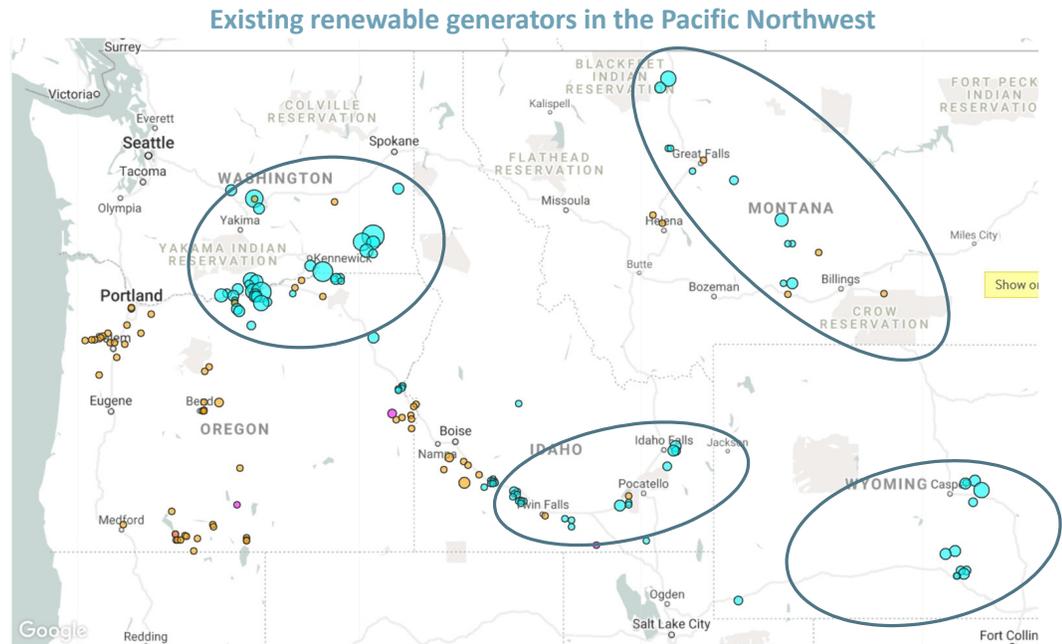
Transmission will be a significant challenge for clean energy procurement

Good renewable resources don't exist everywhere

- Wind in Columbia Gorge, eastern slope of Rockies, Snake River Plain
- Solar in eastern OR and WA, southern ID

Transmission access will be a key challenge

- BPA system is congested across the Cascades
- Lack of RTO means pancaked transmission charges for remote resources



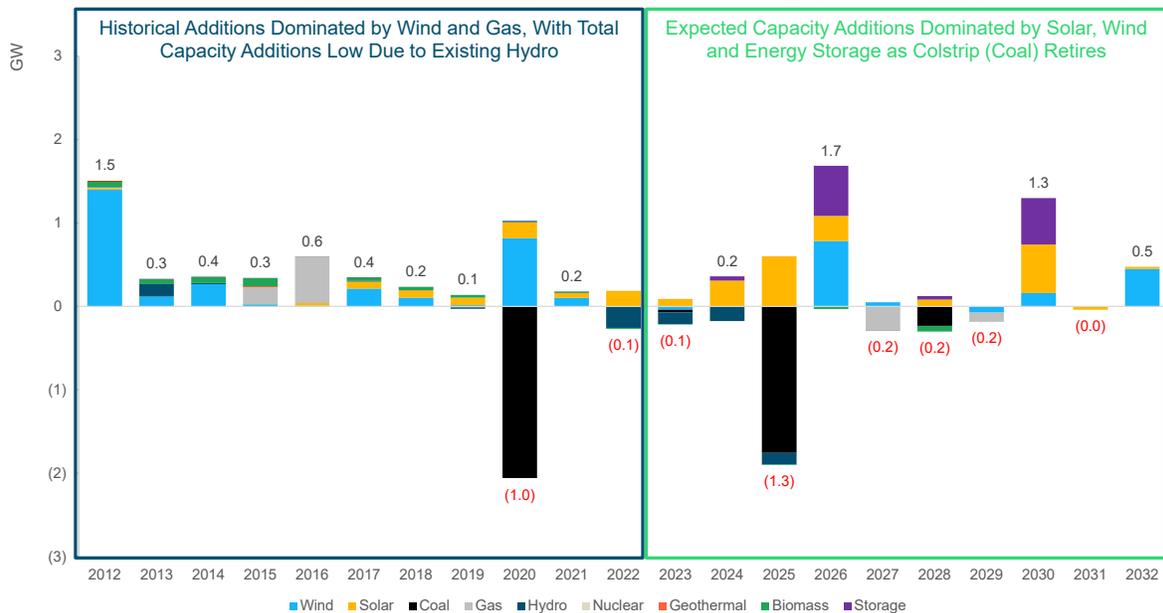
Supply-demand balance is precarious throughout the West

The Western Interconnection is facing immediate resource adequacy challenges

- ⚠ Increased frequency, severity and geographic extent of heat events
- ⚠ Continued retirement of firm resources across the region
- ⚠ Very little development of new firm resources in recent years
- ⚠ Resumption of peak load growth caused by more extreme weather, data centers, electric vehicles, etc.



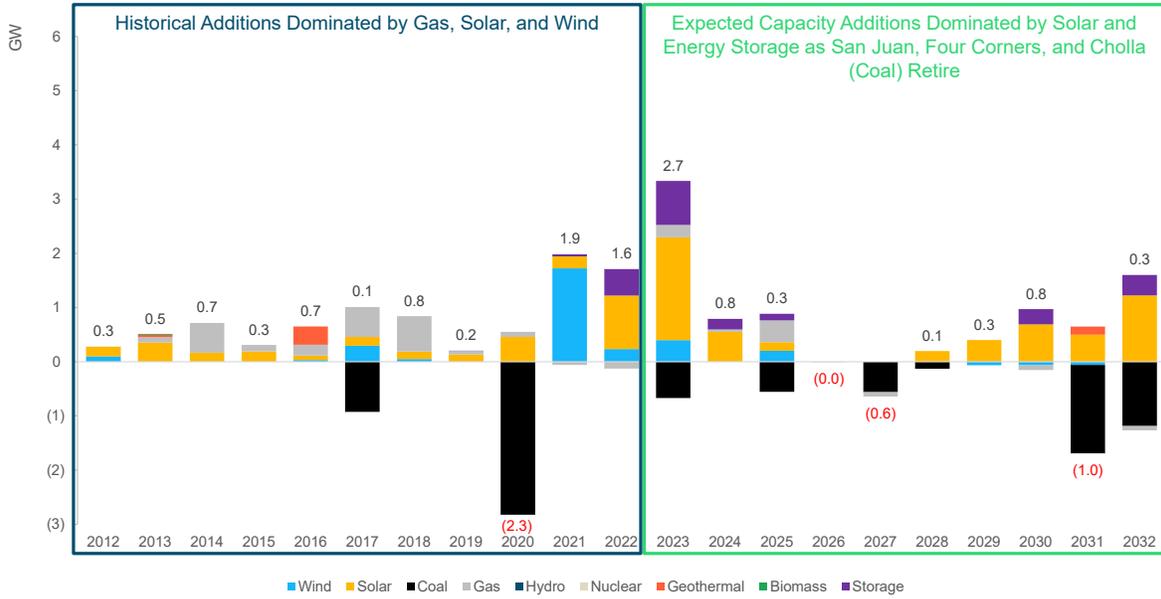
Northwest Capacity Additions and Retirements



Note: Captures WECC areas of BCHA, BPAT, NWMT, PACW, PGE, PSEI, SCL, WACO where data is disclosed.
 Source: 2022 WECC Western Assessment of Resource Adequacy. [Link here.](#)



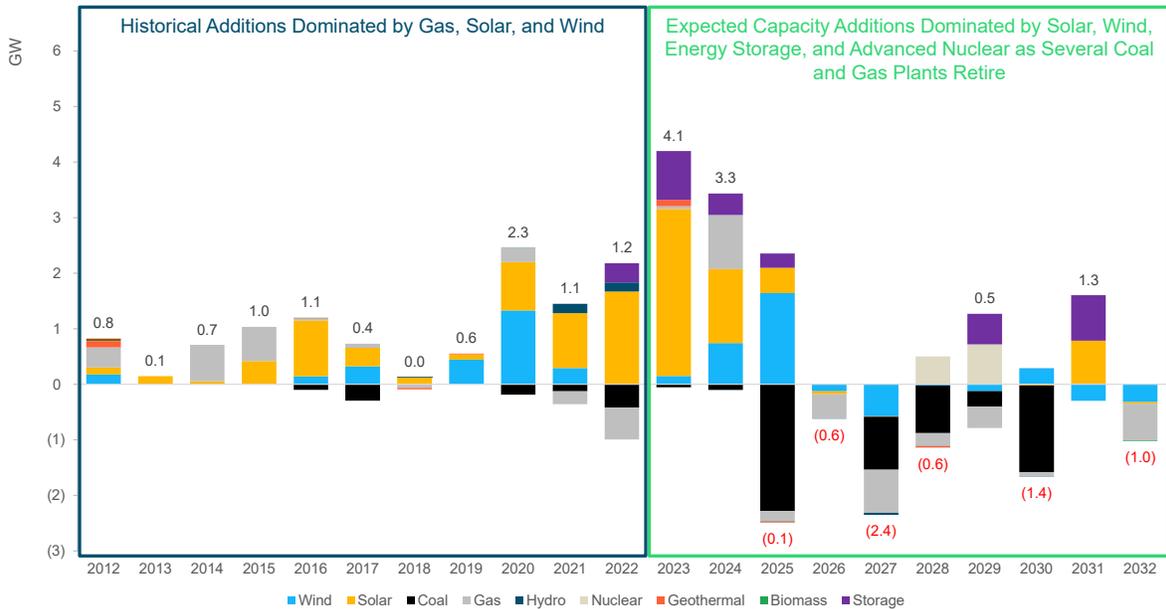
Southwest Capacity Additions and Retirements



Note: Captures WECC areas of AZPS, EPE, PNM, SRP, TEPC where data is disclosed.
 Source: 2022 WECC Western Assessment of Resource Adequacy. [Link here.](#)



WECC Capacity Additions and Retirements Rocky Mountain



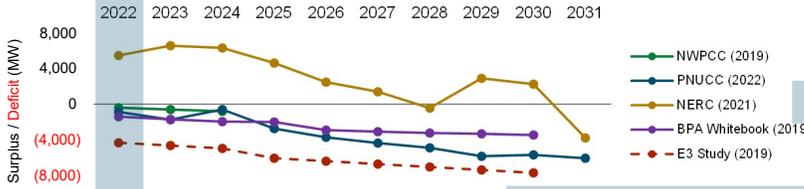
Note: Captures WECC areas of GRID, IPFE, NEVP, PAID, PAUT, PAWY, PSCO, SPPC where data is disclosed.
 Source: 2022 WECC Western Assessment of Resource Adequacy. [Link here.](#)



Northwest load-resource balance is short and getting shorter

By 2030, the region faces a significant need not adequately met by currently planned additions, which are themselves optimistic

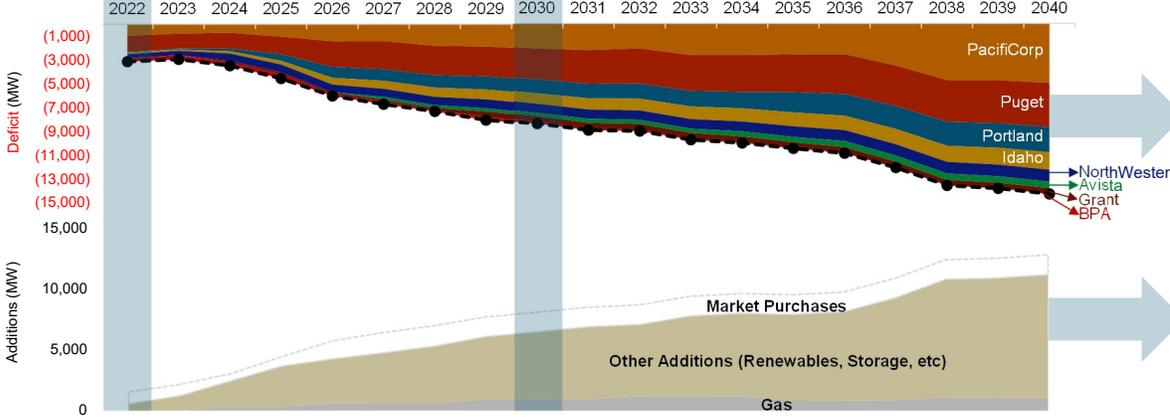
Regional Capacity Already Short for Reliability Planning Purposes, Top-Down or Bottom-Up



Top-Down Regional Assessments

3 – 8 GW capacity need by 2030, with different assumptions for capacity credit (especially hydro) driving differences in results

Bottom-Up Deficit of 1.5 – 2 GW in 2030 After Planned Additions



Bottom-Up Utility IRP Review

8.4 GW capacity need by 2030 before planned additions; PacifiCorp and Puget Sound Energy have the greatest need

IRP Planned Additions

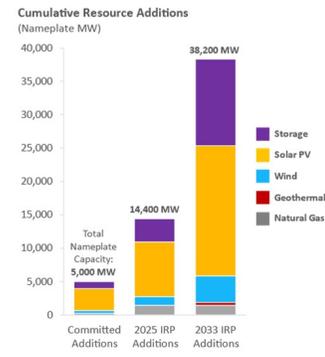
~6.5 GW effective capacity additions by 2030 (up to ~14 GW nameplate capacity), significantly exceeding average capacity expansion rate for 2010-2020 (~1 GW/year)

Energy Environmental Economics Note: E3 top-down assessment utilizes RECAP modeling results from E3's 2019 study [Resource Adequacy in the Pacific Northwest](#). E3 study further shapes the annual capacity need based on proposed coal retirements schedules (as of Oct 2019). E3's capacity deficit does not include any planned additions. Bottom-Up Deficit excludes market purchases.

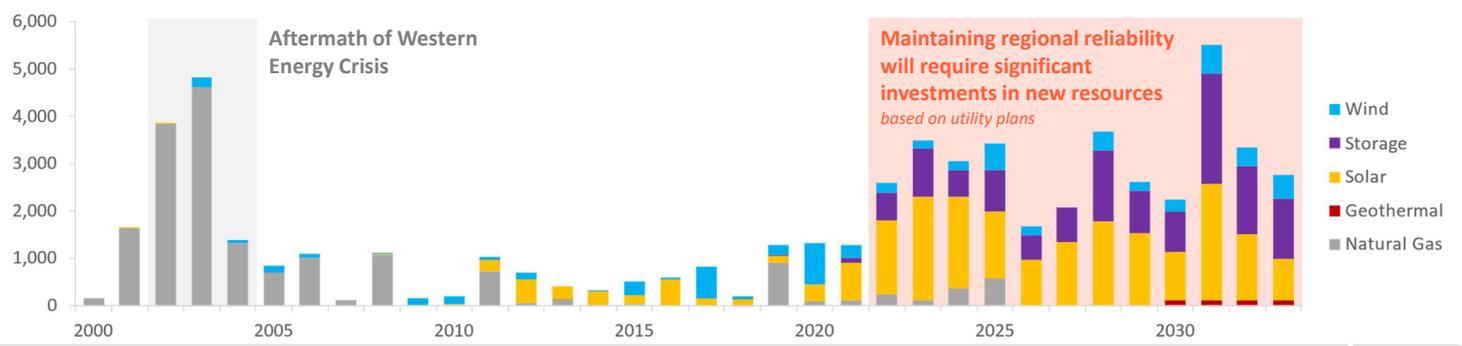


Southwest is roughly in balance, but maintaining that will require resource development at a sustained high pace

- Utilities planning to add 14,000 MW by 2025 and 38,000 MW by 2033
- The resource additions are just about sufficient to maintain resource adequacy under most scenarios
 - The amount of *nameplate* capacity is much larger than the amount of *effective* capacity needed to maintain reliability



New Installed Capacity Additions by Year (Southwest Region) (Nameplate MW)

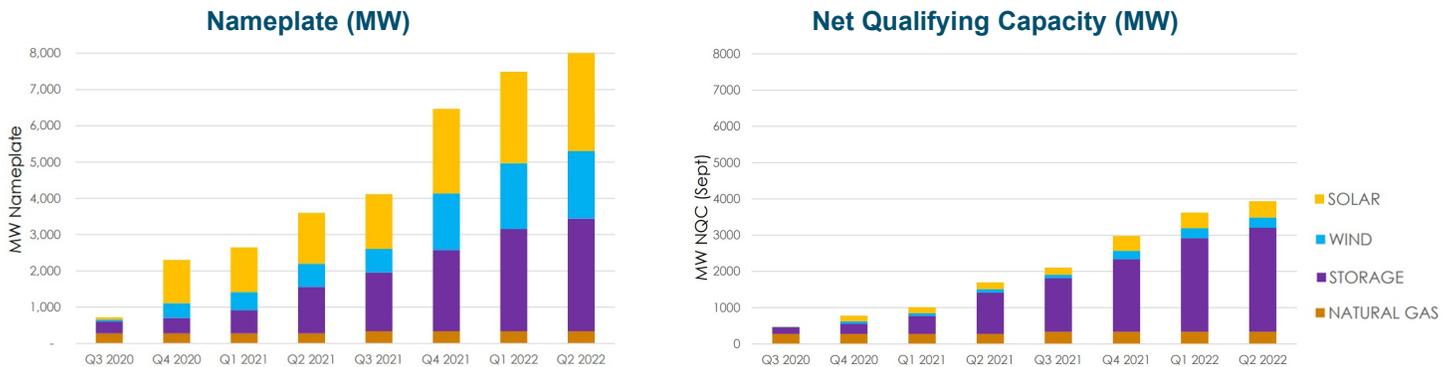




California: November 2019 CPUC order to help address projected resource adequacy capacity shortfalls

- Requested Water Board to extend once-through cooling compliance deadlines for up to three years for 3750 MW of gas plants
- Ordered 3300 MW of new resource procurement by August 2023
 - Incremental to 4000 MW of resources already in development

Cumulative New Resource Additions: 2020-2022



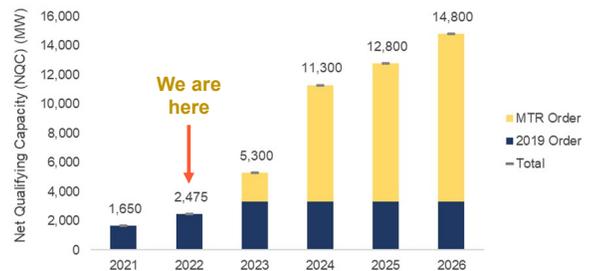
Source: CPUC <https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/summer-2021-reliability/tracking-energy-development/cec-may-reliability-workshop-tracking-energy-development-may-2022.pdf>



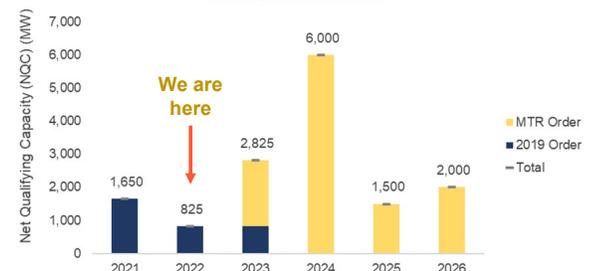
June 2021 Mid-Term Reliability Procurement order requires another 11.5 GW of effective capacity from new resources

- 9.5 GW total must be online by Summer 2025
 - 2023: 2 GW | 2024: 6 GW | 2025: 1.5 GW | + 2.5 GW any year before 2025 (for Diablo Canyon)
 - All resources must be “zero-emissions”
 - No new fossil generation is allowed
 - Demand Response qualifies if it meets additionality requirements
- 2 GW online by Summer 2026*
 - 1 GW “firm, zero-emitting resources”
 - Cannot be weather or use-limited (storage does NOT qualify)
 - Minimum capacity factor of 80%
 - 1 GW long-duration storage (min. 8 hours)
- Higher assumed PRM (22.5%) to address increased risk
- Meant to be sufficient to allow retirement of 6 GW of OTC plants (gas + Diablo Canyon)

Cumulative Additions



Annual Additions



Source: CPUC <https://docs.cpuc.ca.gov/SearchRes.aspx?docformat=ALL&docid=389603637>

Maintaining reliability during the transition will require some difficult decisions



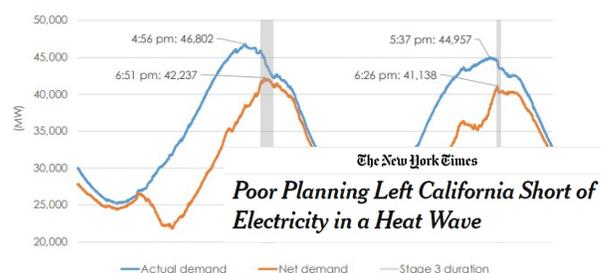
Planning for reliability is increasing in complexity – and importance

Transition towards renewables and storage introduces new sources of complexity in resource adequacy planning

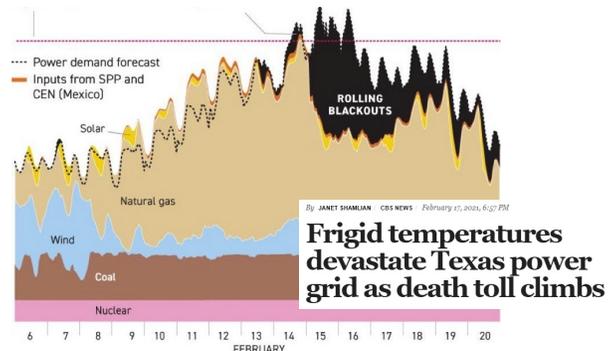
- The concept of planning exclusively for “peak” demand is quickly becoming obsolete
- Frameworks for resource adequacy must be modernized to consider conditions across all hours of the year – as underscored by California’s rotating outages during August 2020 “net peak” period

Reliable electricity supply is essential to our day-to-day lives at home and at work – and will become increasingly important

- Meeting cooling and heating demands under more frequent extreme weather events is may be a matter of life or death
- Economy-wide decarbonization goals will drive electrification of transportation and buildings, making the electric industry the keystone of future energy economy



Graph source: <http://www.caiso.com/Documents/Final-Root-Cause-Analysis-Mid-August-2020-Extreme-Heat-Wave.pdf>



Graph source: <https://twitter.com/bcschaffer/status/1364635609214586882>

The largest resource adequacy challenge will be delivering energy during extended renewable droughts

☞ The combination of solar and batteries is effective at meeting summertime needs driven by heat events

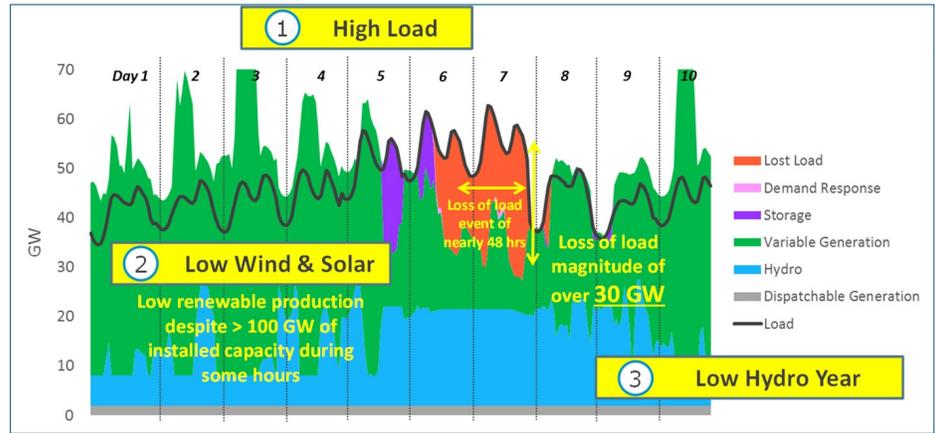
- Supplements the existing portfolio of hydro and natural gas generation

☞ Wintertime cold weather events will pose an increasing challenge due to electrification of building heat

- Vehicle electrification will also add to the challenges

☞ California and the Northwest will each need over 30 GW of firm capacity to maintain resource adequacy even after adding hundreds of GW of wind, solar and batteries

- “Firm capacity” are resources that can run whenever needed

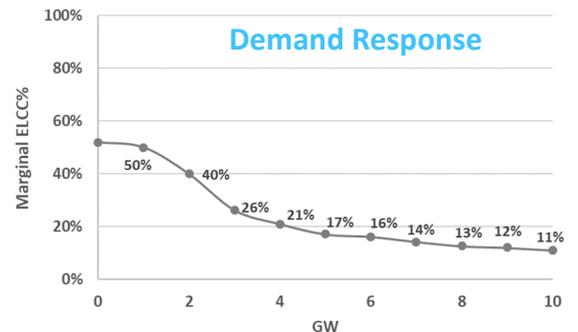
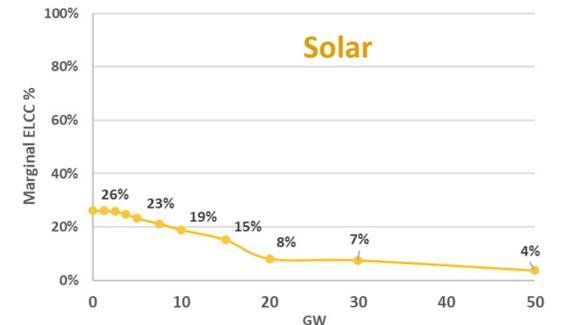
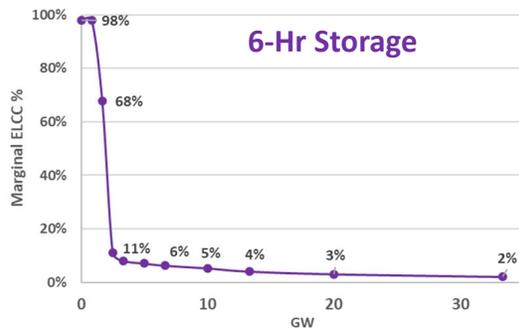
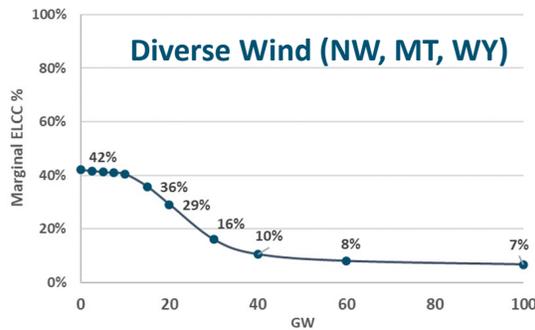


Source: E3, *Resource Adequacy in the Pacific Northwest, 2019*

The capacity contribution of wind, solar, storage and demand response declines as more are added

☞ Pacific Northwest examples shows the diminishing marginal returns as more of a single resource type is added to the system

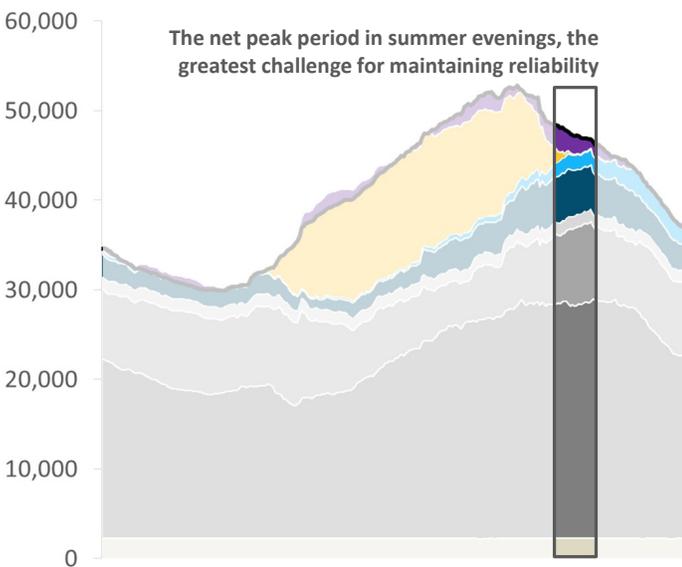
☞ A more diverse portfolio retains more value at higher penetrations



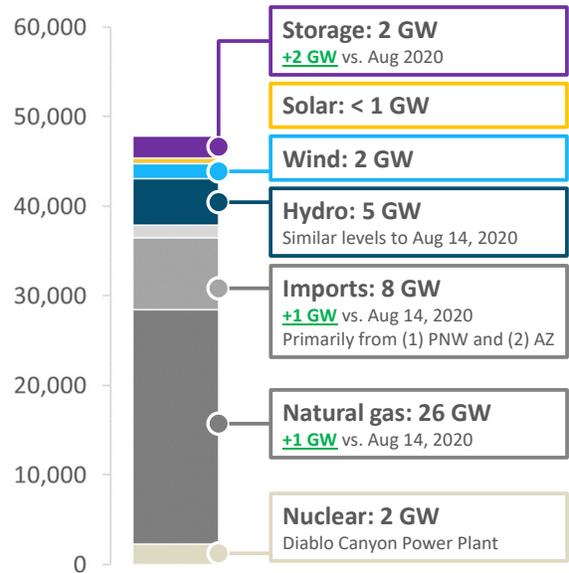
Source: E3, *Resource Adequacy in the Pacific Northwest, 2019*

California, September 6, 2022: All hands on deck!

CAISO System Operations on September 6, 2022 (MW)



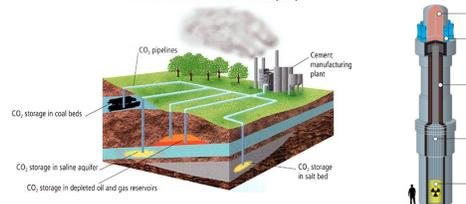
Generation During Hour of Highest Net Load (MW)



Achieving a fully zero-carbon grid will require new technologies

- ⚠️ Firm, carbon-free resources will be crucial for reliability if gas resources are retired
- ⚠️ Candidates include:
 - ❑ Enhanced geothermal
 - ❑ New nuclear (e.g., Small Modular Reactors)
 - ❑ Fossil generation with carbon capture and sequestration
 - ❑ Very long-duration storage energy storage
 - ❑ Clean fuels such as renewable natural gas, hydrogen or synthetic gas
- ⚠️ These technologies have not yet been proven to be safe, resilient, and cost-effective and are not yet commercially available
- ⚠️ One or more must emerge to enable a zero-carbon grid

CARBON CAPTURE AND STORAGE (CCS)



Conclusion



Energy+Environmental Economics



Summary of key takeaways

- ⚠️ **A changing climate and aggressive climate policy are placing enormous strain on our energy infrastructure**
 - Utilities will need to plan for much higher peak loads in both the summer (in the near term) and the winter (in the long term)
- ⚠️ **Maintaining reliable and affordable electricity will require continuing to invest in fossil fuel infrastructure**
 - Firm resources are needed to ensure resource adequacy during and after the transition
 - “Clean firm” sources of generation are needed for zero carbon grid but are not yet ready to scale
- ⚠️ **Utilities will need to be proactive in developing strategies to manage change**
 - **Flexible EV charging** and other flexible loads will be critically important
 - **Dual-fuel heat pumps** and building shell retrofits can blunt the peak impact of electrified heat
 - **Enhanced regional coordination** can help make the most of load-resource diversity across the Western Interconnection
 - **Developing firm resources** in addition to wind & solar to help address near-term reliability needs

Thank you!

Arne Olson, Senior Partner (arne@ethree.com)



Energy+Environmental Economics

