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Maintaining Resource Adequacy on a Changing Electricity System

California Energy Commission
Western Electricity System Integration Workshop
Sacramento, California
December 2, 2022

Energy+Environmental Economics

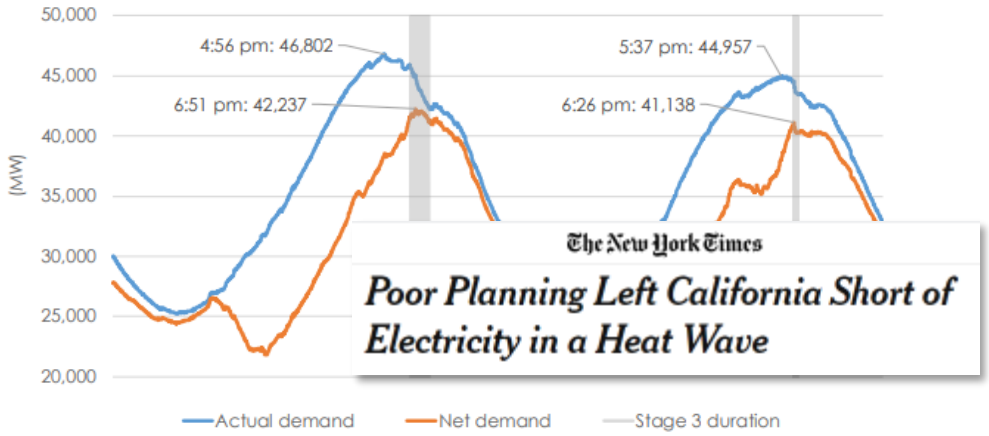
Arne Olson, Senior Partner

Agenda

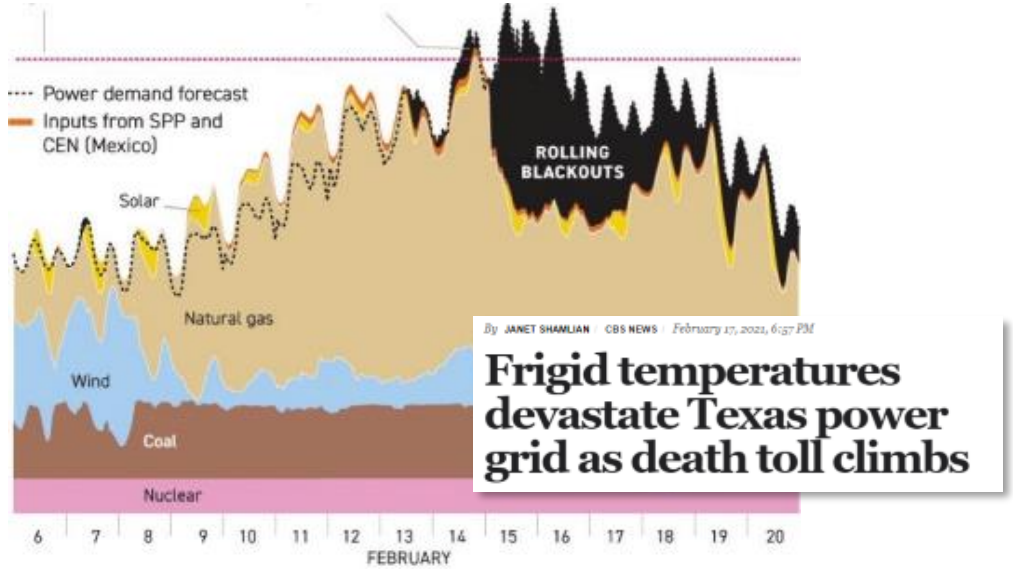
- Introduction – what is resource adequacy
- Resource adequacy will be an increasingly difficult challenge as we move toward a net zero grid
- In the near- to medium-term, we will continue to rely on a mix of conventional and clean resources

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

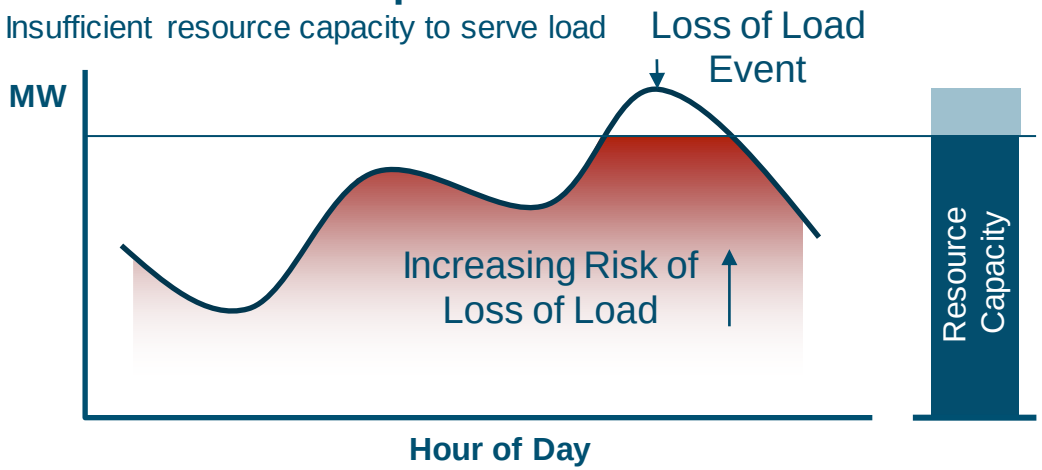


Graph source: https://twitter.com/bcshaffer/status/1364635609214586882

What is resource adequacy?

- **Resource adequacy is a measure of the ability of a portfolio of generation resources to meet load across a wide range of system conditions, accounting for variability of supply & demand**
- **Typically, electricity systems are planned to a standard where loss of load due to insufficient supply occurs very rarely**
  - The most common standard used throughout North America is a "one-day-in-ten-year" standard

Loss of Load Example



NERC Definition of Resource Adequacy:

"The ability of the electric system to supply the aggregate electrical demand and energy requirements of the end-use customers at all times, taking into account scheduled and reasonably expected unscheduled outages of system elements."

Source: NERC Glossary of Terms

Resource adequacy will be an increasingly difficult challenge as we move toward a net zero grid

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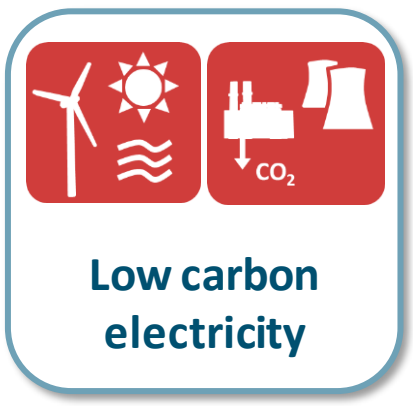
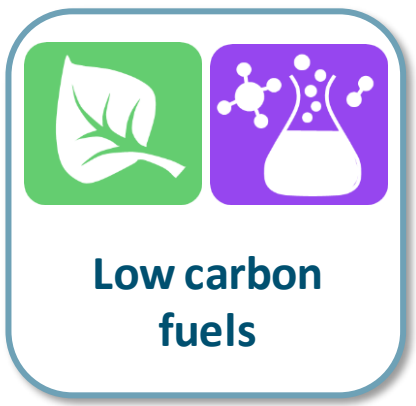
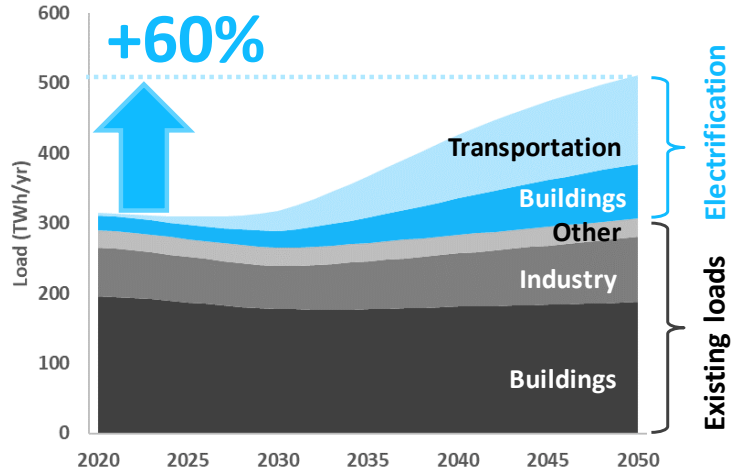
“Four Pillars” of decarbonization point to the crucial role of the electricity sector

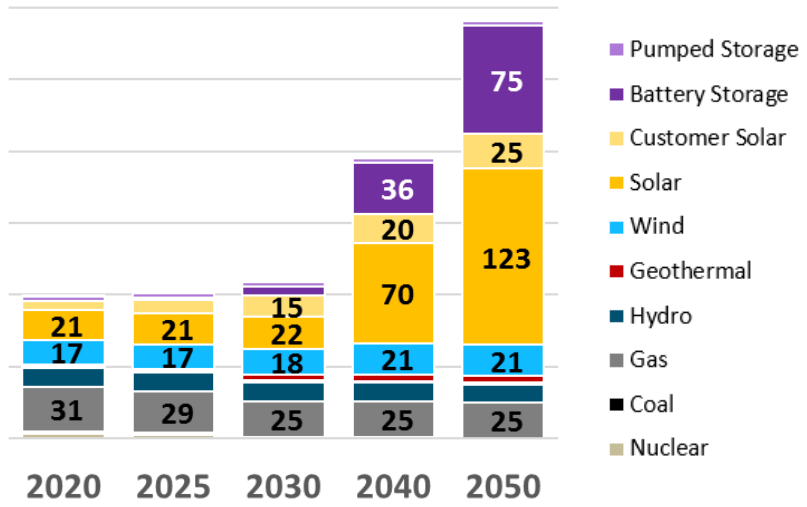




California Electric Loads under Deep Carbon Reductions



California Electric Resources under Deep Carbon Reductions

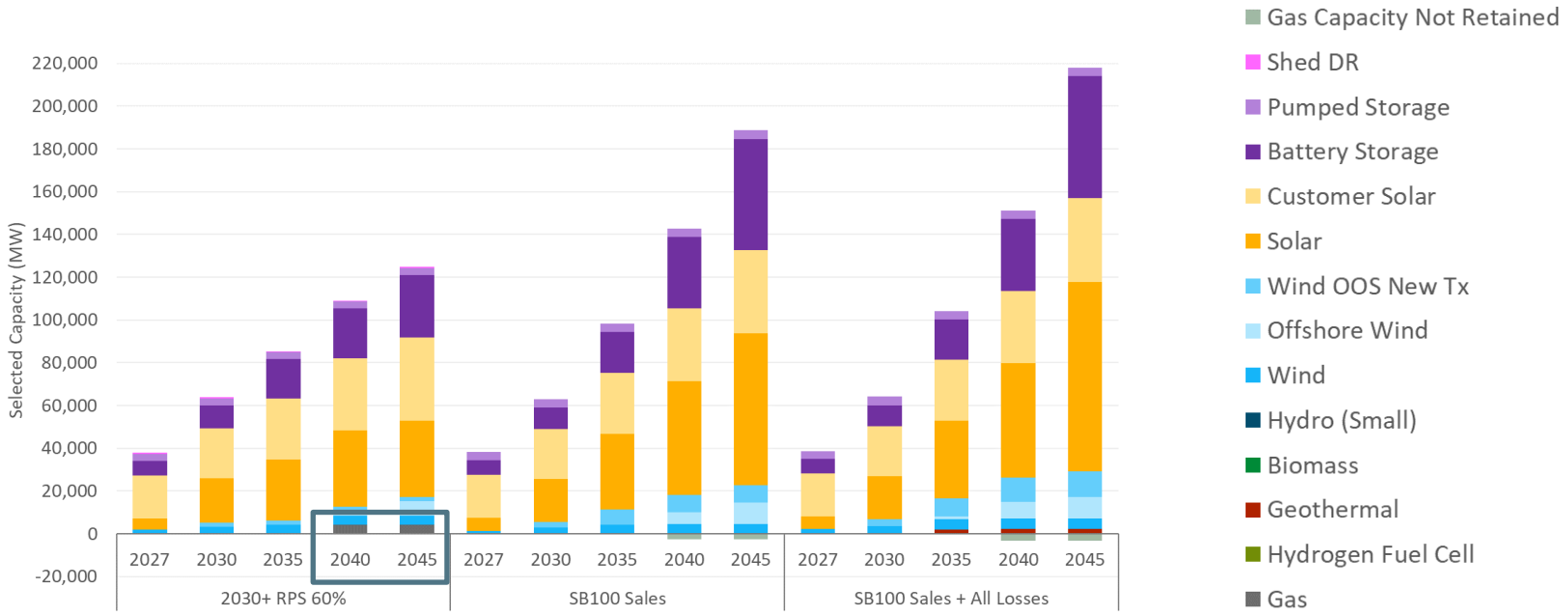


Clean electricity displaces fossil fuels as the main source of primary energy

California's SB 100 study

- **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

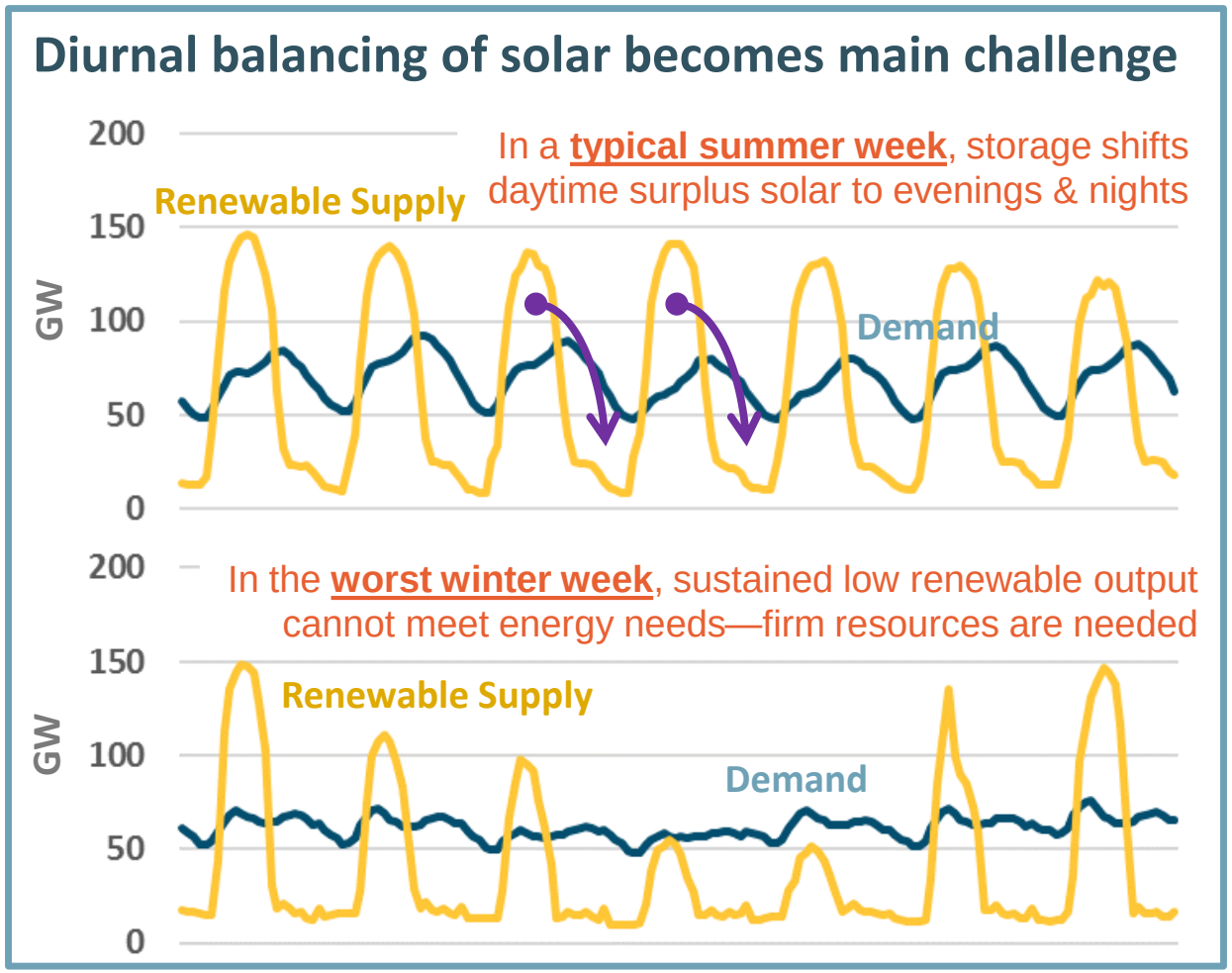
High Electrification



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

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

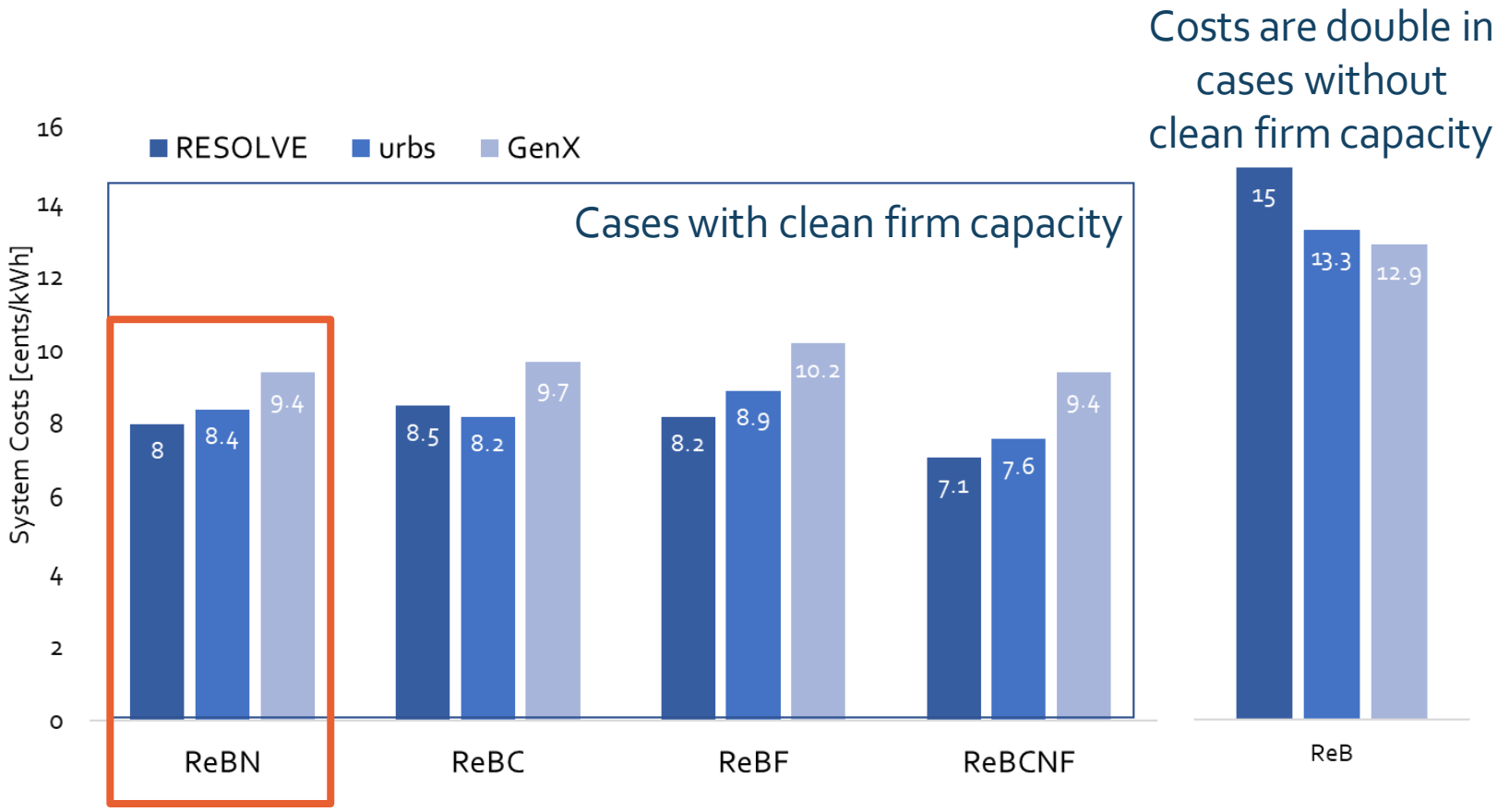
- **The combination of solar and batteries is effective at meeting summertime needs driven by heat events**
  - Supplements the existing portfolio of hydro and natural gas generation
- **Wintertime cold weather events will pose an increasing challenge due to electrification of building heat**
  - Vehicle electrification will also add to the challenges
- **California will still need over 30 MW 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, Long Run Resource Adequacy Under Deep Decarbonization Pathways for California

California "Clean Firm" Power Study: Clean firm resources are needed for California to reach net zero carbon

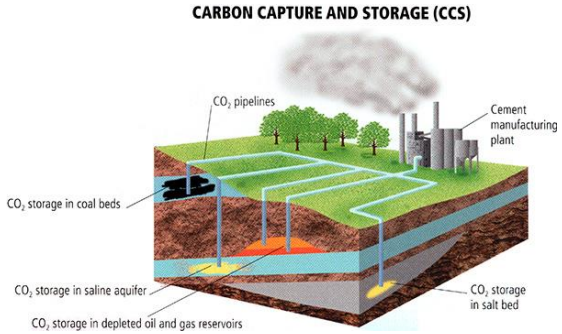
- **Any single clean firm resource (nuclear, gas w/ CCS, hydrogen) can play this role**
- **Clean firm resources also complement each other and can achieve the most cost savings when existing in a system together**

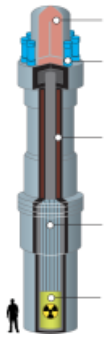


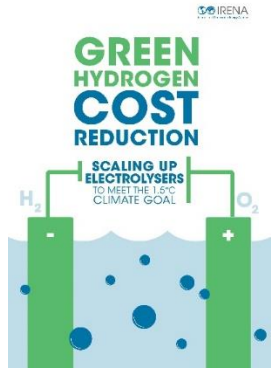
Study funded by Environmental Defense Fund and Clean Air Task Force with analysis by E3, Stanford and Princeton
https://www.ethree.com/e3-contributes-to-new-study-showing-clean-firm-power-is-key-to-decarbonized-california/

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**







Key points from long term transition

- **Firm resources are needed to ensure resource adequacy during and after the transition**
  - Public investment in firm resources will be needed to ensure one or more breaks through
  - Eliminating all carbon emissions from the power system will be difficult or impossible to achieve without a clean firm resource
- **Reasonable electric rates are needed to induce electrification**
  - Consumer economics of heating electrification are difficult
- **Low-capital sources of flexibility will be at a premium**
  - Inducing **load flexibility** through rate design and DER programs
  - **Flexible EV charging** will be critically important
  - **Enhanced regional coordination** can help make the most of load-resource diversity across the Western Interconnection

In the near- to medium-term, we will continue to rely on a mix of conventional and clean resources

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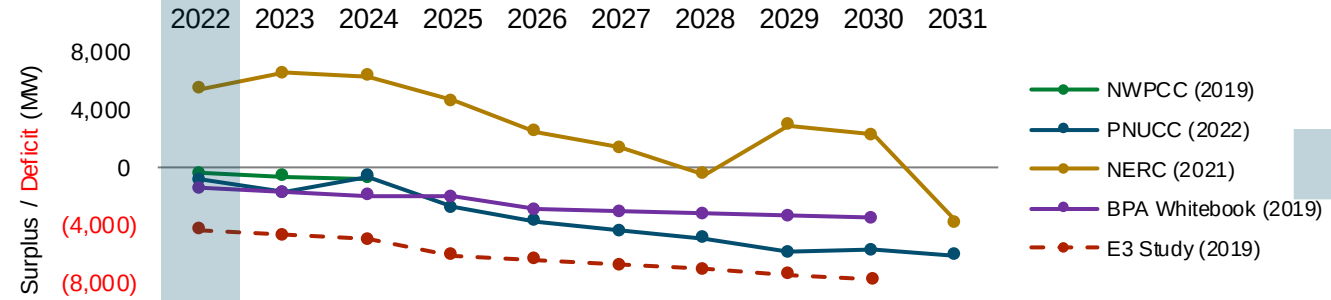
The Western Interconnection is facing immediate resource adequacy challenges

- 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 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

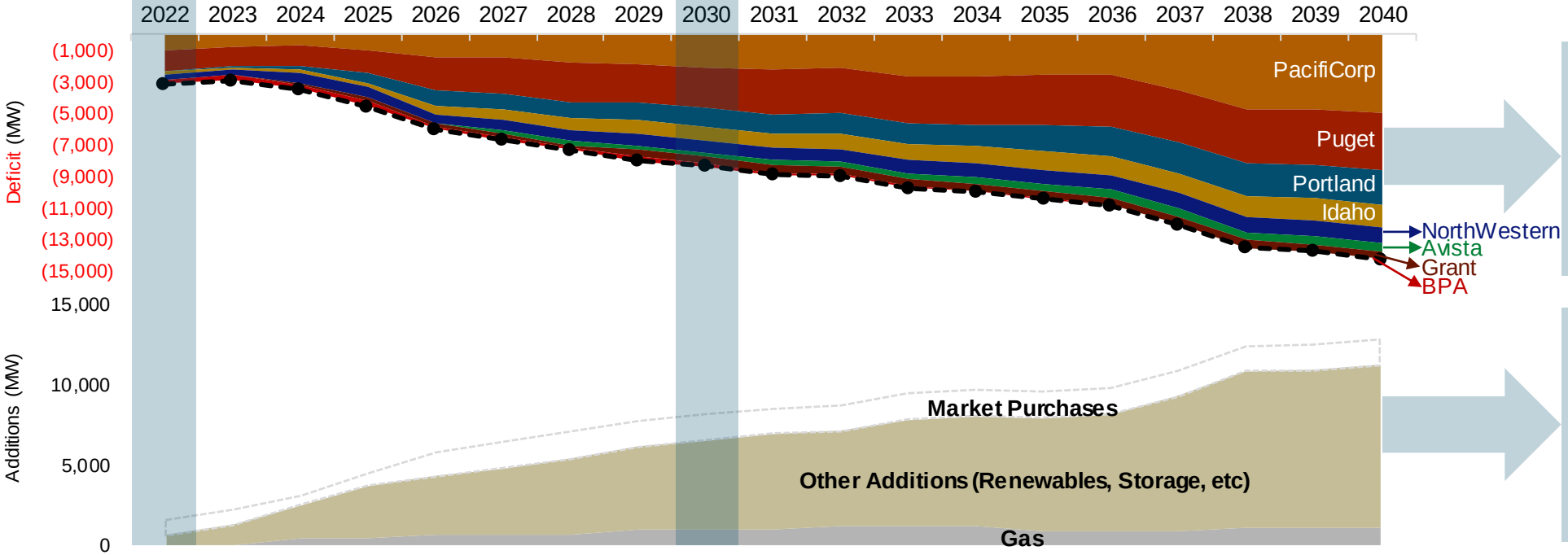
Regional Capacity Already Short for Reliability Planning Purposes, Top-Down or Bottom-Up



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

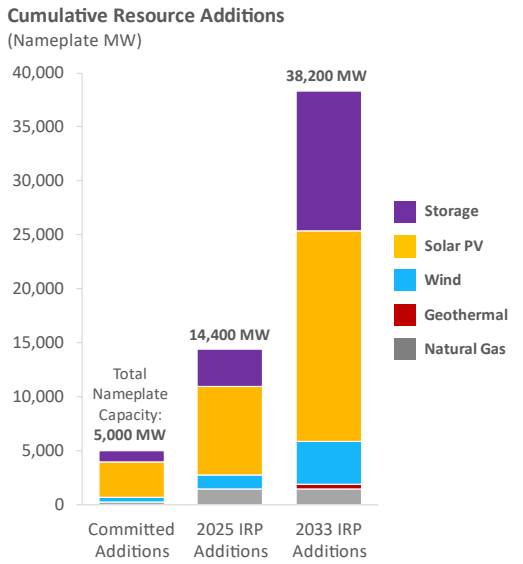
IRP Planned Additions

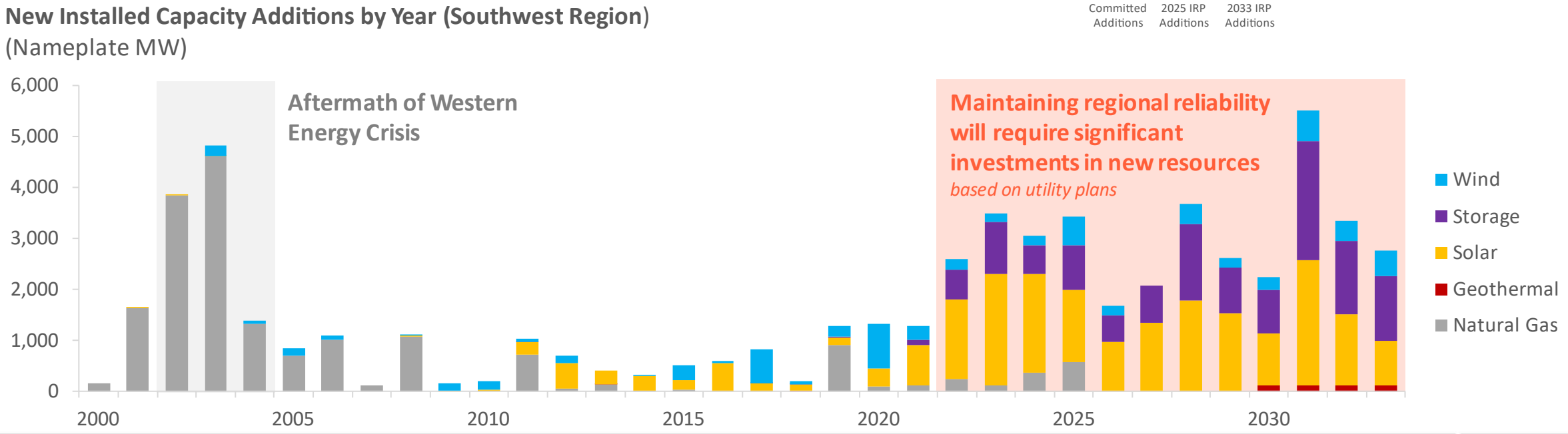
~6.5 GW effective capacity additions by 2030 (up to ~14 GW nameplate capacity), **significantly exceeding average capacity expansion rate for 2010-2020 (~1 GW/year)**

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.

Maintaining load-resource balance in the Southwest will require resource development at 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



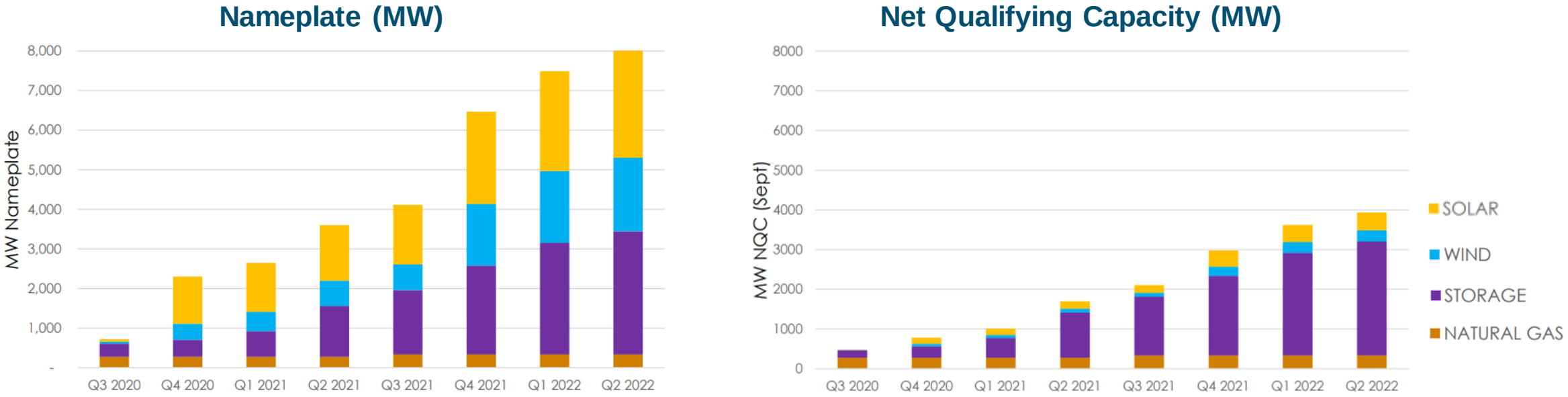


Source: E3, Resource Adequacy in the Desert Southwest

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

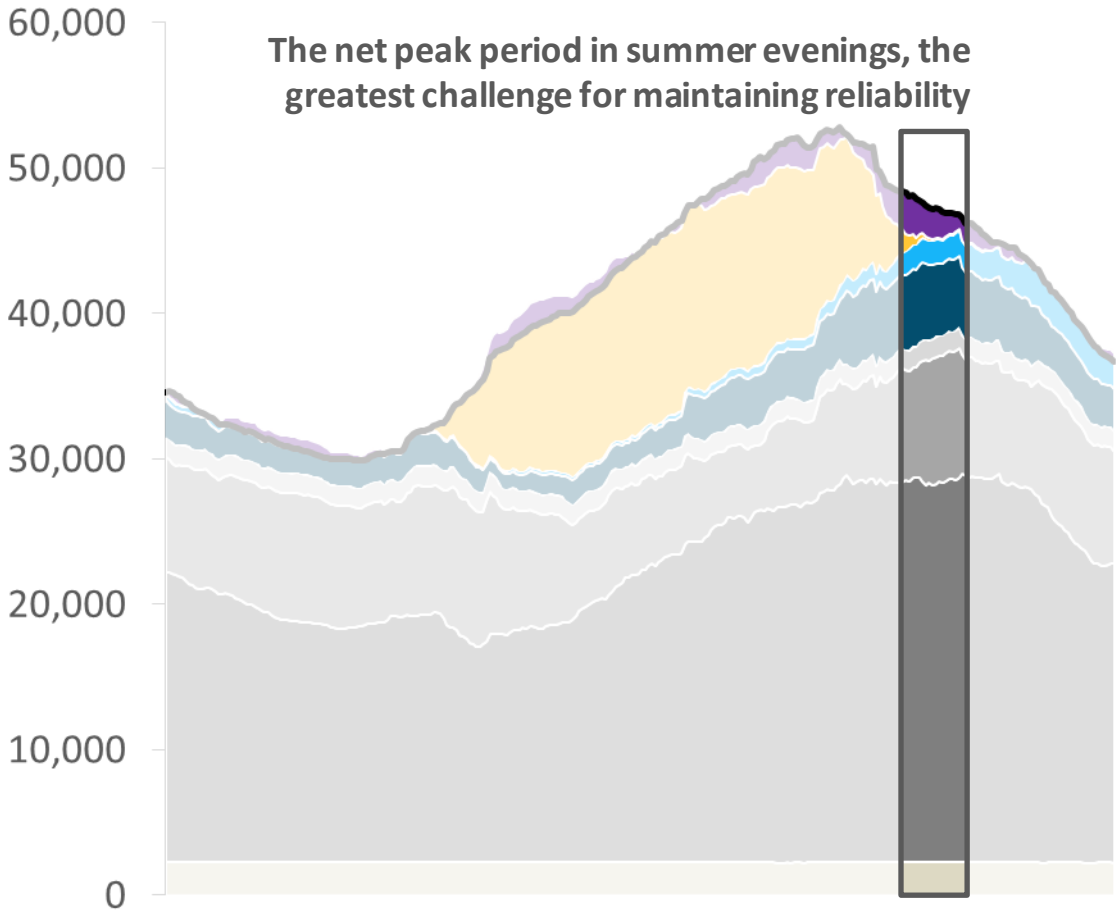
Cumulative New Resource Additions: 2020-2022



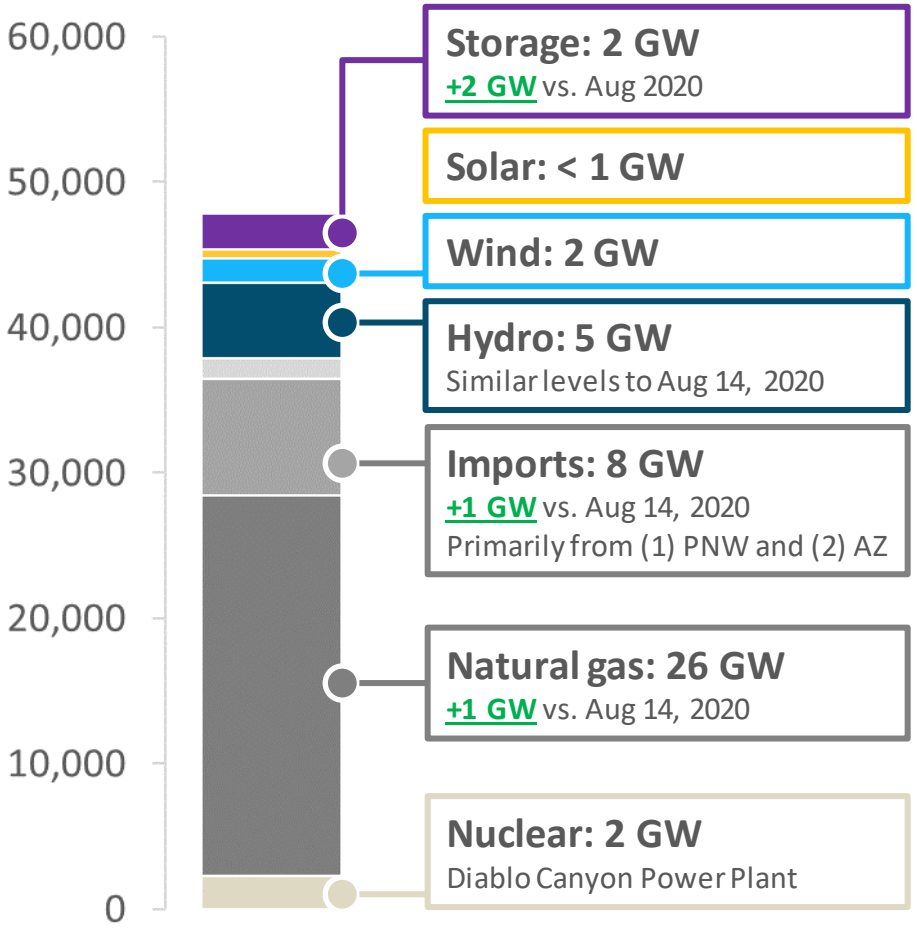
Source: CPUC https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/summer-2021-reliability/tracking-energy-development/cec-may-reliability-workshop-tracking-energy-development-may-2022.pdf

September 6, 2022: All hands on deck

CAISO System Operations on September 6, 2022
(MW)

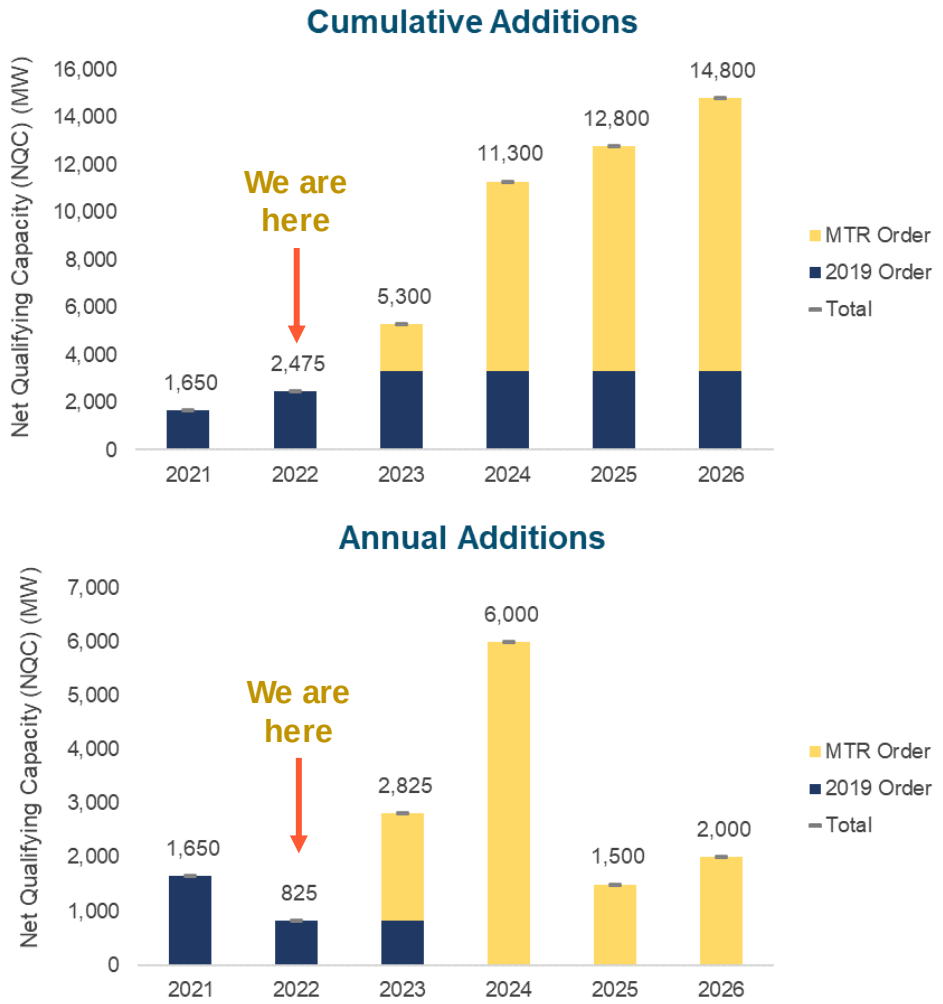


Generation During Hour of Highest Net Load
(MW)



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)**



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

Current and future challenges in western resource adequacy

+ Adapting to more frequent extreme weather

- Heat events in the West are unprecedented in their severity and geographic extent

+ Programmatic changes

- Integration of deterministic "Slice of Day" concept with stochastic loss-of-load modeling
- Proposed Reliable Clean Procurement Program (RCPP)

+ Integrating resource adequacy constructs across the Western Interconnection

- Coordination is necessary to ensure no "double-selling" of resource adequacy capacity
- A west-wide program could leverage load and resource diversity across a larger footprint

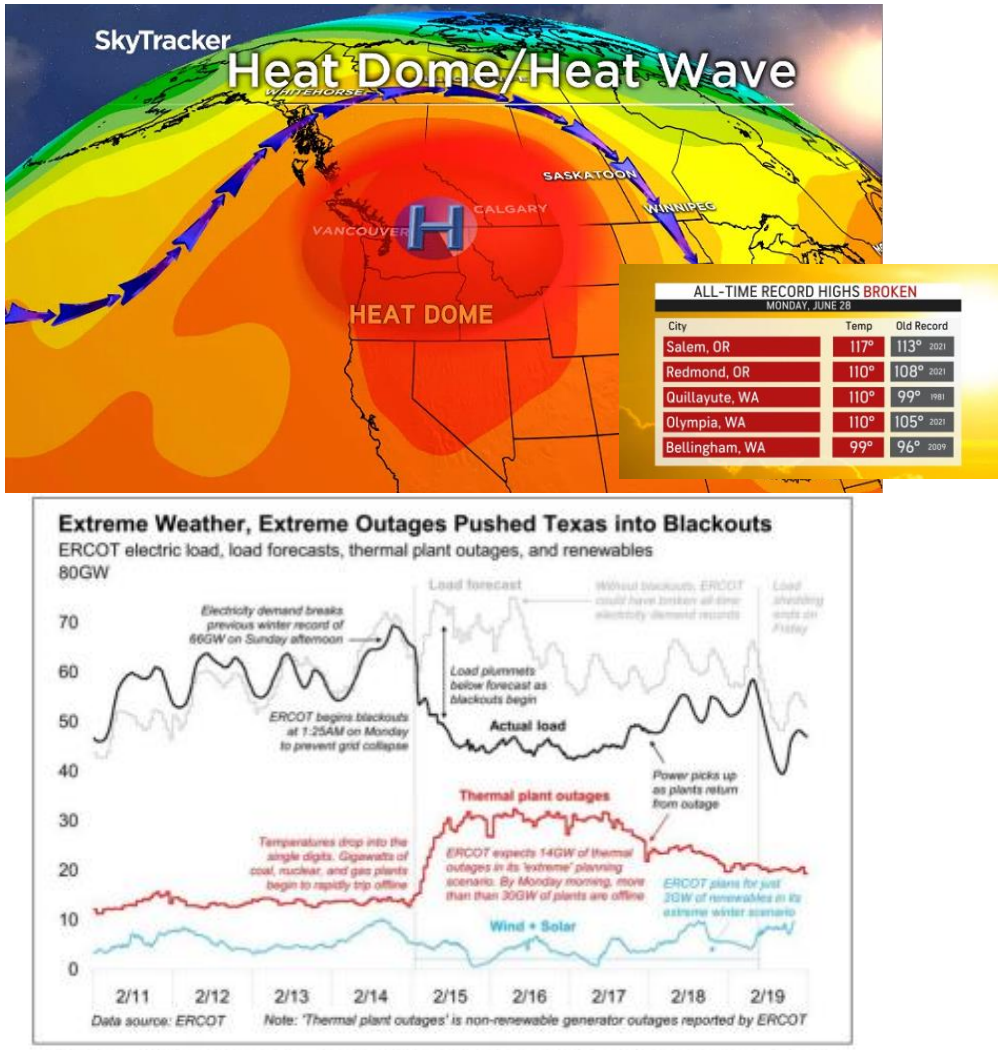


Figure 1. ERCOT data posted to Twitter by Brian Bartholomew (@BPBartholomew)

Thank you!

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

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