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

Northwest Gas Association/
Association of Western Energy Consumers

Sunriver, Oregon

June 8, 2023

Energy+Environmental Economics

Arne Olson, Senior Partner

Themes

1. A changing climate is placing ***INCREASING STRAIN*** on our energy infrastructure

2. Climate policy is driving ***SIGNIFICANT INCREASES*** in the need for energy production and delivery capability

3. The generation supply mix is ***EVOLVING RAPIDLY*** toward variable and dispatch-limited resources

4. Supply-demand balance is ***INCREASINGLY PRECARIOUS*** throughout the West

5. Maintaining reliability during the transition will require some ***DIFFICULT DECISIONS***

1. A changing climate is placing increasing strain on our energy infrastructure

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The climate is transforming: key findings about possible climate futures from the 2021 IPCC report

B.1 **Global surface temperature will continue to increase until at least the mid-century** under all emissions scenarios considered. Global warming of 1.5°C and 2°C will be exceeded during the 21st century unless deep reductions in carbon dioxide (CO2) and other greenhouse gas emissions occur in the coming decades.

B.2 Many changes in the climate system become larger in direct relation to increasing global warming. They include **increases in the frequency and intensity of hot extremes**, marine heatwaves, and heavy precipitation, agricultural and ecological **droughts** in some regions, and proportion of intense tropical cyclones, as well as reductions in Arctic sea ice, **snow cover** and permafrost.

B.3 Continued global warming is projected to further intensify the global water cycle, including its variability, global monsoon precipitation and the **severity of wet and dry events**.

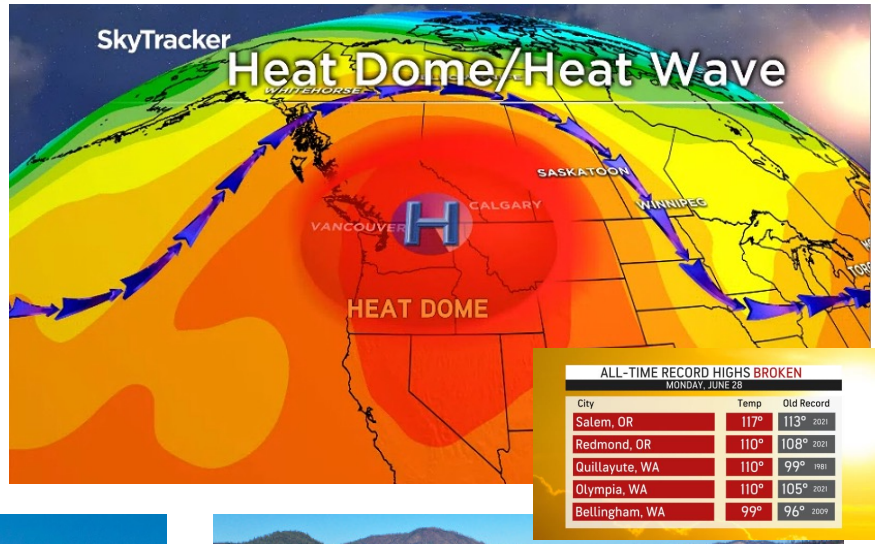
B.4 Under scenarios with increasing CO2 emissions, the ocean and land **carbon sinks are projected to be less effective** at slowing the accumulation of CO2 in the atmosphere.

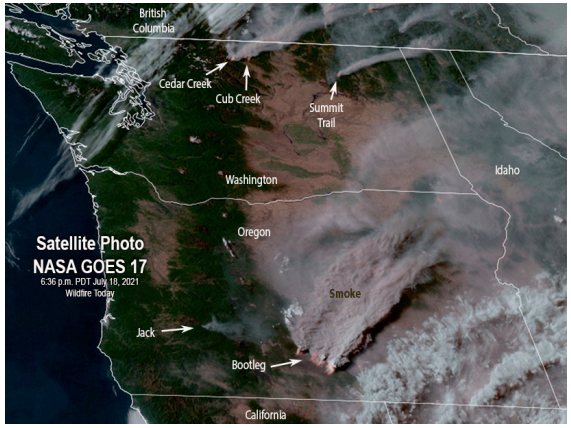
B.5 Many changes due to past and future greenhouse gas emissions are **irreversible for centuries to millennia**, especially changes in the ocean, ice sheets and global sea level.

Intergovernmental Panel on Climate Change, Climate Change 2021: The Physical Science Basis
https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM.pdf

Extreme heat events are causing much higher summer loads

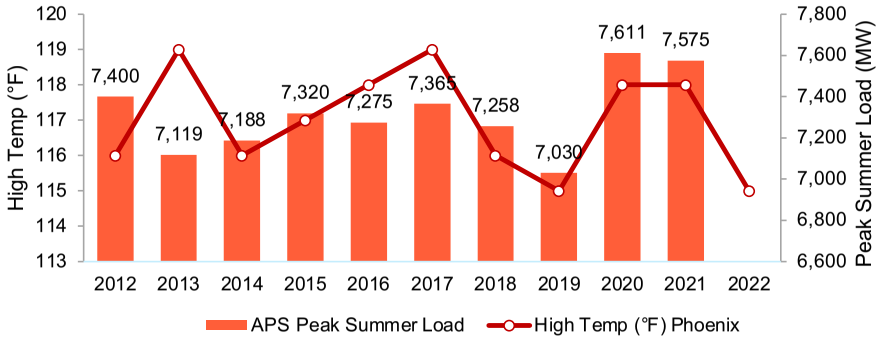
- Many utilities in the Northwest set new summertime ***PEAK DEMAND RECORDS*** during heat dome event on June 29-30, 2021
- Summertime peaks are now approaching or ***EXCEEDING WINTER PEAKS*** across the region
- Higher summer peaks ***CREATE CHALLENGES*** across generation, transmission and distribution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



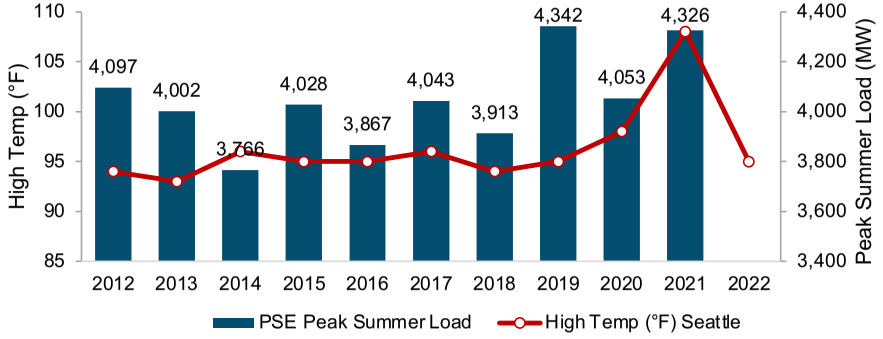


Summer High Temp and Peak Load by Service Territory
Selected WECC Utilities

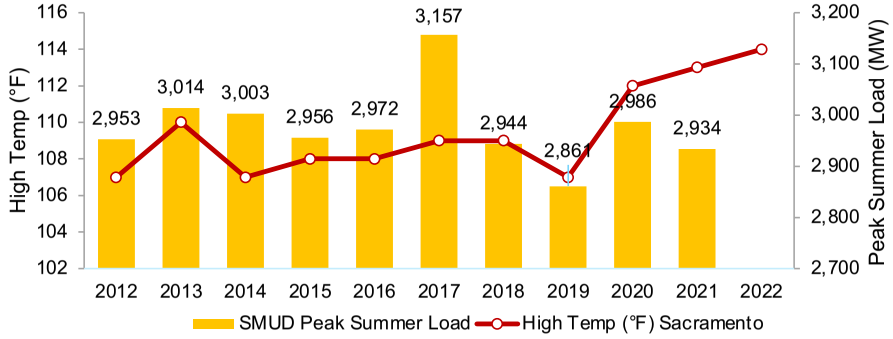
Phoenix (Arizona Public Service)



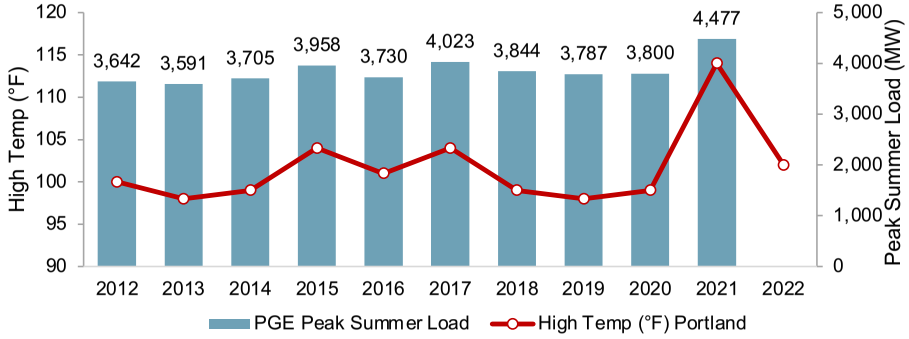
Seattle (Puget Sound Energy)



Sacramento (SMUD)

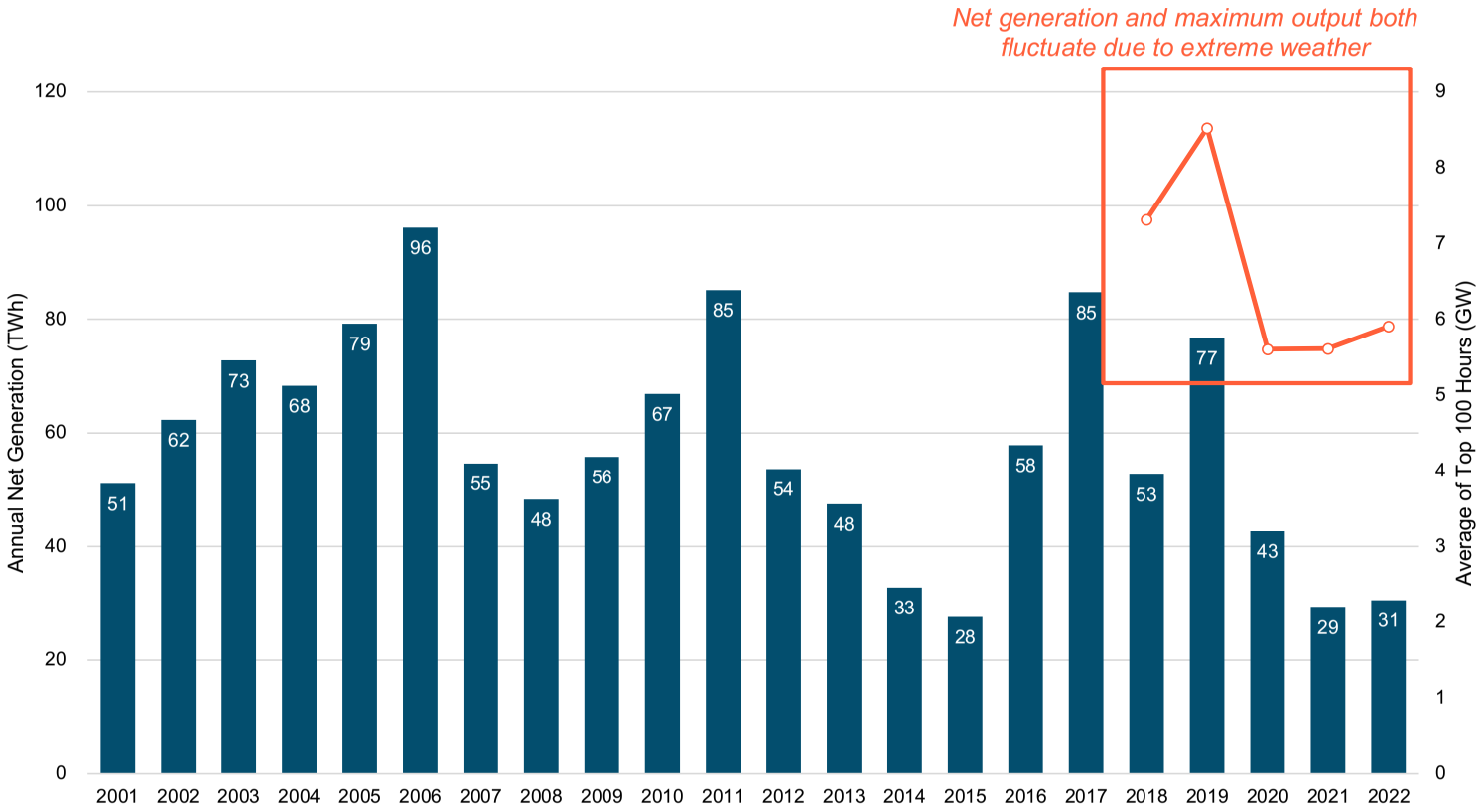


Portland (Portland General Electric)



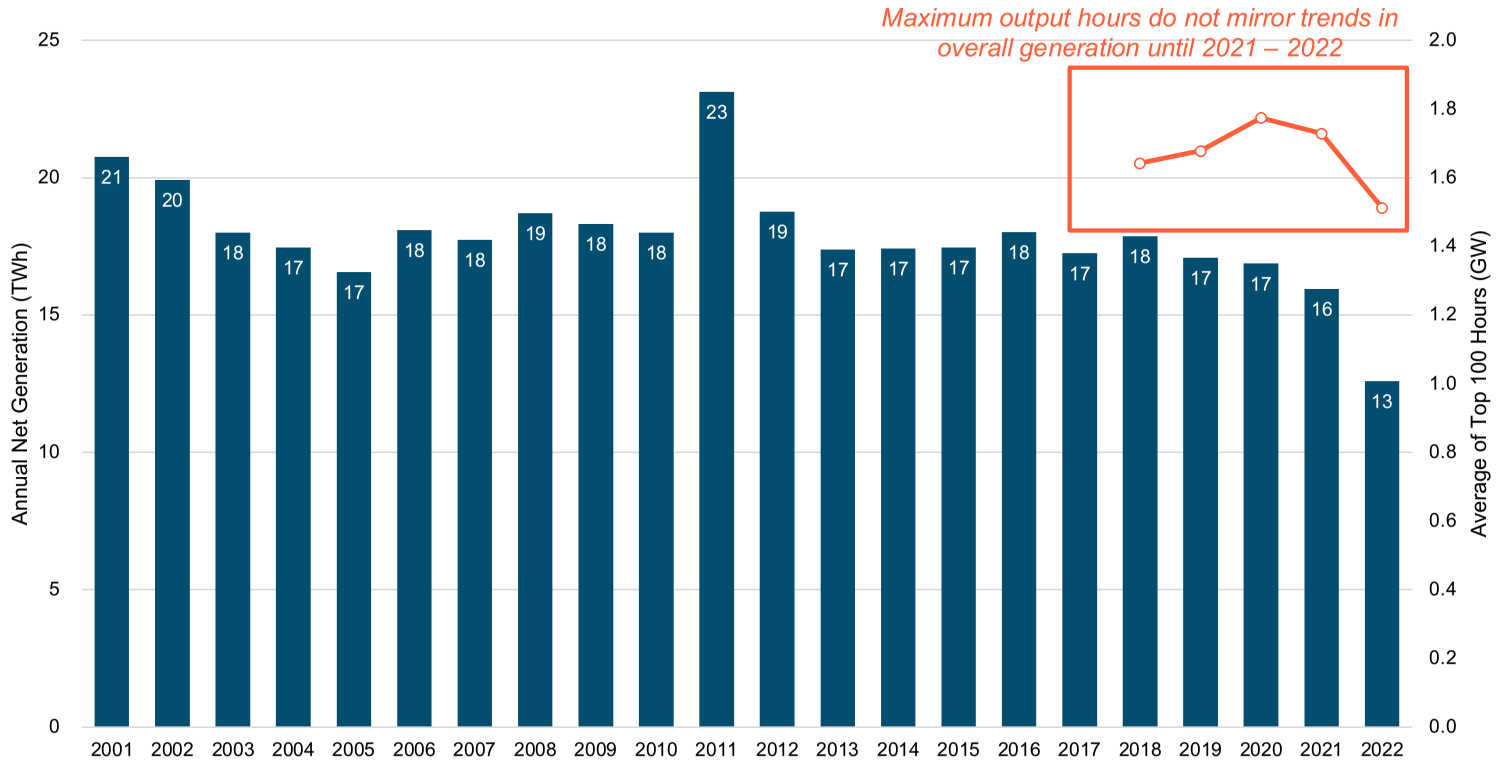
Source: Temperature data: NOAA. Peak load: SNL (S&P Market Intelligence).

Hydro Production
California



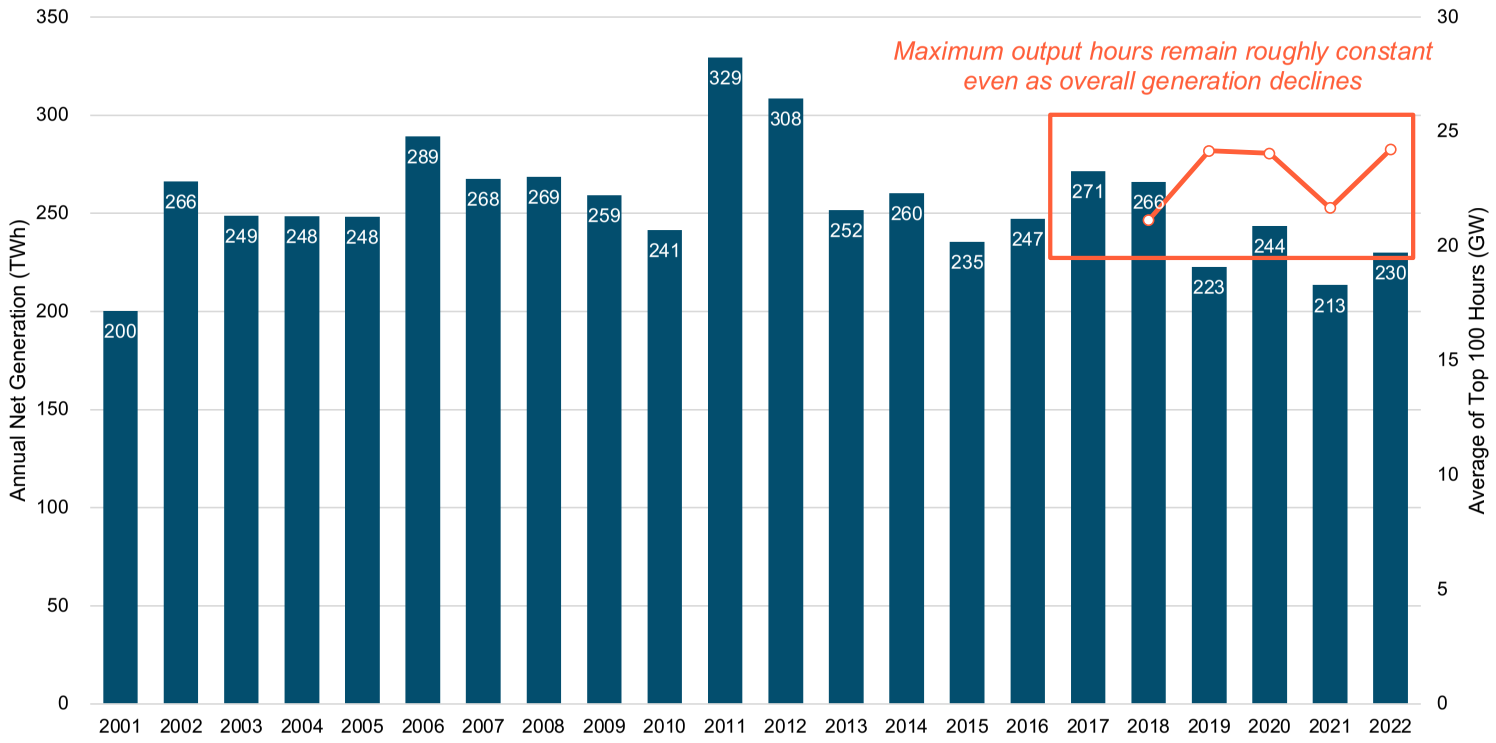
Source: EIA. Link here for hourly data and here for annual data.

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.

2. Climate policy is driving significant increases in the need for energy infrastructure

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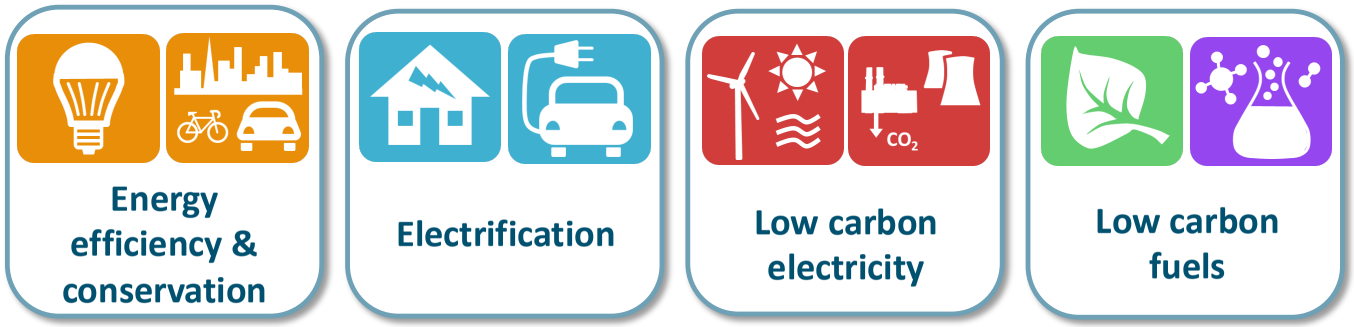
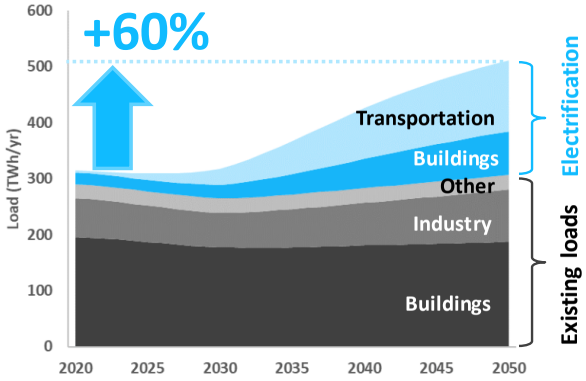
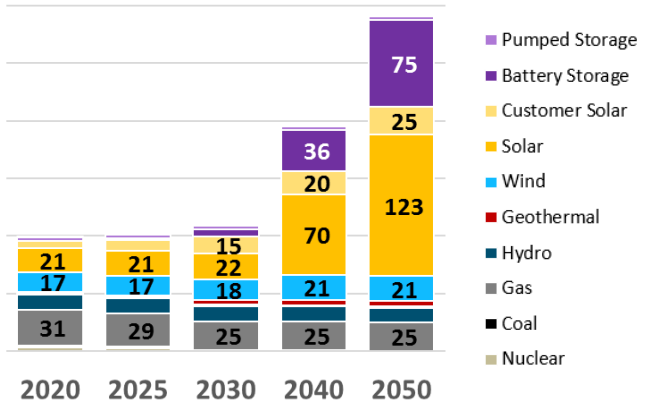
“Four Pillars” of decarbonization point to the crucial role of the electricity sector



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

The policy landscape is transforming: clean energy goals are multiplying

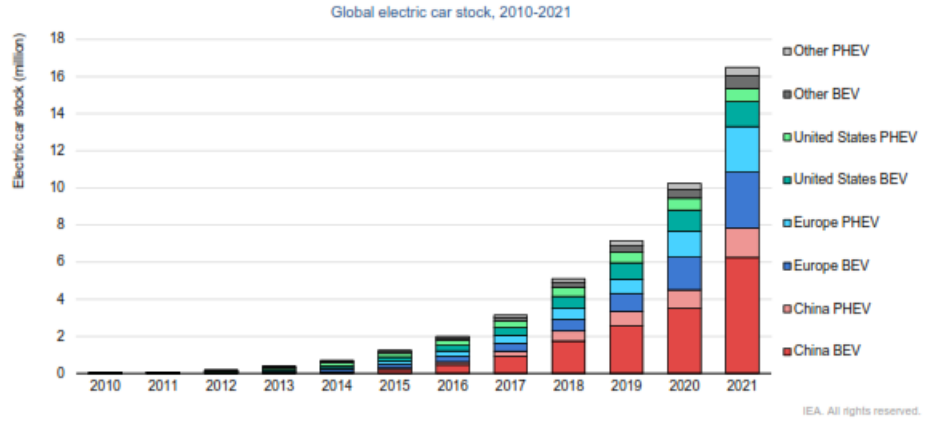
Most of the Pacific Northwest Region is now covered by some type of clean energy goal

Entity	Description
British Columbia	Climate Change Accountability Act (2007): Economy-wide, 40% reduction by 2030, 60% by 2040, 80% by 2050
Washington	Clean Energy Transformation Act (2019): Electricity only, no coal by 2025, carbon-neutral by 2030, 100% clean by 2045
Oregon	100% Clean Energy Bill (2021): Electricity only, 80% carbon reduction by 2030, 90% by 2045, 100% by 2040
Idaho Power	100% clean energy by 2045
Avista	Carbon neutral electricity by 2027, 100% clean energy by 2045
Puget Sound Energy	Beyond net-zero by 2045, which includes: a carbon neutral electric system by 2030 and 100% clean electricity by 2045.
NorthWestern	90% carbon reductions by 2045
Portland General Electric	80% carbon reduction by 2030, net zero carbon by 2040

Adoption of light duty electric vehicles is accelerating rapidly

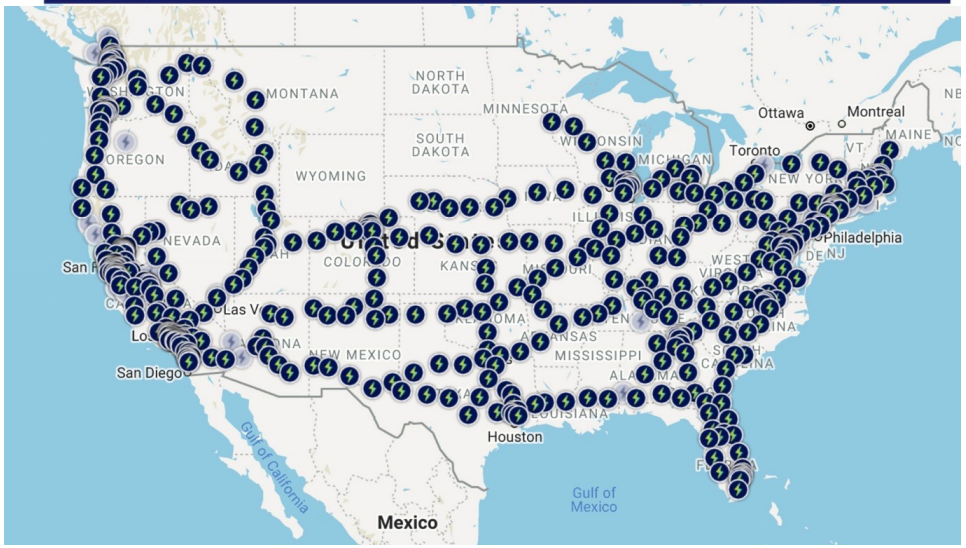
- Vehicle charging load will be become noticeable in the ***NEXT FEW YEARS***
- Initial adoption likely to be concentrated in certain locations creating ***DISTRIBUTION CHALLENGES***
- Utilities will need to be ready for ***SMART CHARGING*** rates, panel installations, charging stations, etc.

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



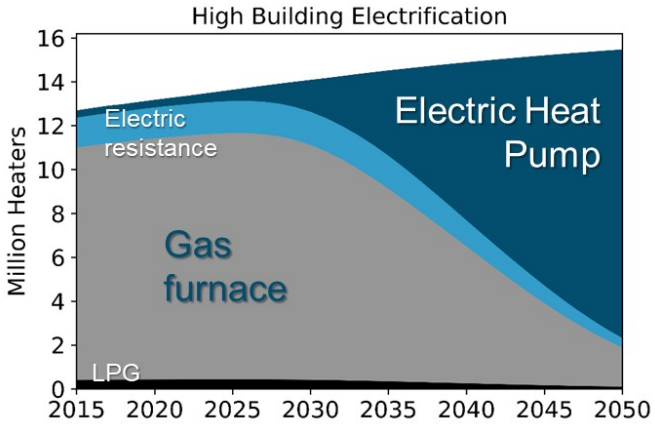
Notes: BEV = battery electric vehicle; PHEV = plug-in hybrid electric vehicle. Electric car stock in this figure refers to passenger light-duty vehicles.
"Other" includes Australia, Brazil, Canada, Chile, India, Japan, Korea, Malaysia, Mexico, New Zealand, South Africa and Thailand. Europe in this figure includes the EU27, Norway, Iceland, Switzerland and United Kingdom.
Sources: IEA analysis based on country submissions, complemented by ACEA; CAAM; EAFO; EV Volumes; Marklines.

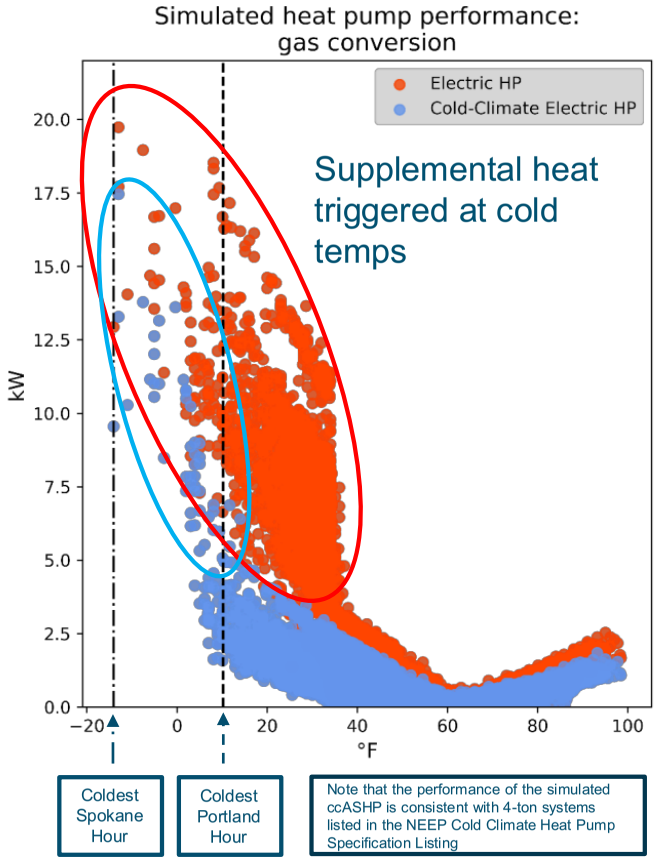
Electrify America – Nationwide DC Fast Charging Network



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

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





3. The generation supply mix is evolving rapidly toward variable and dispatch-limited resources

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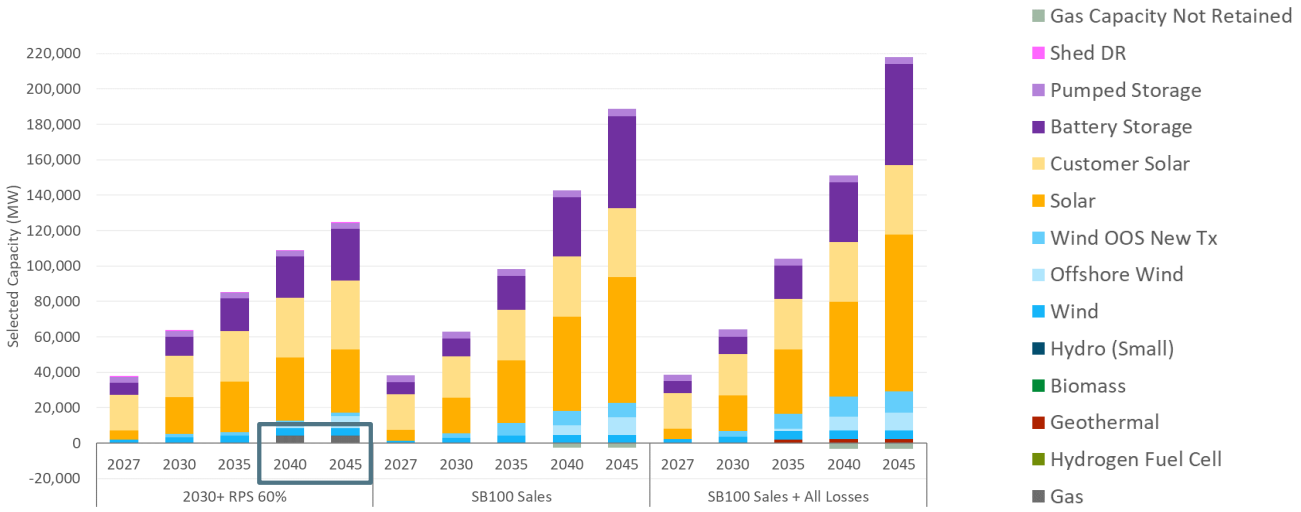
California's SB 100 study calls for hundreds of GW of new wind, solar and batteries

+ **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

High Electrification



Source: CEC, https://www.energy.ca.gov/sb100

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

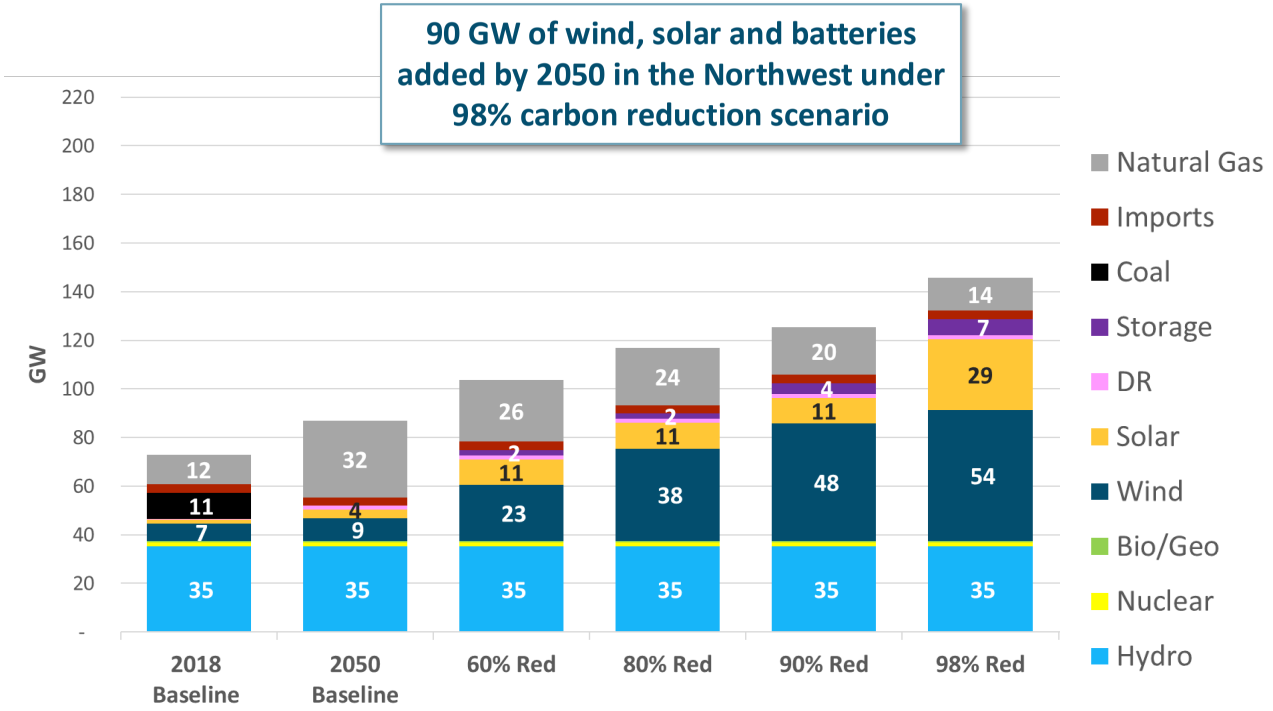
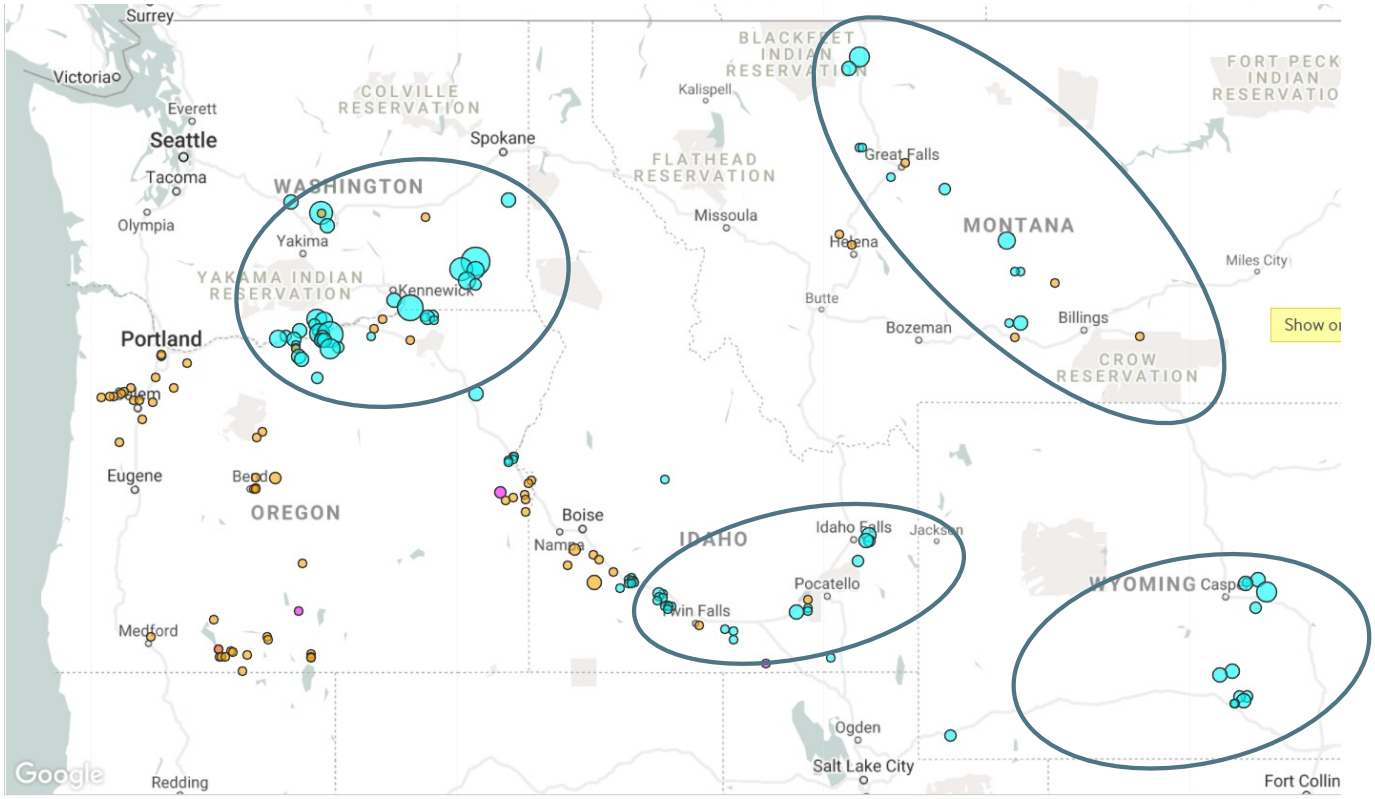


Image source: *Resource Adequacy in the Pacific Northwest (Various utilities, 2019)*

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

Existing renewable generators in the Pacific Northwest



4. Supply-demand balance is increasingly precarious throughout the West

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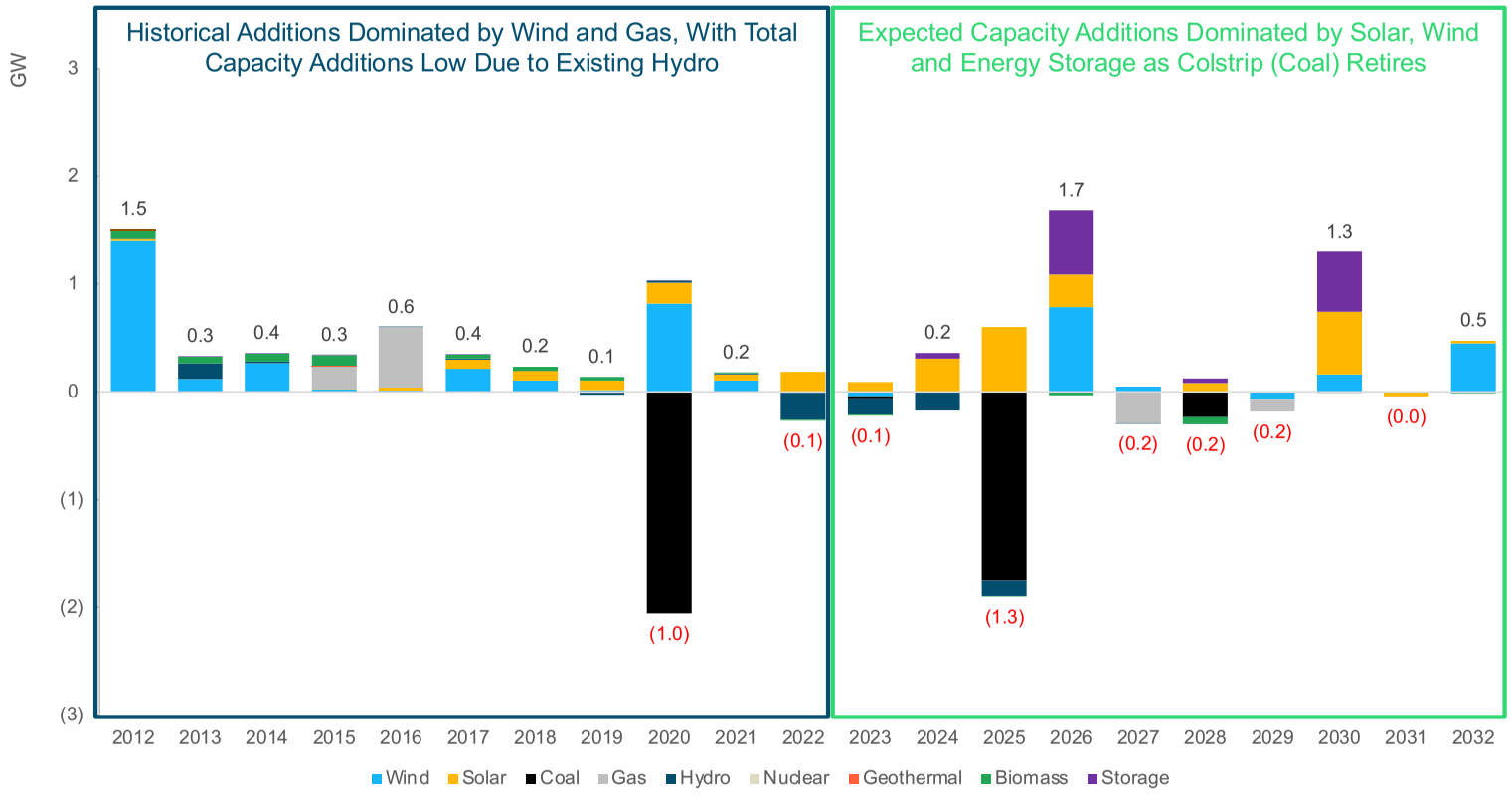
The Western Interconnection is facing immediate resource adequacy challenges

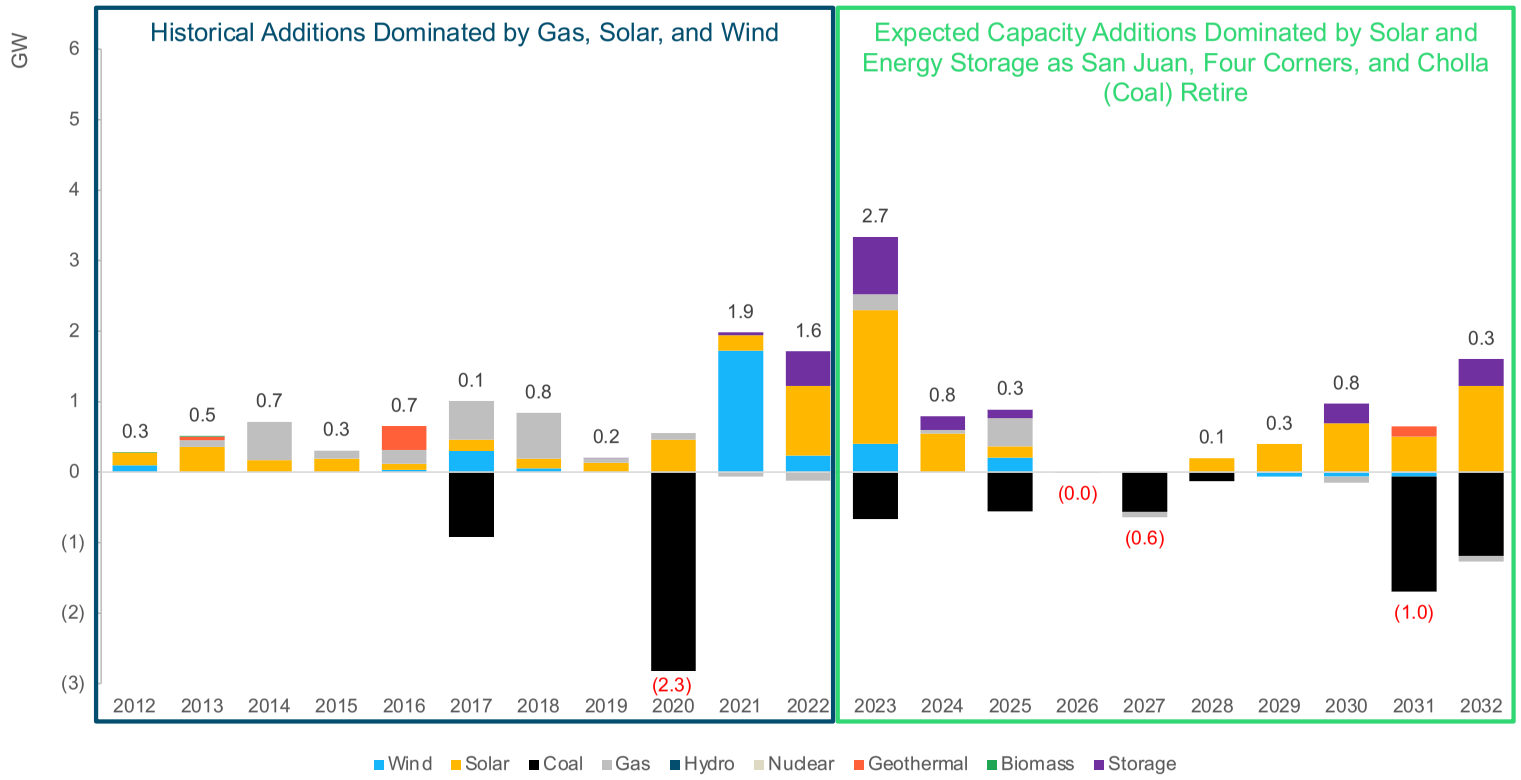
- Increased frequency, severity and geographic extent of heat events
- Continued retirement of firm resources across the region
- Very little development of new firm resources in recent years
- Resumption of peak load growth caused by more extreme weather, data centers, electric vehicles, etc.

Northwest Capacity Additions and Retirements



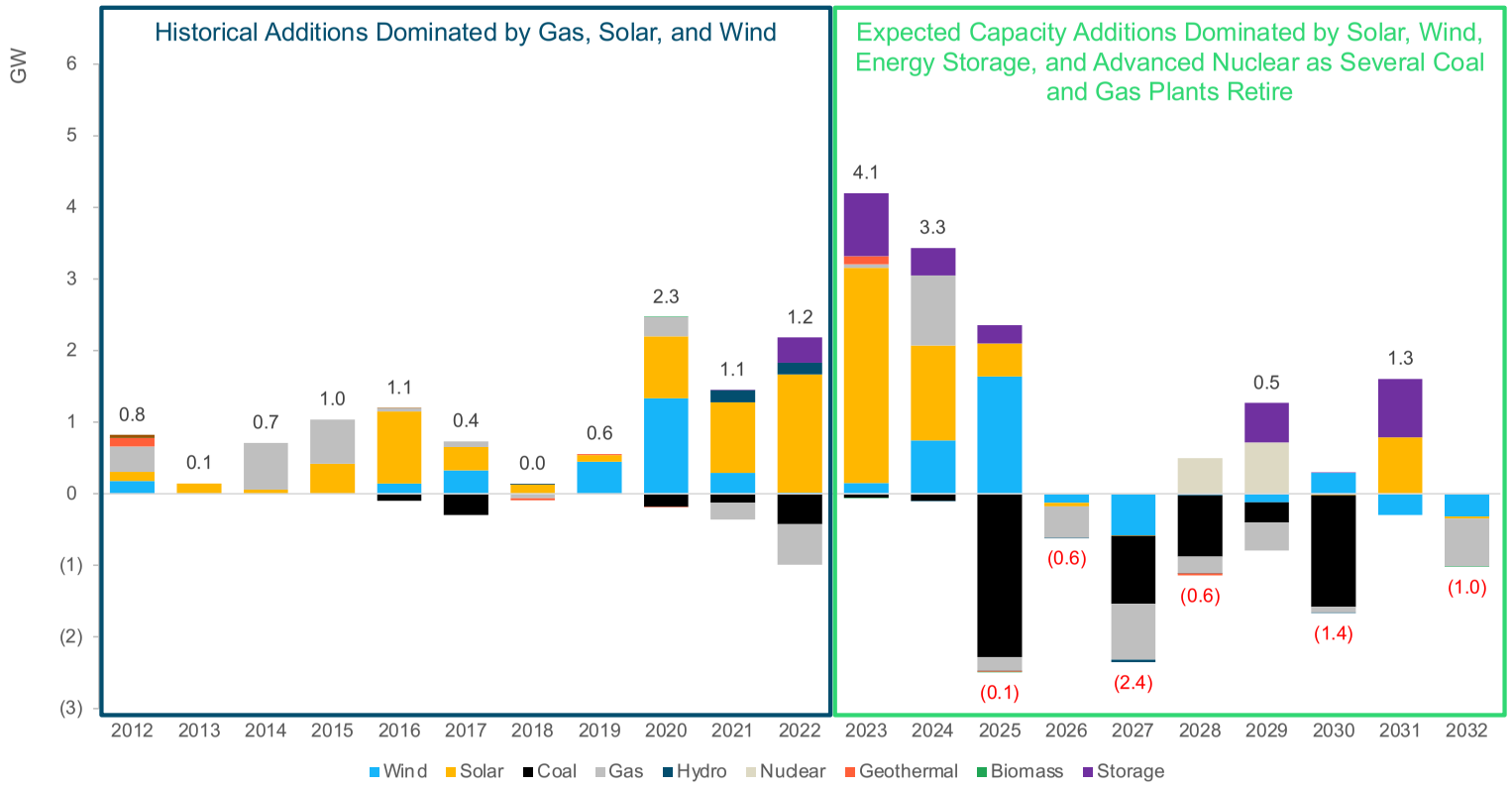
Note: Captures WECC areas of BCHA, BPAT, NWMT, PACW, PGE, PSEI, SCL, WACO where data is disclosed.
Source: 2022 WECC Western Assessment of Resource Adequacy. Link here.

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.

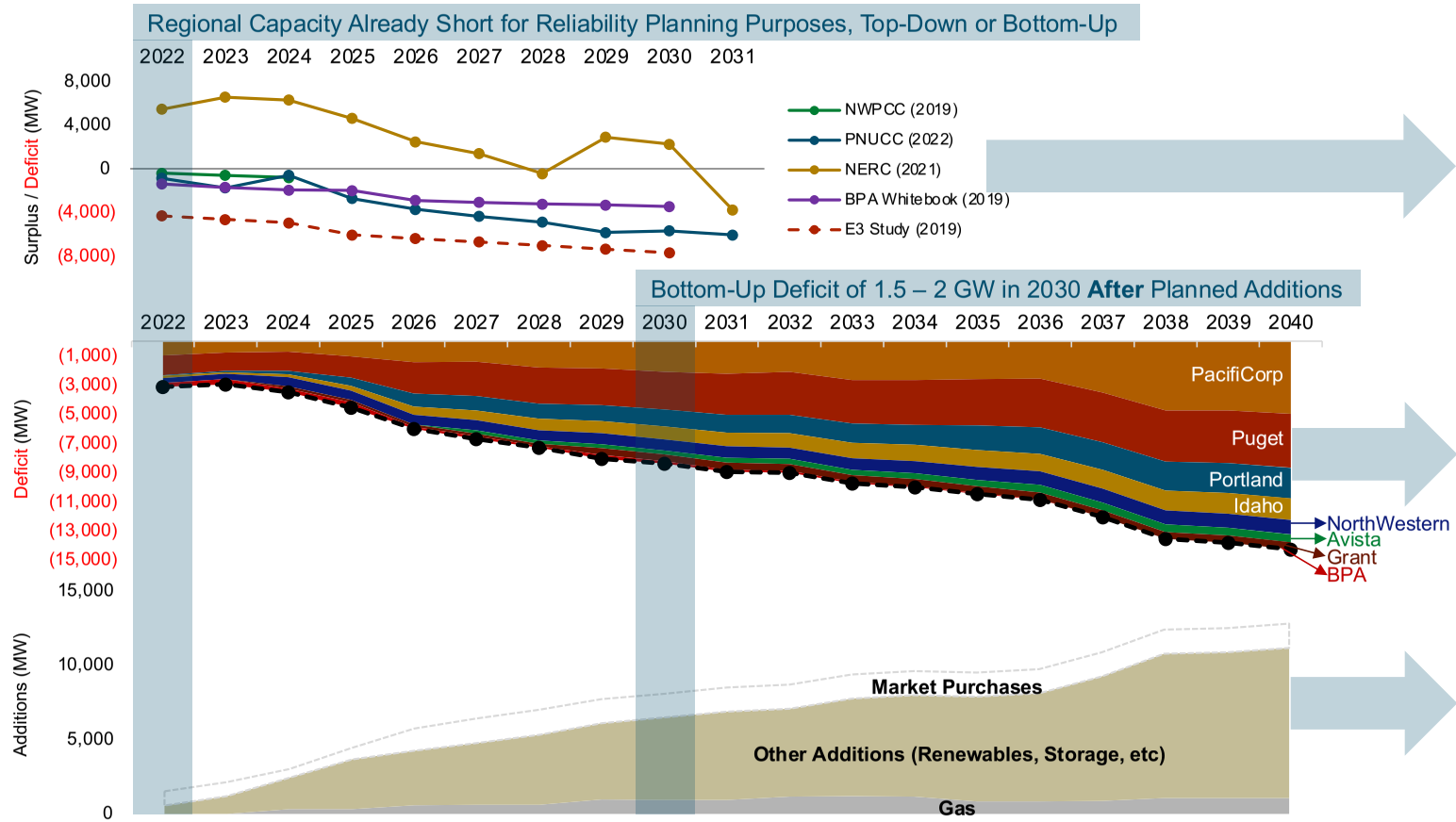
Rocky Mountain Capacity Additions and Retirements



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



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 Utility IRP Review

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

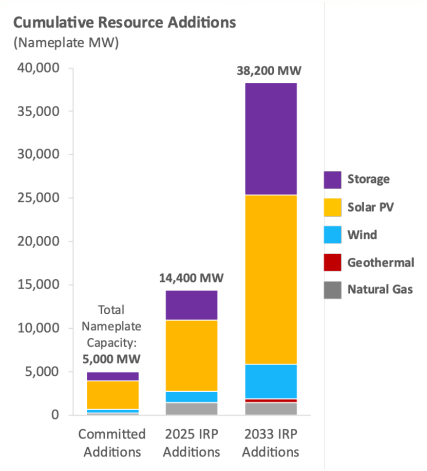
IRP Planned Additions

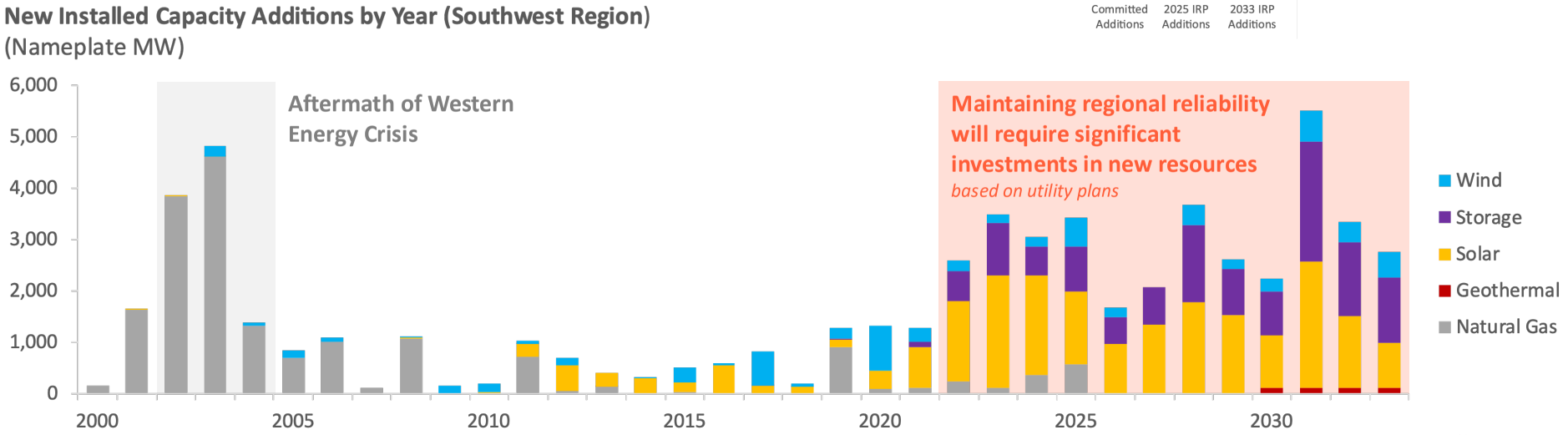
~6.5 GW effective capacity additions by 2030 (up to ~14 GW nameplate capacity), **significantly exceeding average capacity expansion rate for 2010-2020 (~1 GW/year)**

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



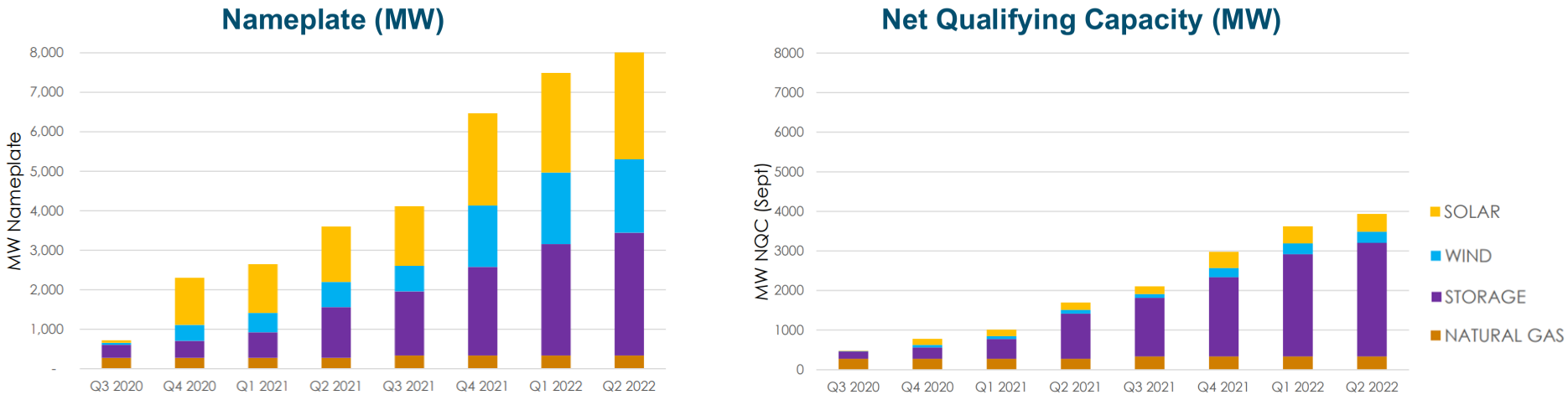


Source: E3, Resource Adequacy in the Desert Southwest

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

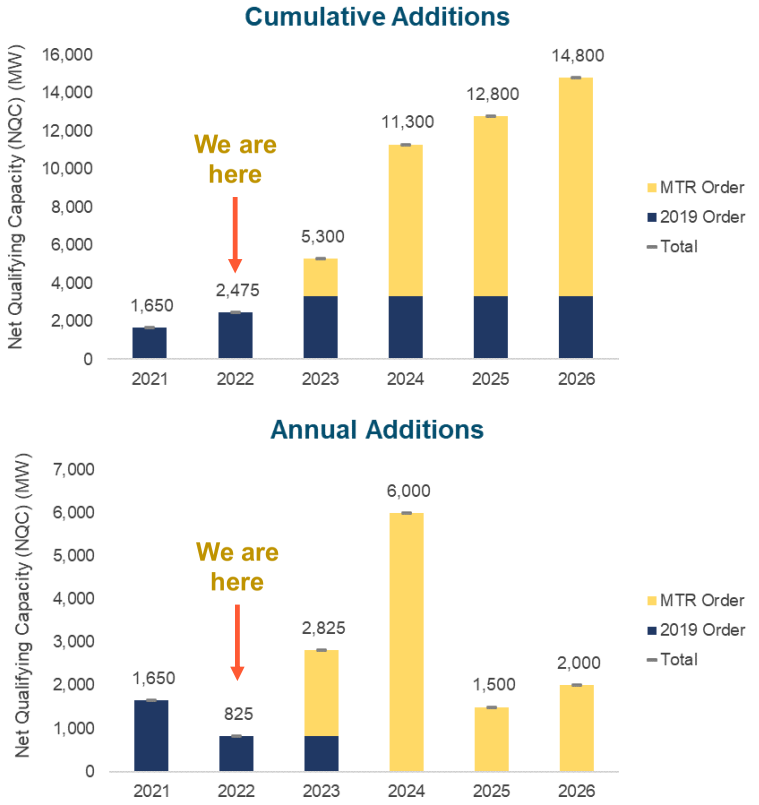


Source: CPUC https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/summer-2021-reliability/tracking-energy-development/cec-may-reliability-workshop-tracking-energy-development-may-2022.pdf

CPUC Mid-Term Reliability Procurement orders require another 16 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"
  - 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)**

CA DWR also now signing contracts with thermal generators for Governor Newsom's "strategic reserve"



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

5. Maintaining reliability during the transition will require some difficult decisions

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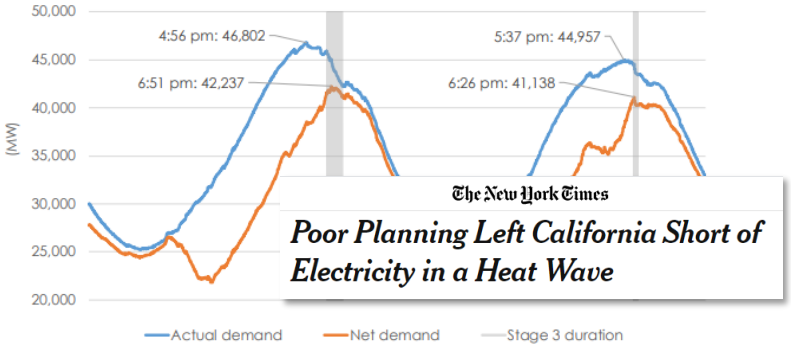
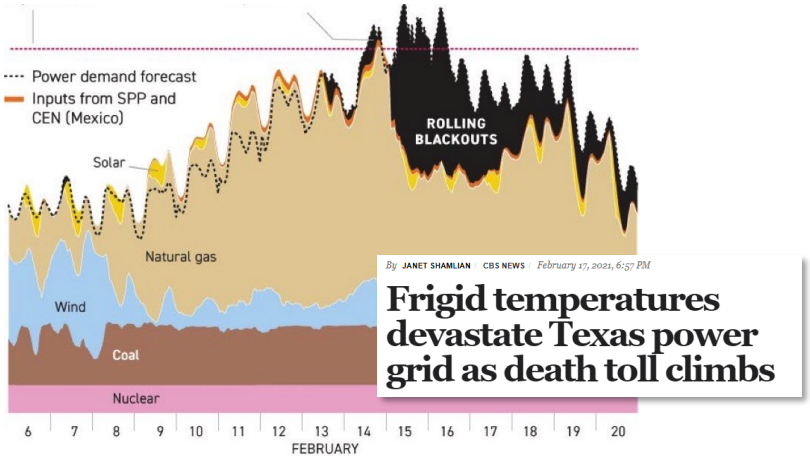
Planning for reliability is increasing in complexity – and importance

- **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



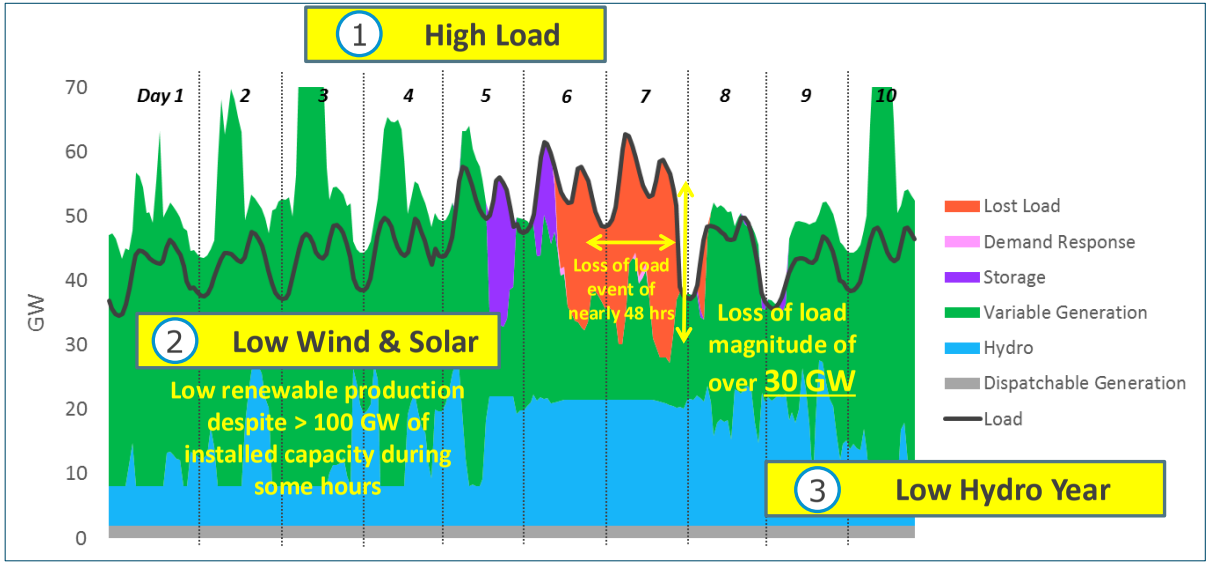
Graph source: http://www.caiso.com/Documents/Final-Root-Cause-Analysis-Mid-August-2020-Extreme-Heat-Wave.pdf



Graph source: https://twitter.com/bcshaffer/status/1364635609214586882

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

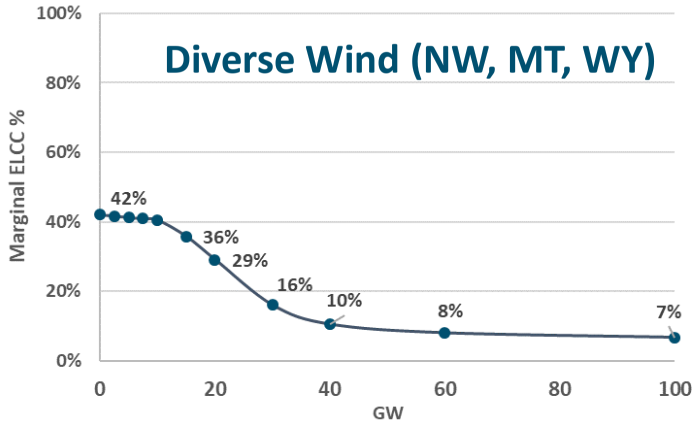
- **The combination of solar and batteries is effective at meeting summertime needs driven by heat events**
  - Supplements the existing portfolio of hydro and natural gas generation
- **Wintertime cold weather events will pose an increasing challenge due to electrification of building heat**
  - Vehicle 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

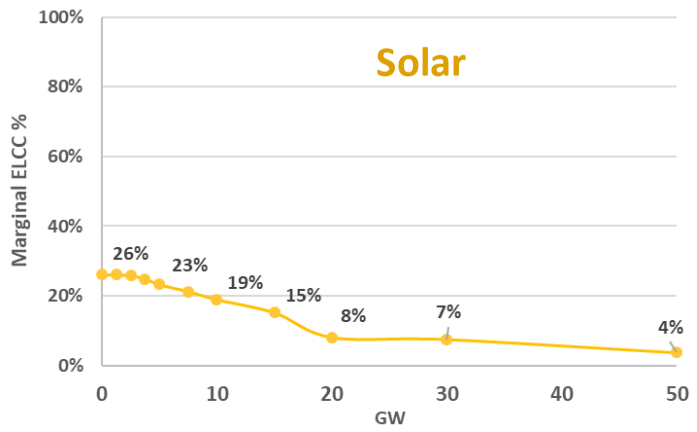


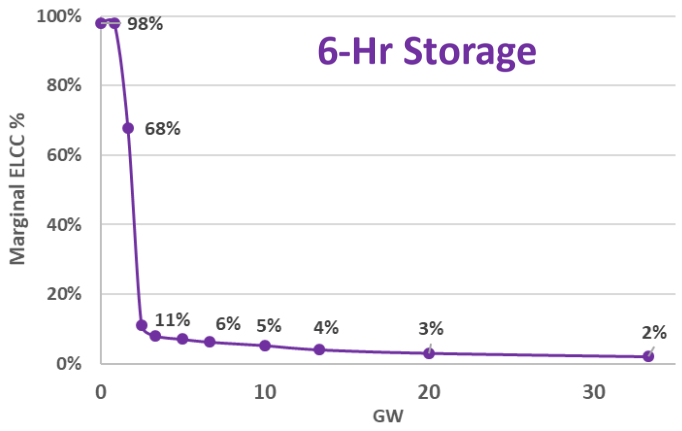
Source: E3, Resource Adequacy in the Pacific Northwest, 2019

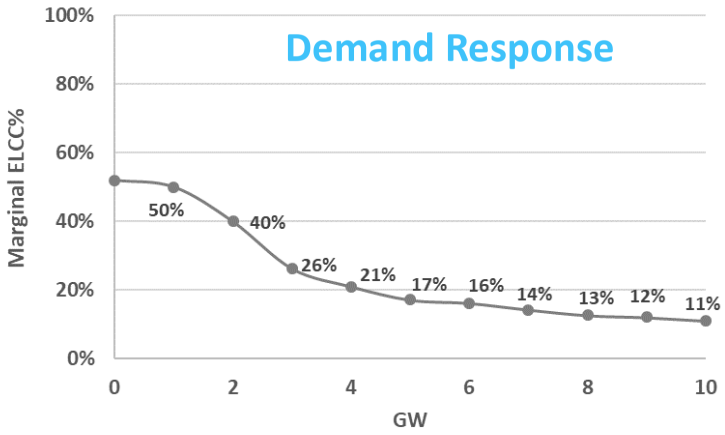
The capacity contribution of wind, solar, storage and demand response declines as more are added

- 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







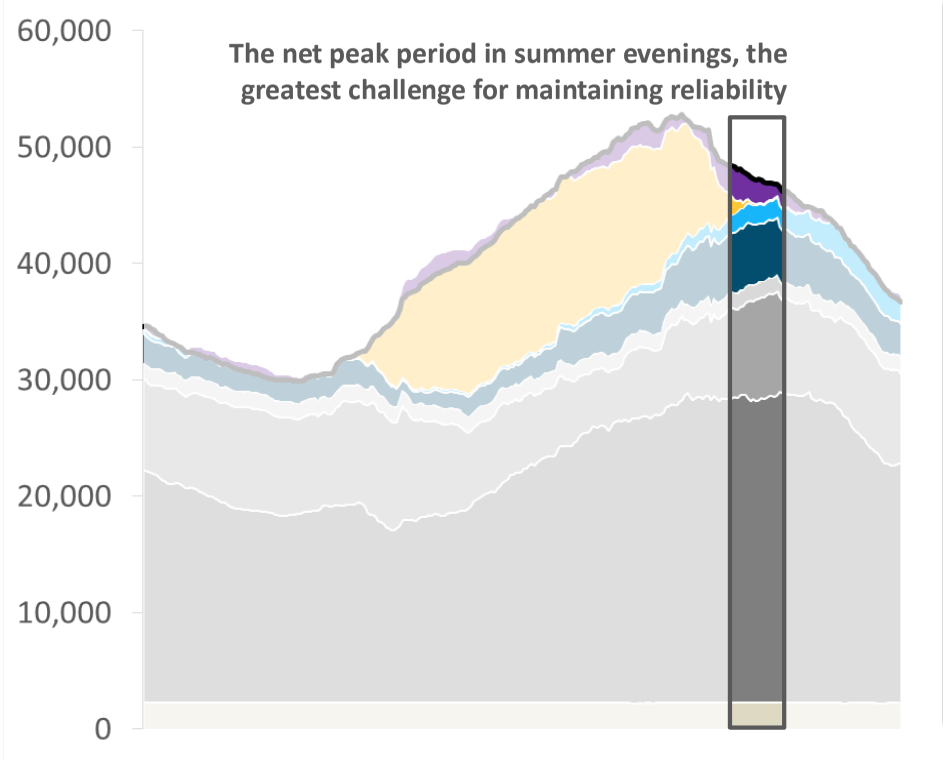


Source: E3, Resource Adequacy in the Pacific Northwest, 2019

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

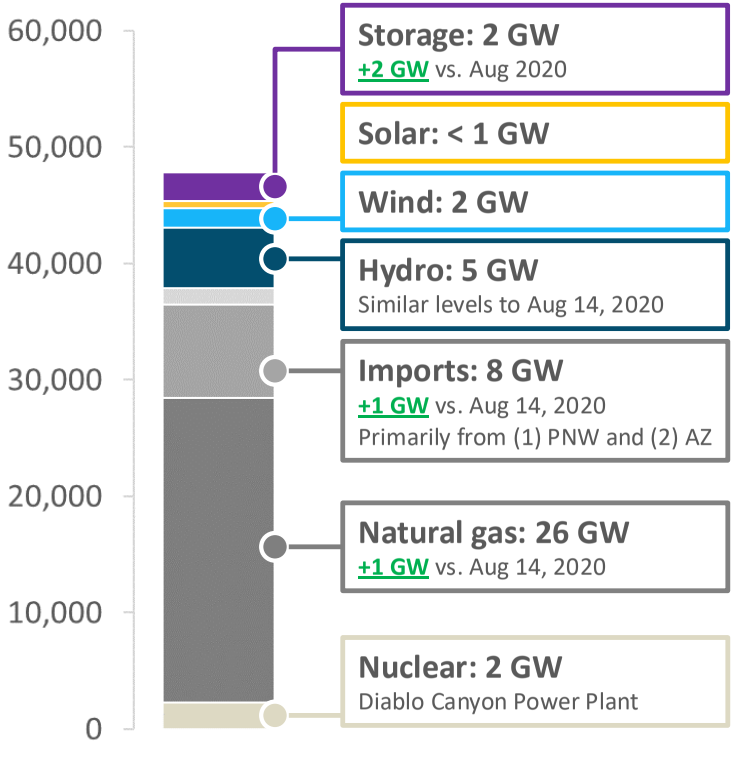
CAISO System Operations on September 6, 2022

(MW)



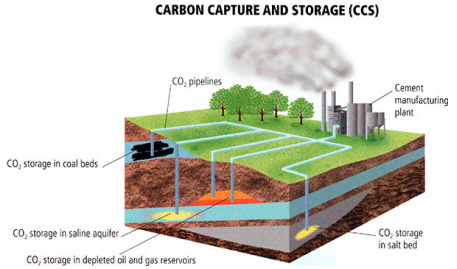
Generation During Hour of Highest Net Load

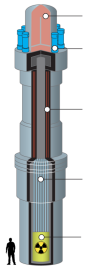
(MW)

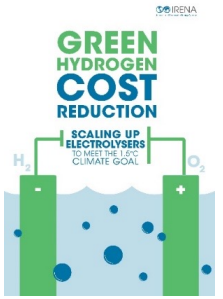


Achieving a fully zero-carbon grid will require new technologies

- ***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 reliable, zero-carbon grid**







Conclusion

Energy+Environmental Economics

Themes

1. A changing climate is placing ***INCREASING STRAIN*** on our energy infrastructure

2. Climate policy is driving ***SIGNIFICANT INCREASES*** in the need for energy production and delivery capability

3. The generation supply mix is ***EVOLVING RAPIDLY*** toward variable and dispatch-limited resources

4. Supply-demand balance is ***INCREASINGLY PRECARIOUS*** throughout the West

5. Maintaining reliability during the transition will require some ***DIFFICULT DECISIONS***

Thank you!

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