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SB 423 Firm Zero-carbon Resources Workshop

November 17, 2023

Introduction

- Q&A and Comments: Zoom Q&A function
- Administrative questions: Zoom Chat function
- Public comments due December 1, 2023
- CEC Docket 21-ESR-01

Comments from the Dais

Agenda

- **Introduction: SB 423 Requirements and Goals of Today's Workshop**
  - Liz Gill
- **Firm Zero-carbon Resource Technology Assessment**
  - Chie Hong Yee Yang
- **SB 423 Reliability Analysis**
  - Hannah Craig
- **Question and Answer**

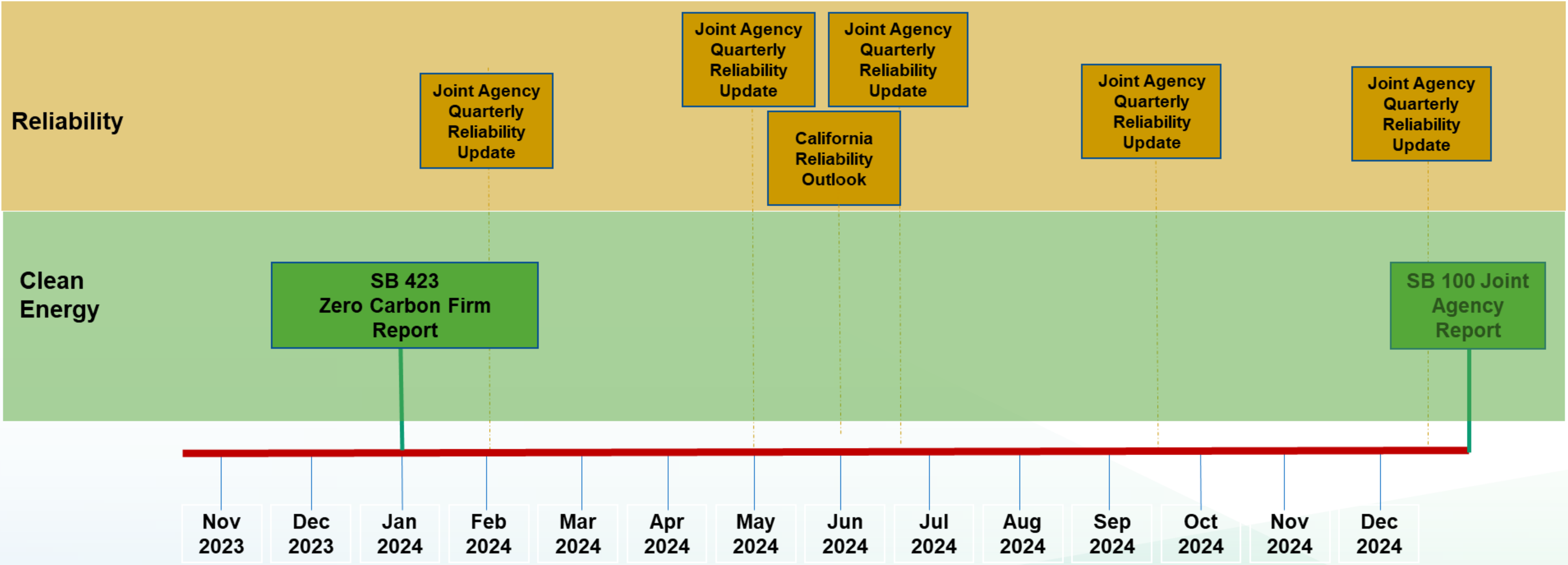
SB 423 CEC Requirements

- Identifying commercially feasible and nearly feasible firm zero-carbon resources that can enhance grid reliability while reducing greenhouse gas, air contaminant, and air pollutant emissions.
- Evaluating the potential need for these resources, considering various cost and performance scenarios to incorporate renewable energy into the grid on a daily, multi-day, and seasonal basis.
- Identifying barriers to the development of these resources and proposing solutions, including options for procurement by various entities.
- Recommending changes to research, demonstration projects, and energy incentives to enhance the contributions of zero-carbon resources to grid reliability, with a focus on reducing emissions in disadvantaged communities.
- Evaluating load-serving entities' resource plans under extreme weather conditions and assessing their resilience, especially during prolonged periods of low renewable energy generation.
- Assessing the use of energy storage to achieve the goals set forth in this section.

Scope of This Report

- Identify and assess readiness, cost, and characteristics of firm zero-carbon resources
- Identify barriers to firm zero-carbon resource deployment
- Evaluate the role of firm zero-carbon resources in resource portfolios
- Evaluate portfolios under extreme weather events

Related Clean Energy and Reliability Efforts



Goals of this Workshop

- Present preliminary information on the readiness, cost and performance attributes of firm zero-carbon technologies
- Present preliminary results of reliability modeling assessing:
  - The relative reliability value of firm zero-carbon resources
  - The reliability of portfolios under extreme weather events

SB 423 Firm Zero-carbon Resources

Chie Hong Yee Yang, Energy Assessments Division

November 17, 2023

Overview

- What is Firm Zero-carbon
- Identification Assessment of Firm Zero-carbon Resources
- Reliability of Load Serving Entity (LSE) Integrated Resource Plans (IRPs)
- Recommended Changes to R&D Projects
- Barriers
- Conclusions and Recommendations

Defining Firm Zero-carbon Resources

"Firm zero-carbon resources are electrical resources that can individually, or in combination, deliver zero-carbon electricity with high availability for the expected duration of multiday extreme or atypical weather events, including periods of low renewable energy generation, and facilitate integration of eligible renewable energy resources into the electrical grid and the transition to a zero-carbon electrical grid."

Working Definition

Firm Zero-carbon Resources are resources or combination of resources that reliably produce zero-carbon electricity on demand, ensuring a consistent and stable power supply for extended periods and/or are eligible for the Renewable Portfolio Standard (RPS).

<u>For the purposes of this analysis, a firm zero-carbon resource must satisfy the following criteria:</u>

- **Provides steady electricity output**
  - No stand-alone wind or solar resources
  - Zero-carbon fuels storage (e.g., hydrogen storage, reservoirs)
  - Natural gas pairing with CCUS allowable (100% capture rate or partial counting for less than 100%
  - Flex fuel may be acceptable
- **Enables multi-day operations**
  - Able to operate during subsequent days of an extreme event
  - Systems must be dispatchable or baseload – not necessarily 24/7

Overview of Firm Zero-carbon Resources

Resources	Technologies
Solar/Wind + Storage	Solar/Onshore Wind/Offshore Wind + Storage (Lithium-Ion)
Long-Duration Energy Storage	Flow, Iron Air, Zinc, Compressed Air Energy Storage – must be charged with clean energy
Hydropower	Pumped Storage Hydro, Large Hydro, Small Hydro
Geothermal	Conventional Hydrothermal, Enhanced Geothermal Systems
Renewable Natural Gas	Thermochemical (Gasification and Pyrolysis), Anaerobic Digestion, and Landfills
Hydrogen	Fuel Cells, Combustion Turbines, Reciprocating Engines, Non-Combustion and Non-Fuel Cell Gas Fueled Generators, Hydrogen Storage
Carbon Capture	Point Source Capture
Fission	Small Modular Reactors
Fusion	Inertial Confinement Fusion, Magnetic Confinement Fusion

Role of Resources

- **Local Reliability**
- **Resiliency[1]**
- **System Reliability**
- **Emissions**

Resources	Role		
Solar/Wind + Storage	◐	●	●
Long-Duration Energy Storage (LDES)	◐	●	●
Hydropower	●	●	○
Geothermal	●	●	○
Renewable Natural Gas (RNG)	●	●	○
Hydrogen	◐	●	○
Modular Fission Reactors	◐	●	●
Fusion		●	●
Carbon Capture		●	●

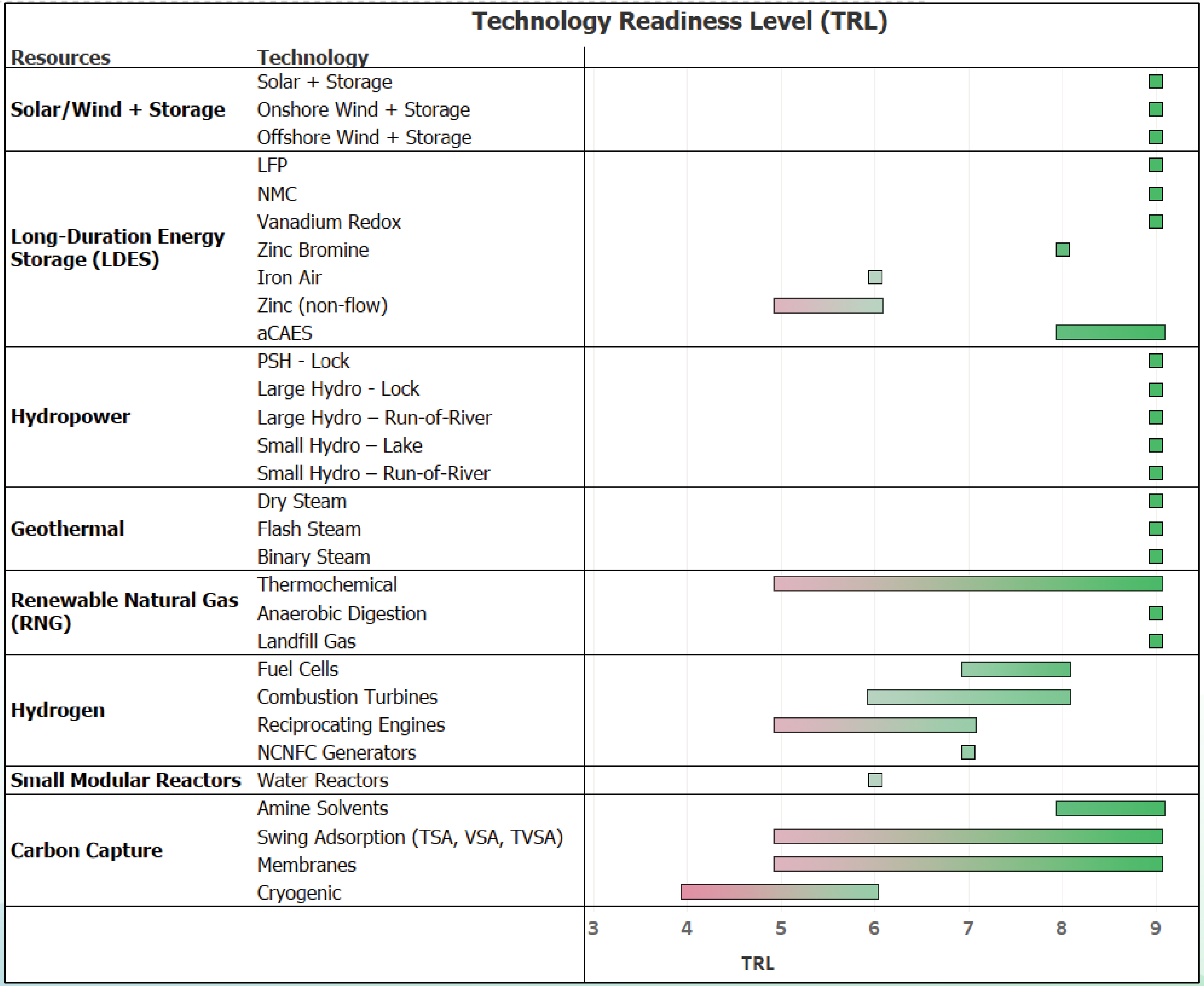
- Local Reliability
- Resiliency
- System Reliability
- Zero Emissions
- Low Emissions

Note on hydrogen: combustion produces NOx emissions

Technology Readiness

Technology Readiness Levels (TRL) are a systematic metric that is used to assess the maturity of a particular technology.

- **TRL 1** - Basic Principles Observed
- **TRL 2** - Technology Concept Formulated
- **TRL 3** - Proof of Concept
- **TRL 4** - Technology Validated in Lab
- **TRL 5** - System Prototype Demonstrated in Relevant Environment
- **TRL 6** - System Model or Prototype Demonstrated a Relevant Environment
- **TRL 7** - System Prototype Demonstrated in an Operational Environment
- **TRL 8** - Actual System Completed and Qualified
- **TRL 9** - Full-Scale Deployment



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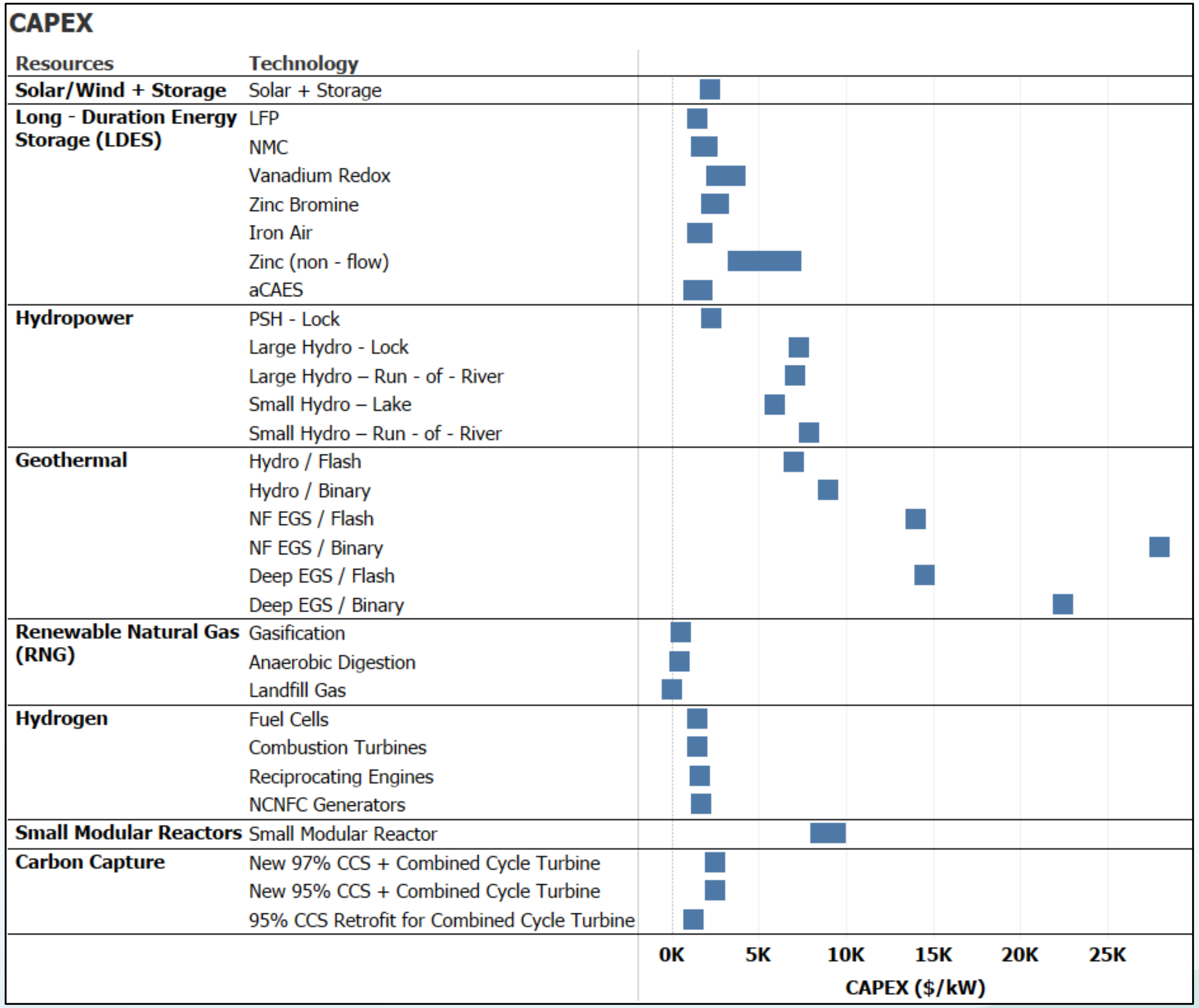
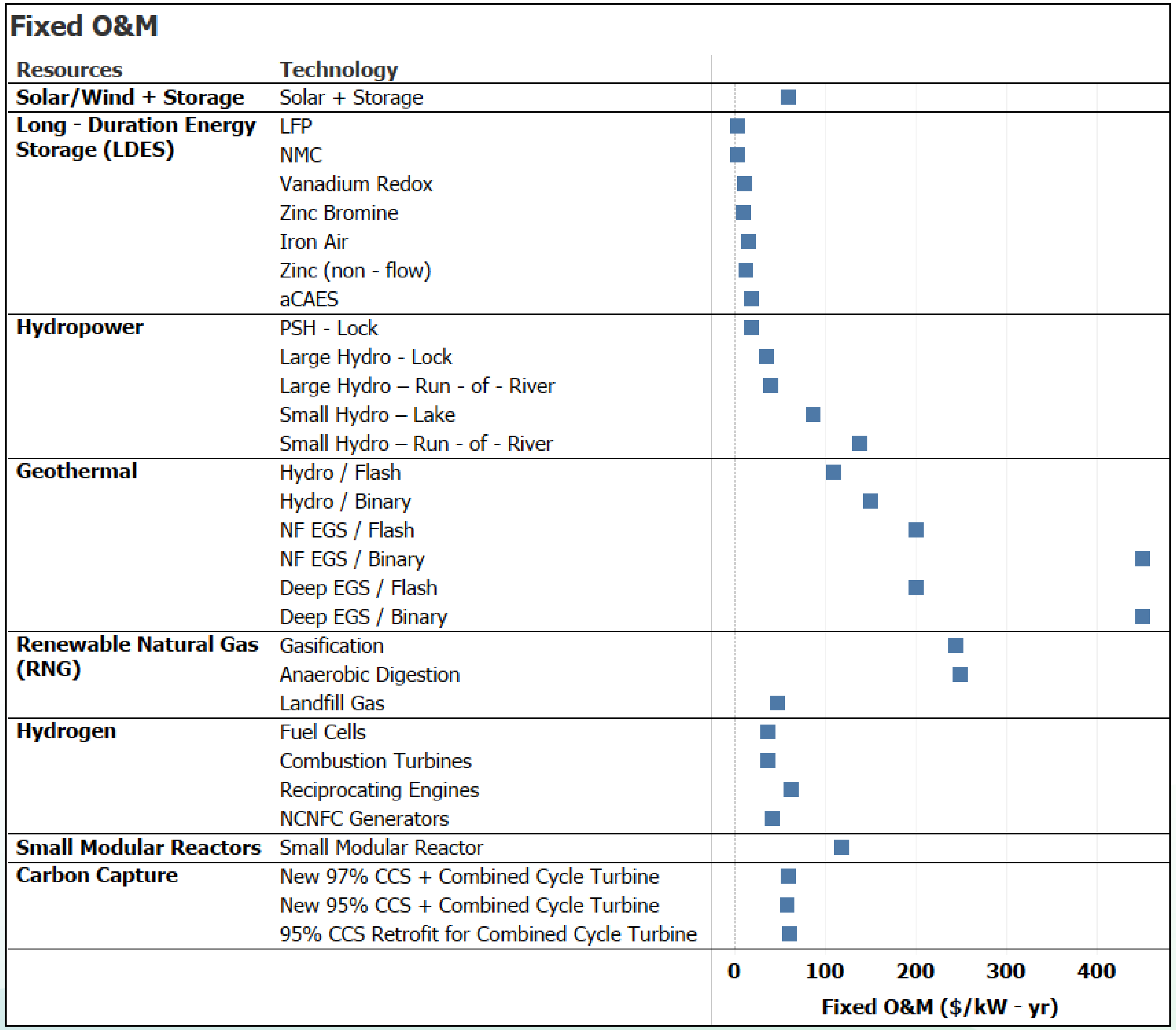
Costs



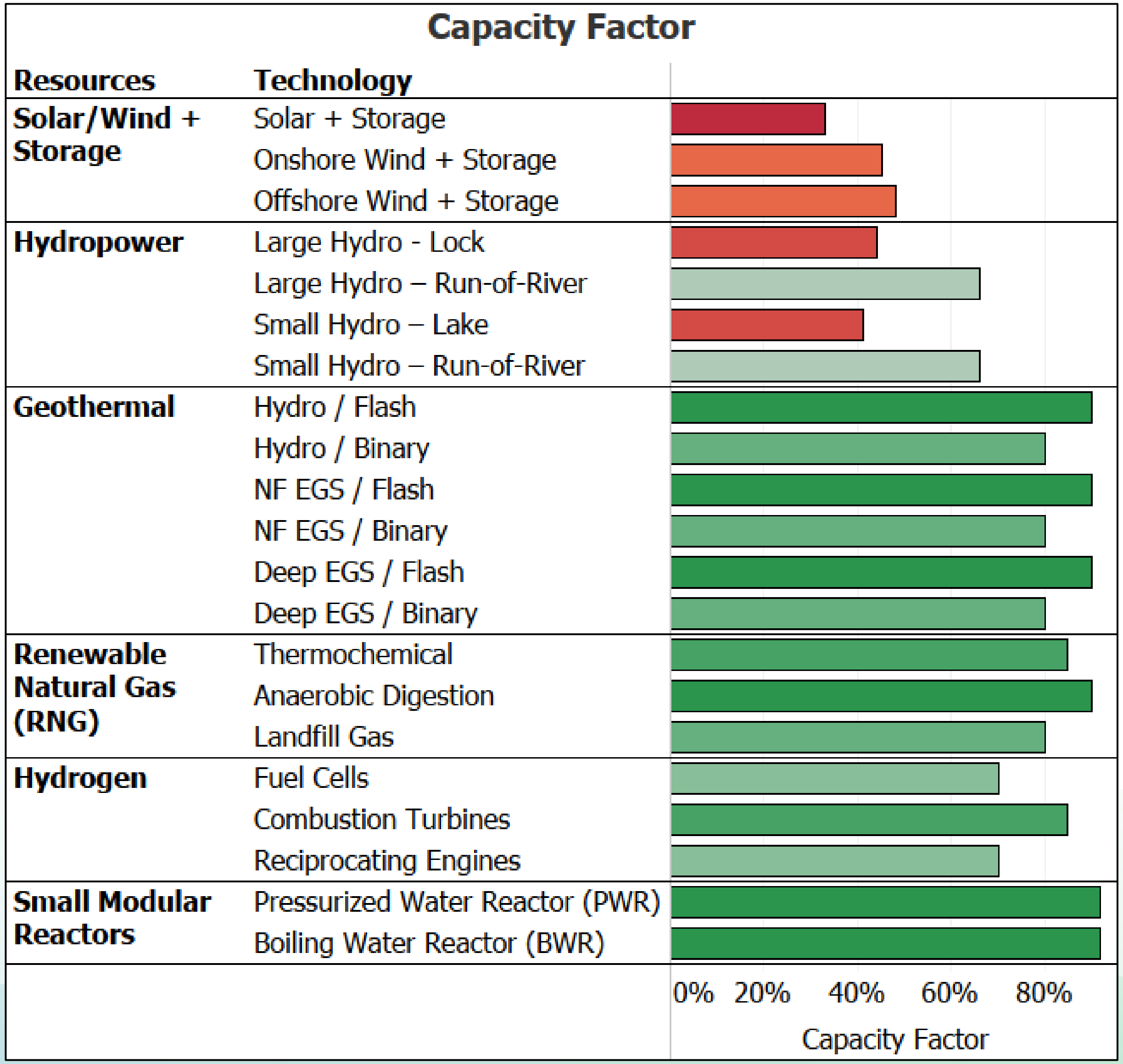


Note: limited or no data on wind resources

Performance

Capacity factor is a measure that represents the actual output of a power plant or energy system over time, compared to its maximum potential output if it operated at full capacity continuously.

- expressed as a percentage
- higher capacity factor indicates consistent operation.



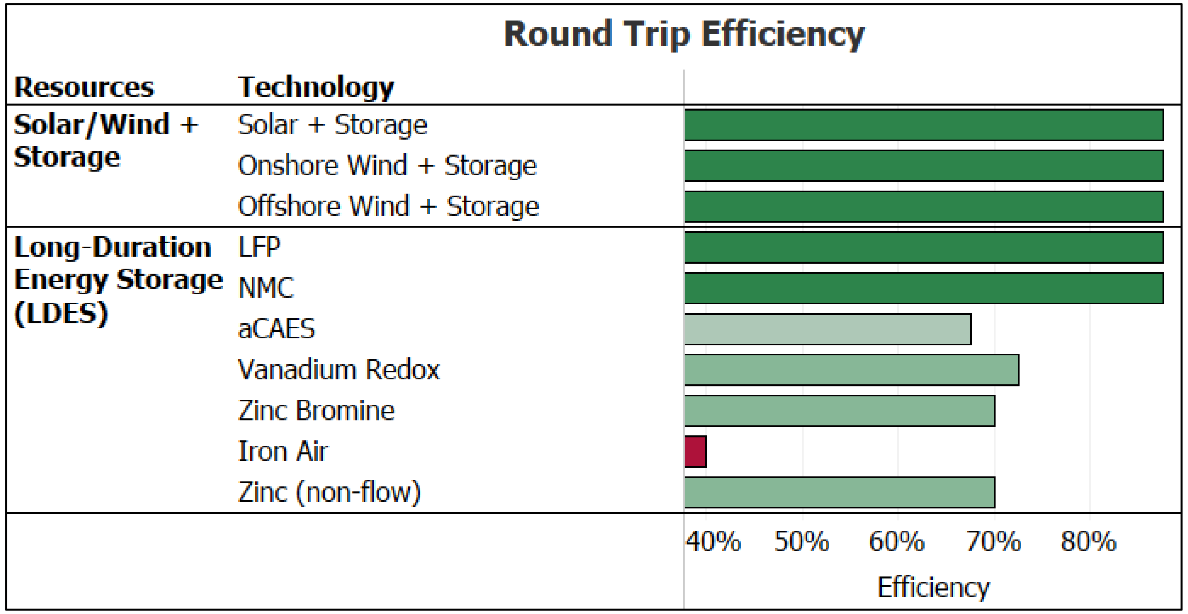
Note: capacity factors for wind resources is based on nation-wide data on the wind resource only.

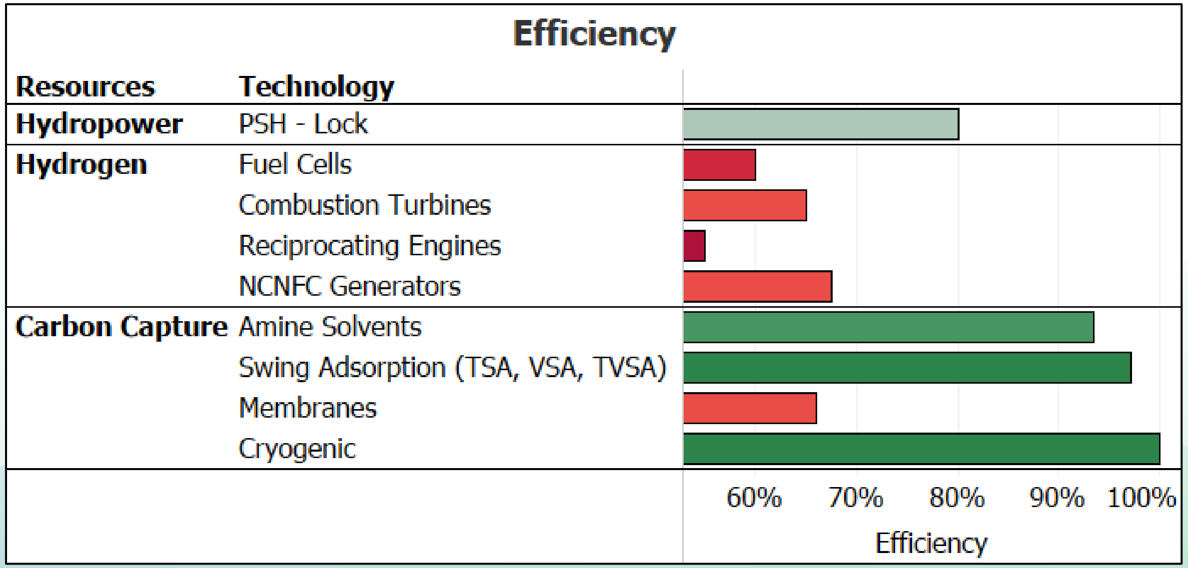
Performance

Round trip efficiency (RTE) is a measure of how well a system can convert and then recover energy, expressed as the percentage of energy output compared to the energy input in a complete cycle.

Efficiency is a measure of how well a power plant converts the energy in its fuel into electricity.

- How effectively a power plant generates electricity from the fuel it uses





Note: RTE for hybrid/co-located systems is based on storage technology only.

Research and Development

Research programs, funding and incentives

- Electric Program Investment Charge – EPIC
- Long Duration Energy Storage (LDES) Program
- Clean Hydrogen Program (AB 209)
- $1.2 billion federal funding for Hydrogen Hub
- Active Gas Research and Development projects supporting hydrogen production and use

https://www.energy.ca.gov/publications/2023/eos-energy-storage-utility-demonstration-non-flammable-aqueous-zinc-battery

https://www.cnbc.com/2021/08/25/form-energy-raises-240-million-on-iron-air-battery-promise.html

https://fuelcellsworks.com/news/u-s-department-of-energy-makes-historic-award-of-up-to-1-2-billion-for-a-regional-clean-hydrogen-hub-in-california/

EPC-19-045, Invinity Vanadium Flow Battery installed at the fire station run by the Soboba Band of Luiseno Indians

Conclusions

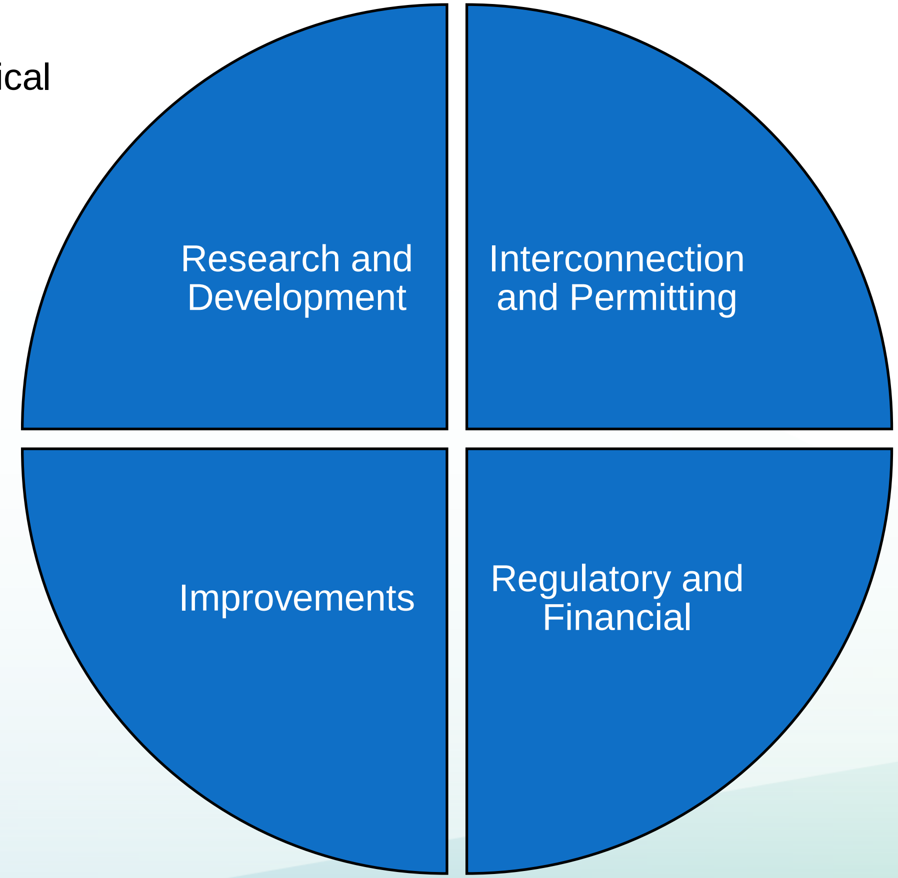
Four overarching themes for key takeaways. Each theme encompasses various crucial elements from the extensive takeaway list, and a detailed breakdown, for each resource, will be provided in the release of the draft report.

Research and Development

- How can programs meet technological development needs?
- Identify potential solutions
- Define key steps for emerging technologies

Interconnection and Permitting

- How can processes be more streamlined and expedited?
- What outreach and education is needed?
- Identify best practices



Improvements

- How to improve existing infrastructure?
- Identify opportunities to repurpose and upgrade.

Regulatory and Financial

- What financial and regulatory signals are needed?
- How to optimize financial models to account for a diverse portfolio of resources?

Question and Answer

SB 423 Reliability Analysis

Hannah Craig, Energy Assessments Division

November 16, 2023

Objectives of SB 423 Reliability Modeling

- Evaluating the potential need for these resources, considering various cost and performance scenarios to incorporate renewable energy into the grid on a daily, multi-day, and seasonal basis.

- Evaluating load-serving entities' resource plans under extreme weather conditions and assessing their resilience, especially during prolonged periods of low renewable energy generation.

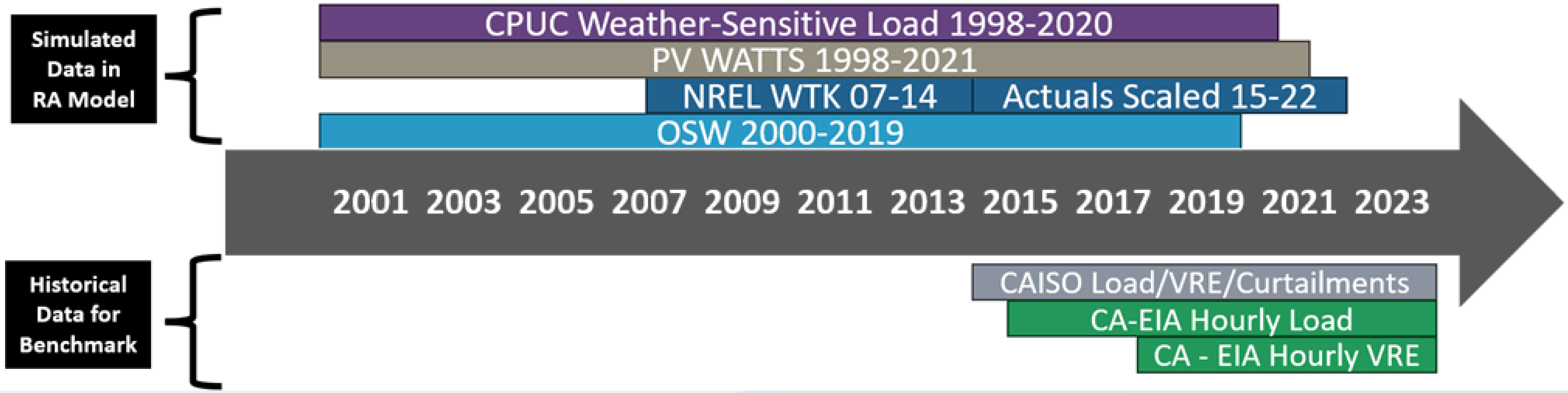
Overview

- **Modeling Objective #1:** How does incorporating more firm resources into the portfolio affect the requirement for other resources?
  - Provide high level insight into the tradeoffs associated with firm and non-firm resources in a reliable system.

- **Modeling Objective #2:** What reliability concerns can occur with existing resource plans during multi-day weather events in the near and mid term?
  - Identify what multi-day weather events are of most concern.
  - Assess the greatest risks within those multi-day weather events.

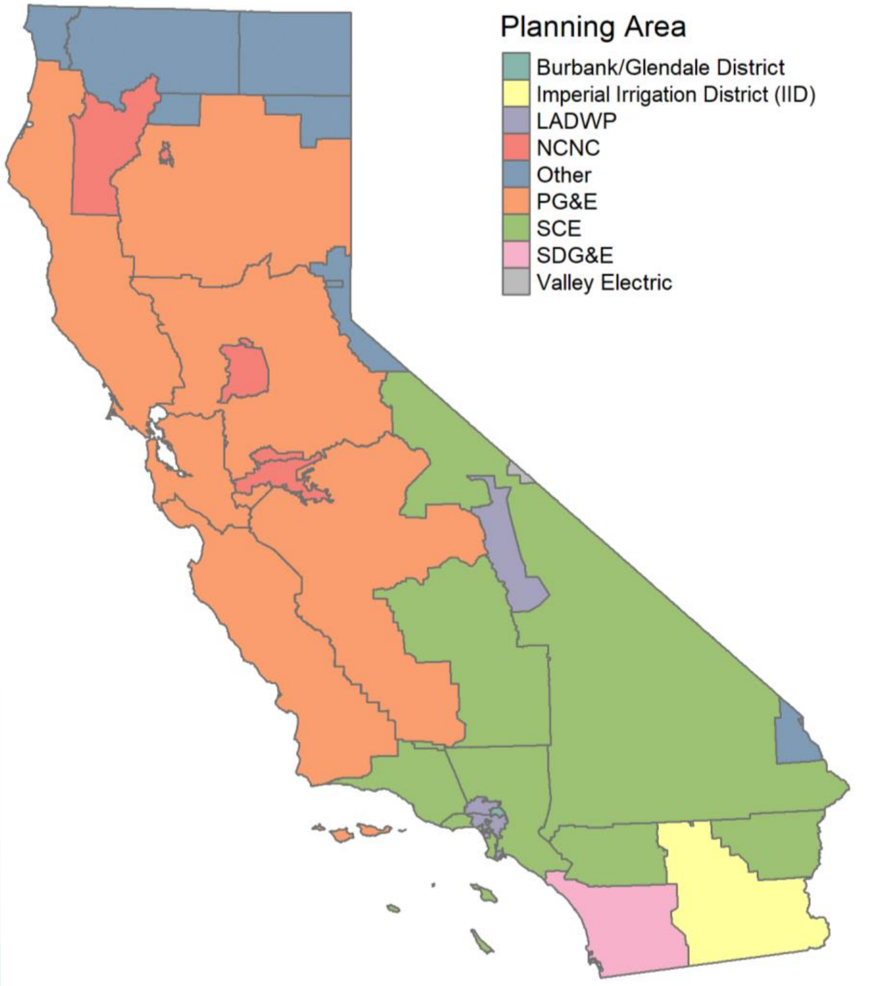
Reliability Model Basics

- Stochastic model utilizes15 weather years from 2007-2021
- CPUC demand profiles based on the 2022 CED and wind/solar shapes generated from NREL weather data
- Each weather year is run with 20 outage samples, using forced outage data from GADS



Statewide Model

- CEC model includes full detail on CA power plants but does not model WECC in detail.
- CAISO has a 5,500 MW import constraint at peak and the state has a 12,400 MW constraint for all hours of the day.
- New resources based on the Preferred System Plan adopted in 2021.
- Results reported statewide.



Firm Resources Value

Modeling Objective #1: How does incorporating more firm resources into the portfolio affect the requirement for other resources?

Firm Resources Value

PSP resources linearly scaled back to establish a baseline with LOLE of .1

Firm resources removed

Non-firm added until LOLE returns to .1

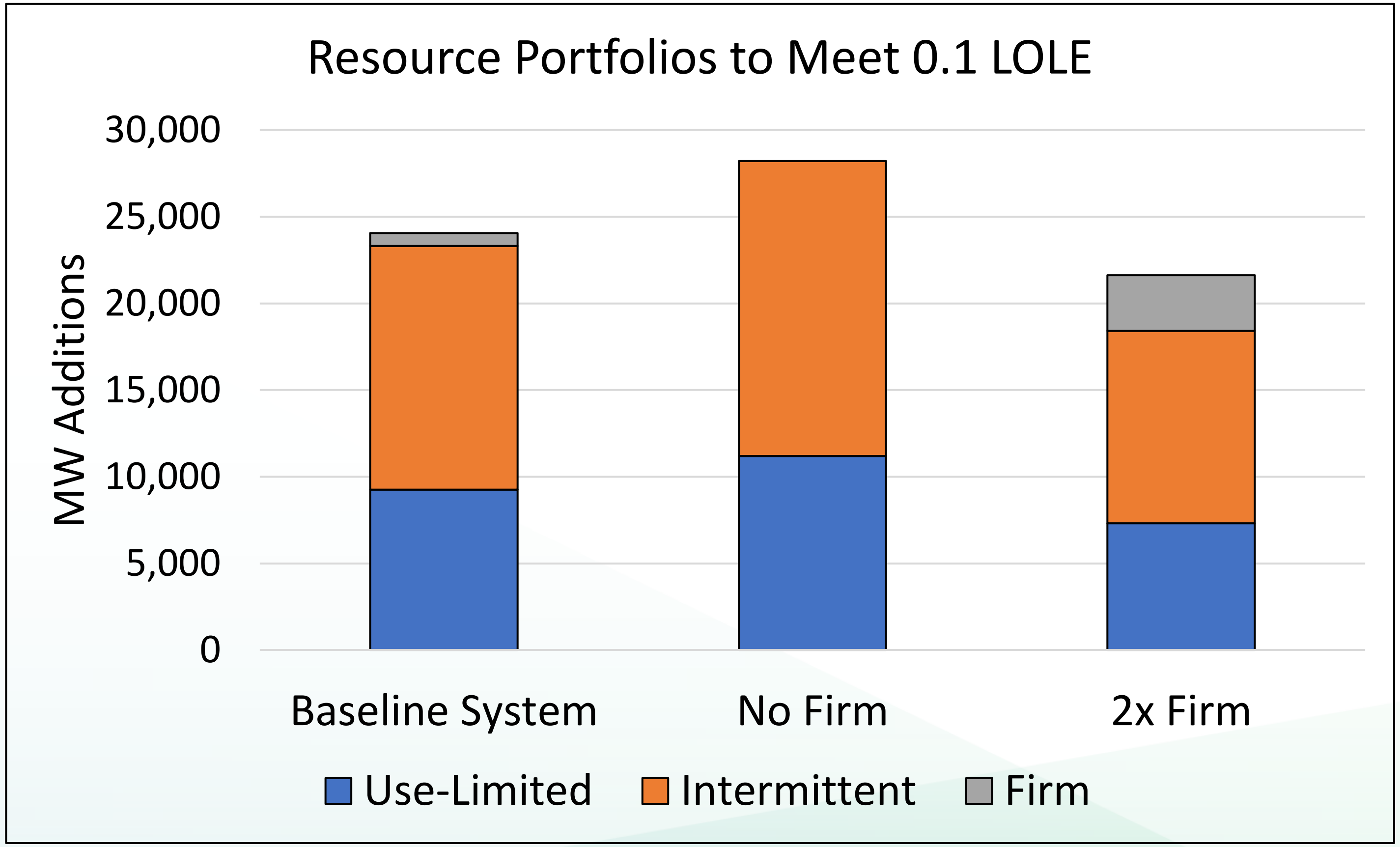
Firm resources doubled

Non-firm removed until LOLE returns to .1

The result is three portfolios with the same LOLE and 0x, 1x, 2x firm resources.

Results

	Resources
Firm	Biomass ST
	Geothermal
	16-Hour Storage
Use-Limited	Storage
	Demand Response
Intermittent	Onshore Wind
	Offshore Wind
	OOS Wind
	Solar



MW Equivalence

- Reliability can be met with firm or non-firm resources.
  - It requires about 20% more dispatchable use-limited resources to replace reliability benefits of firm resources.
  - The non-firm resources will generate significantly more renewable energy overall, since so much of the firm portfolio is hydro storage.
- Other factors such as cost, feasibility and renewable energy production should be considered in resource planning and procurement.

	Baseline	No Firm	2x Firm
Firm	1,608	0	3,216
Use-Limited	9,260	+1,944	-1,945
Intermittent	14,050	+2,949	-2,951

Multi-Day Events

Modeling Objective #2: What reliability concerns can occur during multi-day weather events in the near and mid term?

Multi-Day Events

A broad range of “Multi-Day” events are captured, which include 2-7 day events.

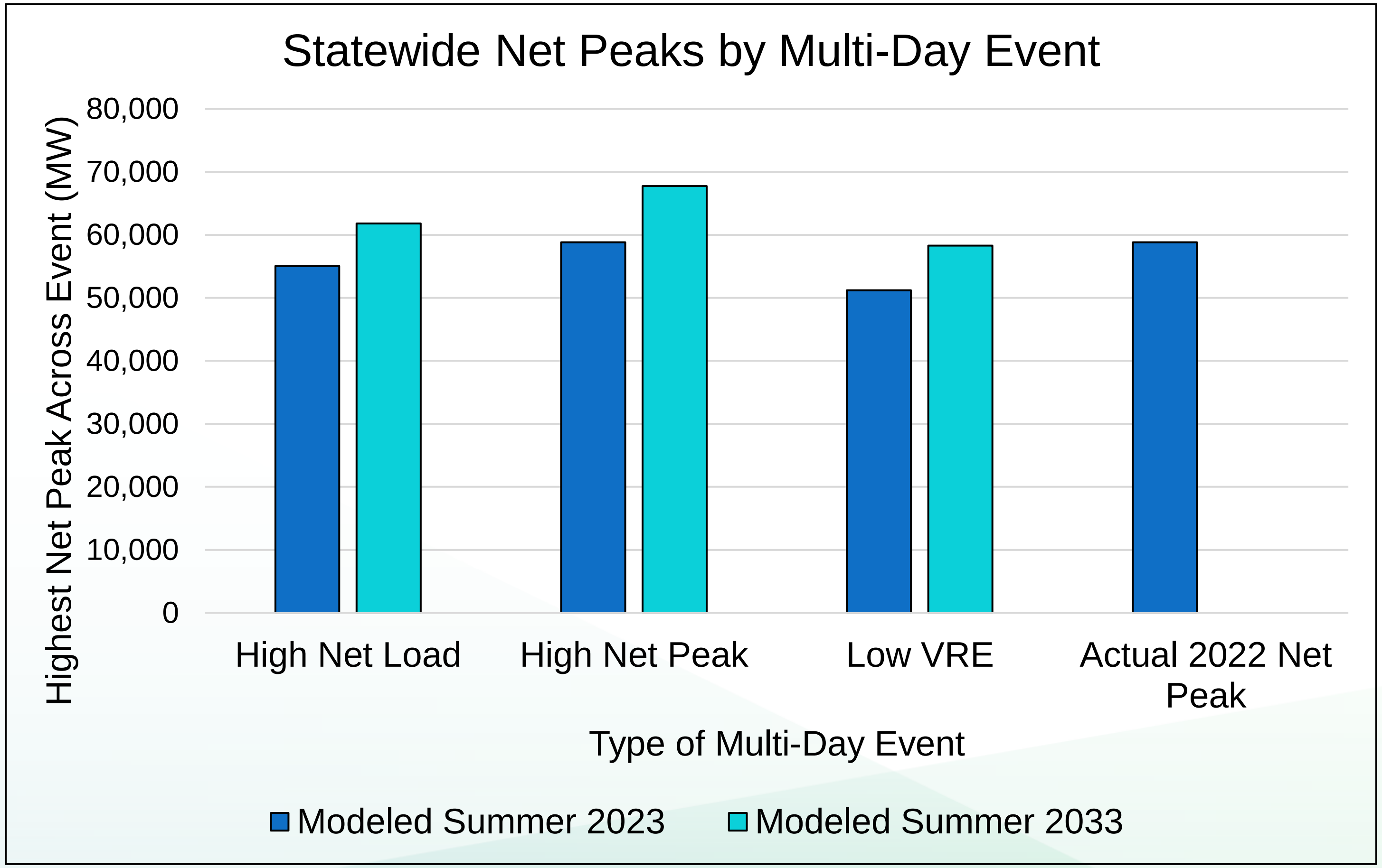
- The initial analysis used the 2023 economic year for identification of periods of high risk
- Analysis focused on 3-day events, as roughly 80% of the 2-6 day events are coincident with the 3-day period.

The following are calculated for every season for weather years 2007-2017:

- **Daily Net Load (MWh)** - Gross Load – VRE Generation
  - Identifies times when the power system would be stressed to provide high-levels of energy for multiple days coincident with load.
  - This case is primarily focused on quantifying the impact of *energy constraints* on system reliability.
- **Daily Net Peak (MW)** – Rolling Average of the peak gross load – VRE
  - Identifies when the system experiences multiple peak demand days in a row
  - This case is primarily focused on quantifying the impact of *capacity constraints* on system reliability.
- **VRE Share (%)-** VRE as percentage of Gross Load
  - Identifies when wind and solar make up the smallest percentage of resources serving load
  - This case is primarily focused on quantifying the impact of sustained, multi-day low renewable availability on system reliability.

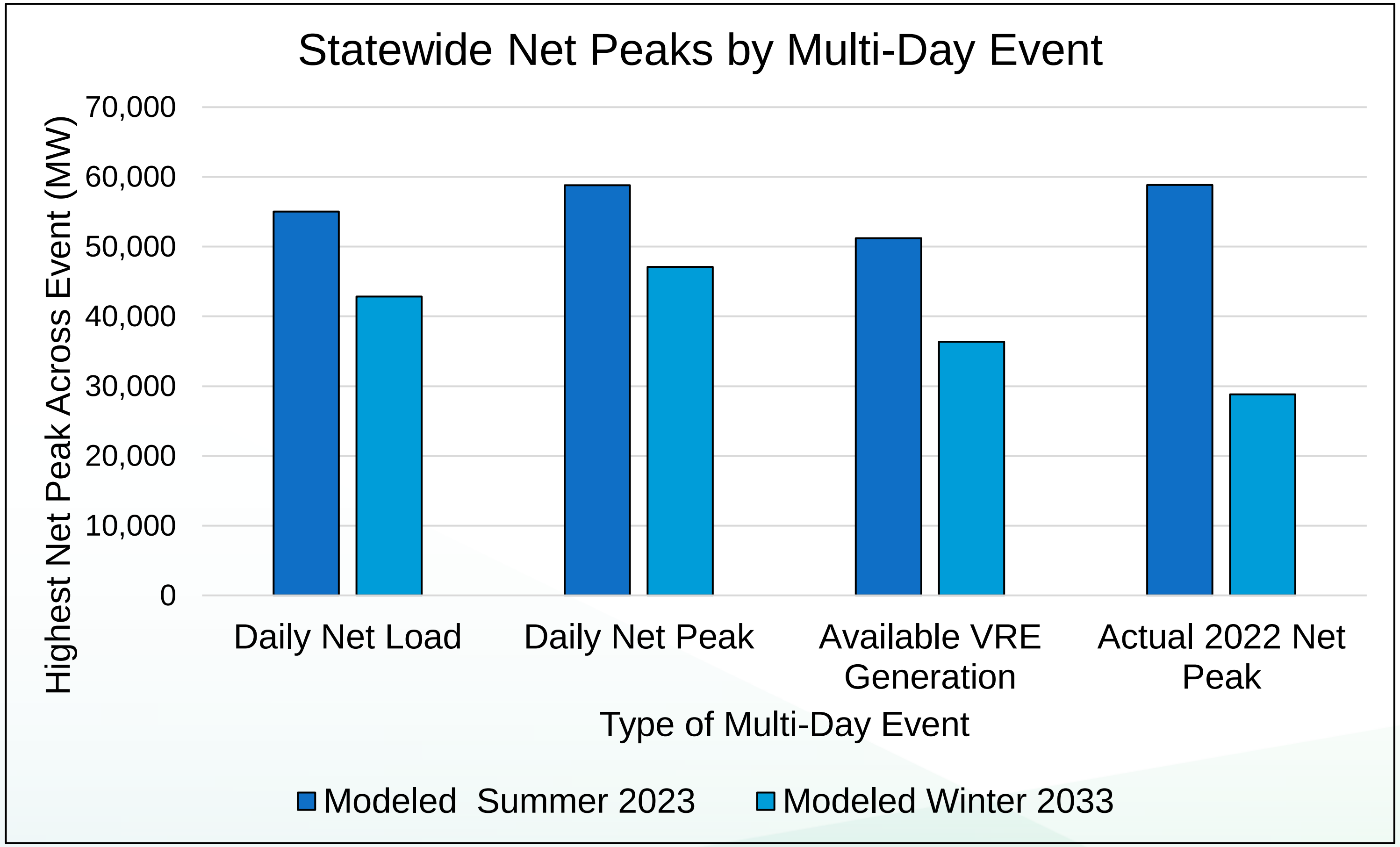
Multi Day Event Demand Peaks

- Peaks in Modeled Summer 2023 high net peak event are comparable to September 2022.
- High Load Event net peaks are not far behind.
- Net peaks in the low renewable generation scenario are significantly lower than the other two.



Winter 2033

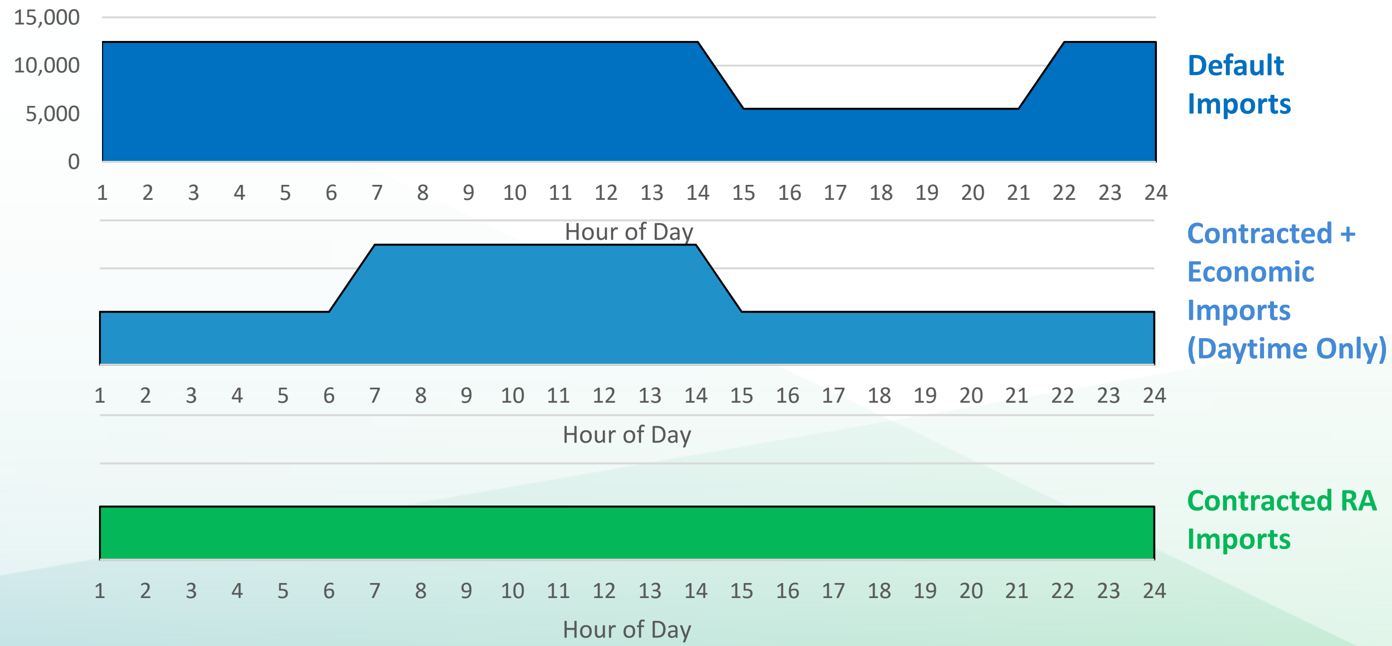
- Winter peaks are far below summer peaks, even in 2033.
- The demand shapes are based on the 2022 CED, which doesn't include as much building electrification



Multi-Day Events

- 3-day stress periods were modeled with 250 outage samples and four separate import cases
- Goal of the import stress cases is to see whether issues occur when energy is restricted to the system and whether outages are caused by peak capacity shortfalls on certain days or long periods of high energy need.

	Definition
Default Imports	5,500 MW at peak, 12,400 MW other hours
Contracted + Economic Imports	5,500 MW at peak and overnight, 12,400 MW midday
Contracted RA Imports only	5,500 MW all hours
No Imports	0 imports all hours



Multi-Day Event Results

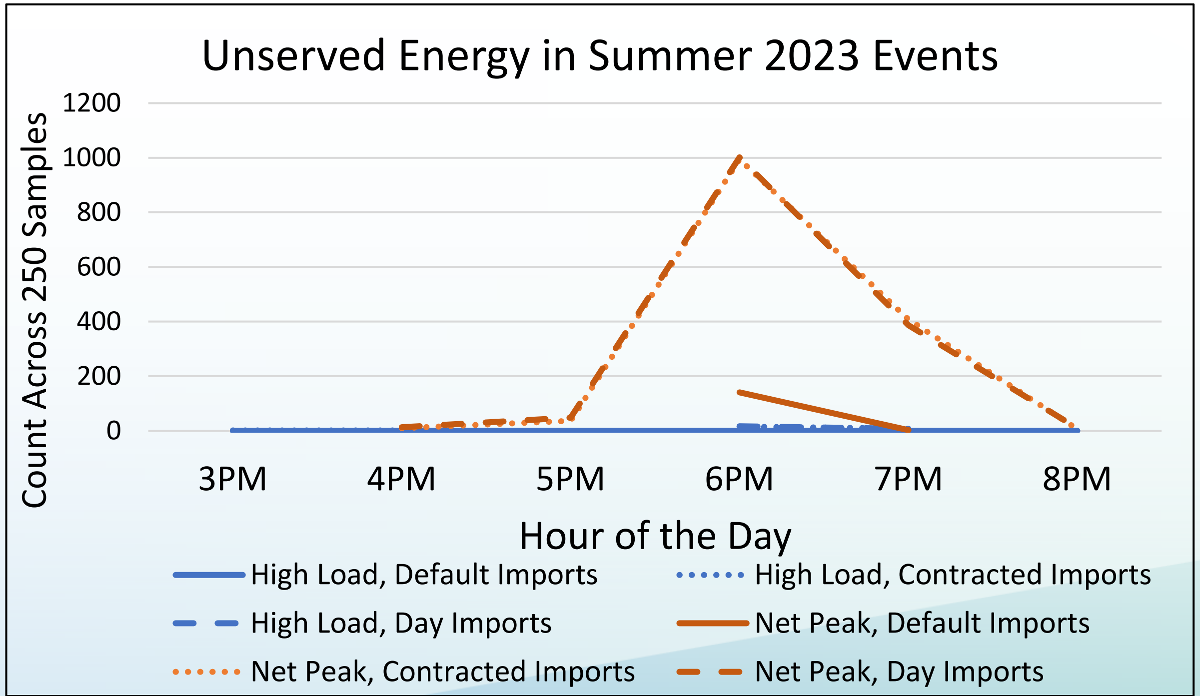
- Summer remains more challenging than winter, even in 2033.
- High net peaks are more challenging than extended periods of high load.
- Economic imports improve summer reliability even outside the traditional 3pm-9pm peak window.

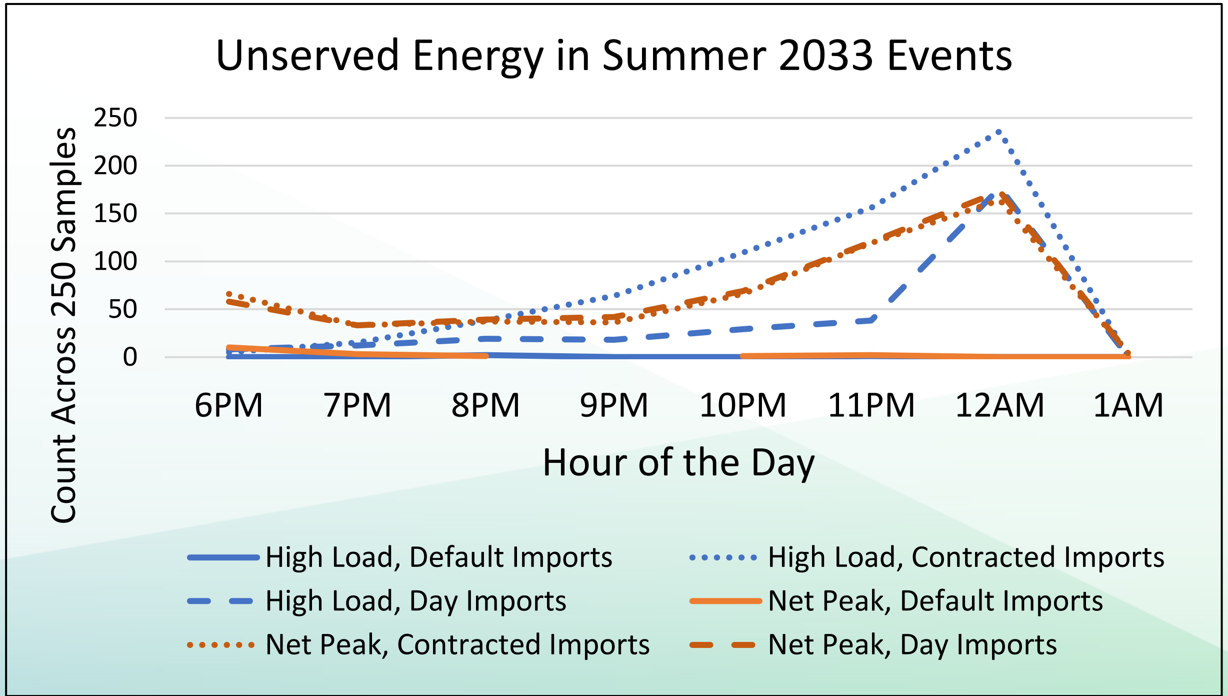
Probability of unserved energy in the sample

	Summer Stress Tests						Winter Stress Tests					
	2023			2033 Full PSP			2023			2033 Full PSP		
Imports Sensitivities	High Load Energy	High Load Peak	Low VRE Event	High Load Energy	High Load Peak	Low VRE Event	High Load Energy	High Load Peak	Low VRE Event	High Load Energy	High Load Peak	Low VRE Event
Default Imports	0%	36%	0%	1%	4%	0%	0%	0%	0%	0%	0%	0%
Contracted + Economic Imports (daytime only):	6%	100%	0%	61%	100%	1%	0%	0%	0%	0%	0.4%	0%
Contracted RA Imports only	5%	100%	0%	72%	100%	2%	0%	0%	0%	0%	0%	0%
No Imports	100%	100%	99.6%	100%	100%	100%	0%	0%	0%	0%	22%	0%

Primary Challenge Shifts from Net Peak to Overnight by 2033

- In 2023, unserved energy is an issue at net peak
- In 2033, expansion of energy storage leads to less unserved energy overall, less unserved energy at net peak, but more issues late at night when batteries are depleted
- The high load event experiences challenges with charging batteries sufficiently when imports are restricted during the day





Further Research

- Analysis will be continued in future releases of the CRO and the IEPR.
- Expansions on the topic may include:
  - New demand forecast incorporates more building electrification will affect analysis of multi-day events in winter and value of resources providing energy overnight.
  - Value of firm resources may change when modeling out to 2045 with more restrictions on gas plants, such as decreased capacity, decreased capacity factors, or both.
  - More analysis on how other reliability indicators like Expected Unserved Energy or Loss of Load Hour are affected by portfolios with more firm resources.
  - More analysis on how additional firm resources affect system operations.

Q&A

Public Comment

Zoom App/Online

- Click “raise hand”

Telephone

- Press *9 to raise hand
- Press *6 to mute/unmute

When called upon

- CEC will open your line
- Unmute on your end
- Spell name and state affiliation, if any
- 3 minutes or less per speaker, 1 speaker per entity

3-MINUTE TIMER

Appendix

Multi-Day Events

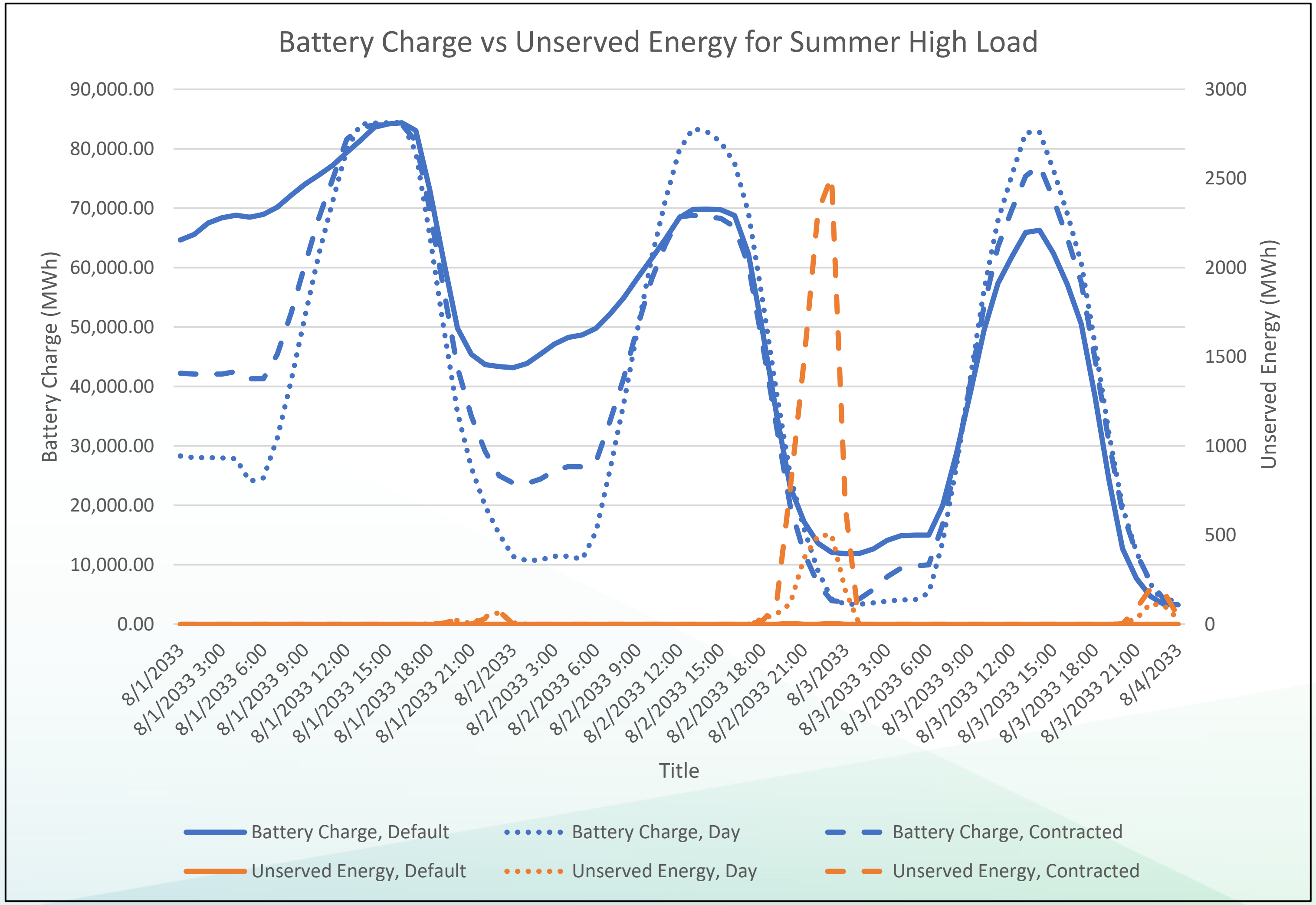
- SB 423 requires the study of LSE's plans under multi-day extreme and atypical weather events that occur at least as frequently as once per ten years
- Historical extreme dates were selected representing net load, net energy, and renewable energy minimums over a 3-day period.

Summer 2023	Weather Year Date	Daily Net Peak	Daily Net Energy
Daily Net Load	8/1/2017	53,388	890,417
	8/2/2017	55,047	1,003,179
	8/3/2017	53,255	986,909
Daily Net Peak	8/31/2017	58,039	950,482
	9/1/2017	58,815	877,420
	9/2/2017	58,310	880,638
Available VRE Generation	9/18/2016	48,032	703,266
	9/19/2016	50,901	823,848
	9/20/2016	51,196	875,981
2022 Heat Event	9/6/2022	58,841	1,004,160

Winter 2033	Weather Year Date	Daily Net Peak	Daily Net Energy
Daily Net Load	12/20/2010	42,841	840,113
	12/21/2010	41,034	823,134
	12/22/2010	38,411	777,819
Daily Net Peak	12/4/2013	42,890	526,300
	12/5/2013	47,116	678,284
	12/6/2013	44,222	730,061
Available VRE Generation	1/22/2013	36,371	719,256
	1/23/2013	36,280	718,782
	1/24/2013	35,844	715,609
2022 Dec Peak	12/14/2022	28,839	423,754

Summer High Load Event 2033

- The 2033 high load event is both capacity restricted (cannot store enough energy in batteries to make it through peak) and energy restricted (cannot get enough energy on the system to charge batteries completely)



Spring and Fall

- Spring event sees no risk
- Fall event (October 25) risk driven from variety of factors.
  - Simulated ’23 Fall Net Peak = 50 GW
  - Simulated ‘23 Summer Net Peak = 58 GW
  - 2.5GW less Hydro, 2 GW more Maintenance
  - Less VRE Available

	Spring Stress Tests						Fall Stress Tests			
	2023			2033 - Full PSP			2023		2033 - Full PSP	
Imports Sensitivities	High Load Energy	High Load Peak	Low VRE Event	High Load Energy	High Load Peak	Low VRE Event	High Load Energy & Peak	Low VRE Event	High Load Energy & Peak	Low VRE Event
Default Imports	0%	0%	0%	0%	0%	0%	0%	0%	0.4%	0%
Contracted + Economic Imports (daytime only):	0%	0%	0%	0%	0%	0%	0%	0%	19%	0%
Contracted RA Imports only	0%	0%	0%	0%	0%	0%	0%	0%	14%	0%
No Imports	0%	0%	0%	8%	0%	0%	100%	0%	100%	0%