DOCKETED	
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Document Title:	Presentation - Advancing Non-Lithium-Ion Long-Duration Energy Storage Technologies Workshop Slides
Description:	Presentation slides from the April 5, 2022 staff workshop on Advancing Non-Lithium-Ion Long-Duration Energy Storage Technologies.
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Advancing Non-Lithium-Ion Long-Duration Energy Storage Technologies

April 5, 2022

Workshop Starts at 10 AM

Advancing Non-Lithium-Ion Long-Duration Energy Storage Technologies

10:00 am	Workshop Overview and Safety Instructions
10:05 am	Opening Comments from Chair Hochschild and the Dais
10:25 am	Overview of EPIC Program and Long Duration Energy Storage Activities
10:45 am	Department of Energy (DOE) Long Duration Energy Storage Plans
11:00 am	CPUC Update on Energy storage and long duration energy storage role in future resource adequacy and planned future energy storage procurements
11:15 am	CAISO Update on the role of energy storage and long duration energy storage in future of state level grid management
11:30 am	Panel: Energy Storage Stakeholders—What new opportunities do non-lithium-ion long duration energy storage technologies offer California?
11:50 – 12:45 am	Lunch Break

Advancing Non-Lithium-Ion Long-Duration Energy Storage Technologies

12:45 pm	Panel: Industrial Stakeholders—What is needed to allow non-lithium-Ion technologies compete with Lithium-ion in future competitive procurements?
1:20 pm	Open Discussion and Questions with Presenters
2:00 pm	Public Comments
2:20 pm	Closing Comments
2:30PM	Workshop Ends

Overview of EPIC Program and Long Duration Energy Storage Activities

Jonah Steinbuck, Deputy Director
Mike Gravely, Team Lead / Supervisor
Energy Research and Development Division

Storage to Play Big Role in California's Clean Energy Future

- 3,000+ MWs battery energy storage currently installed or approved
- ~15,000 MWs of energy storage by 2032 in CPUC Integrated Resource Plan and Long-Term Procurement Plan (2022)
- 30,000 - 55,000 MWs of energy storage by 2045 from SB 100 planning

R&D Investments in Governor's Proposed FY2022-23 Budget

- **Incentives for Long-Duration Storage: $380M**
- Green Hydrogen: $100M
- Industrial Decarbonization: $210M
- Food Production Investment Program: $85M

NOTE: Final funding defined in approved FY 2022-23 state budget

Electric Program Investment Charge (EPIC Program)

- Ratepayer-funded program
- Administered by CEC, PG&E, SCE, and SDG&E
- ~$130 M/year invested in CEC Program
- EPIC 4 (2021-2025)
  - Storage included (early-stage focus)

CALIFORNIA'S INVESTMENT IN CLEAN ENERGY INNOVATION

EPIC is California's premier public interest research program investing over $130 million annually to unleash innovation.

Entrepreneurial Ecosystem

$143 million invested

Through EPIC, the CEC is building a world-class ecosystem supporting clean energy entrepreneurship.

Resiliency & Safety

$106 million invested

Helping communities, businesses, and public agencies build a safer, more resilient energy system.

Building Decarbonization

$170 million invested

Improving the affordability, health, and comfort of buildings.

Grid Decarbonization & Decentralization

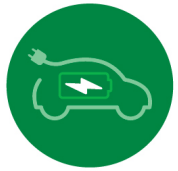
$154 million invested

Improving the cost competitiveness and performance of key technologies.

Industrial & Agricultural Innovation

$113 million invested

Scaling specialized technology solutions to drive energy efficiency without compromising production.



Transportation Electrification

$33 million invested

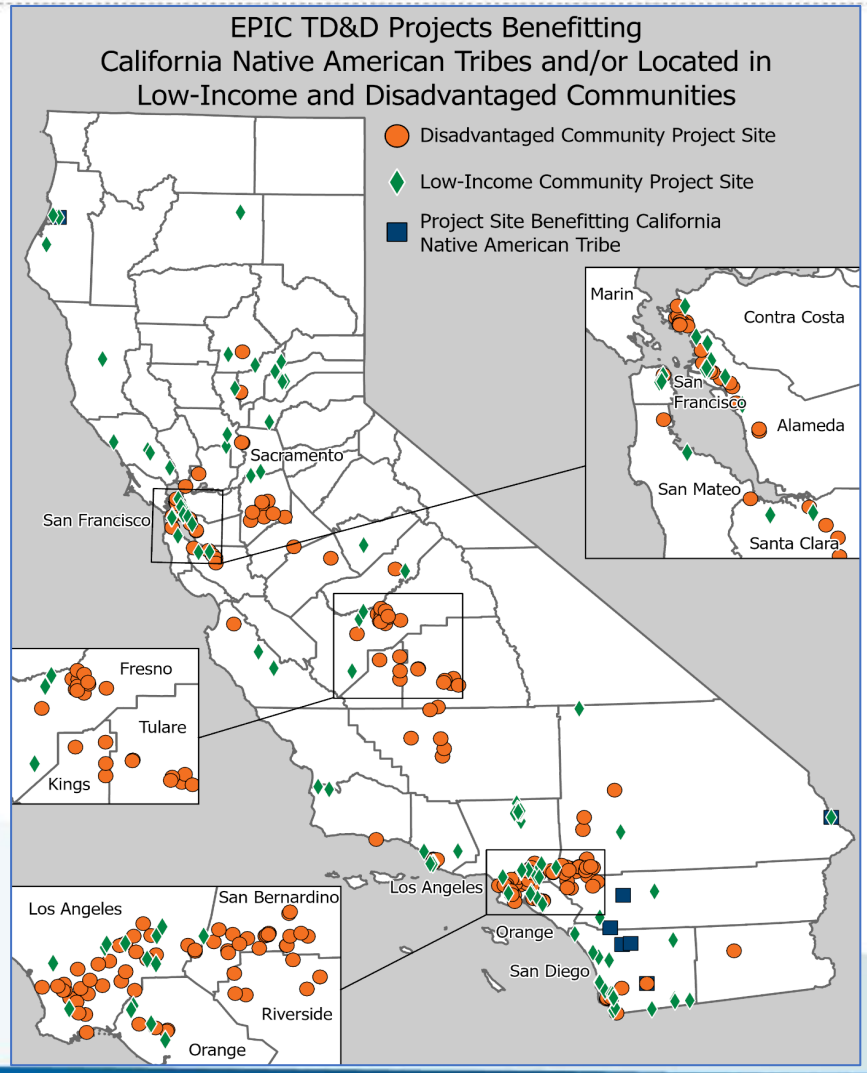
Supporting advances that reduce the cost of electric vehicle ownership and support the grid.

**Total investment, 2012-2019*

EPIC Program Overview

$1+ Billion	EPIC funds invested in California-grown innovation
$7.8 Billion	Private investment raised by businesses after receiving EPIC funding
437	Projects funded across California
55%	The increase in successful exits by start-up companies funded by the CEC through EPIC for 2021

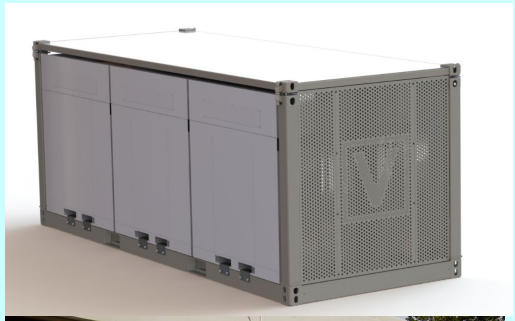
EPIC Demos in Under-resourced Communities

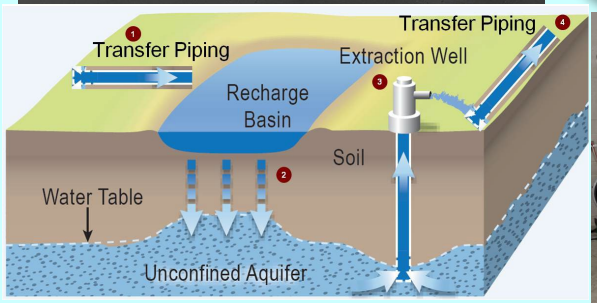


- $173M+ in **Disadvantaged Communities**
- $118M+ in **Low-Income Communities**

67% tech demo funds

A Decade History of EPIC Energy Storage R&D





EPIC Interim Plan Energy Storage Planned Solicitation

Optimizing Long-Duration Energy Storage to Improve Grid Resiliency and Reliability in Under-resourced Communities (Scheduled Release April/May 2022)

- Demonstrate increased resiliency and reliability of clean long-duration energy-storage systems to critical facilities in under-resourced communities.
- Clean alternative to back-up diesel generators and ability to “ride out” PSPS events and other grid power-loss events.
- Operate during grid outages that last 24-36 hours.
- Budget $30M

R&D Investments in Governor's Proposed FY2022-23 Budget

- **Incentives for Long-Duration Storage: $380M**
- Green Hydrogen: $100M
- Industrial Decarbonization: $210M
- Food Production Investment Program: $85M

NOTE: Final funding defined in approved FY 2022-23 state budget

Incentives for Long-Duration Storage
Governor's Proposed FY 2022-23 Budget

- $380M
- Deploy technologies on the verge of commercialization and position to scale to commercial deployment in the next 5 to 10 years.
- 8+ hours in duration (stretch goal of 20 to 100 hours)
- Does not include lithium-ion or pumped hydro
- Build on lessons learned from EPIC over the last 10 years

2020 – A Pivotal Year for Long-Duration Storage R&D

- $100M+ invested in energy storage in 2020
- Supporting new and emerging non-lithium-ion technologies
- 11 field demonstrations of non-lithium ion long-duration energy storage
  - 20+ hours of duration for two demos
- 8 applied research grants
  - 20 hours to 100+ hours of duration for three projects
  - Green hydrogen storage applications in three grants
- Two grants awarded to study the best use of long-duration energy storage and to develop deployment scenarios to meet California's energy goals

400 KW/10 hours Demonstration Systems ($27M EPIC, $31M Match)
2020 Energy Storage Solicitation

Rincon Band of Luiseno Indians

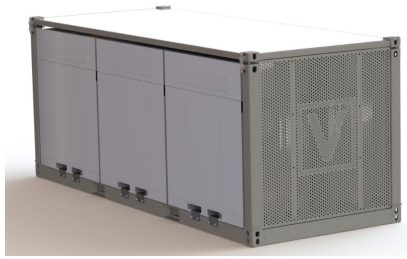
- Vanadium Redox Flow Battery + Flywheel
- Casino and resort

INVINITY ENERGY SYSTEMS

AMBER KINETICS

Indian Energy

- Vanadium Redox Flow Battery, Zinc Hybrid Cathode Battery, and Flywheel
- Miramar MCAS military base



INVINITY ENERGY SYSTEMS

eos Eos Energy Storage

Kinetic Energy Storage Corporation

400 KW/10 hours Demonstration Systems
2020 Energy Storage Solicitation

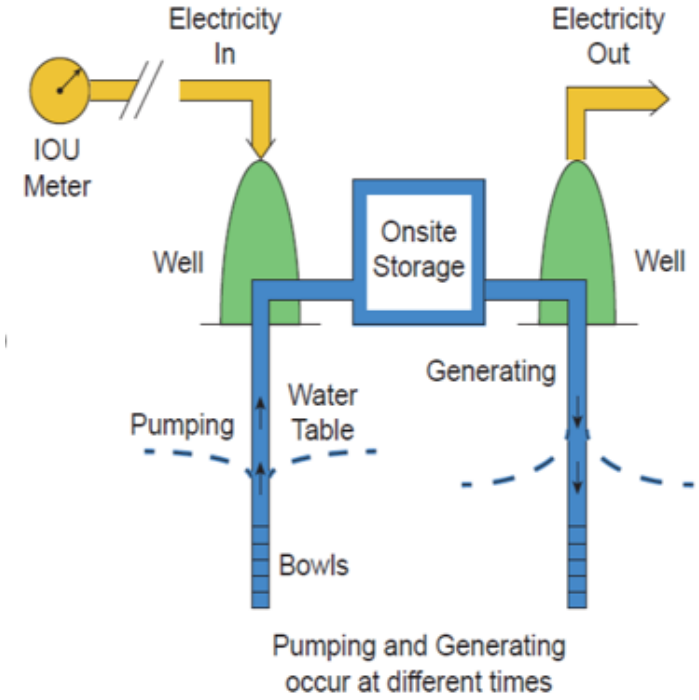
charge bliss

KAISER PERMANENTE®

- Long-duration battery, renewable energy microgrid at hospital
- Feasibility, safety, and cost effectiveness
- Disadvantaged and low-income communities
- 10+ hours using non-Lithium battery chemistry

Antelope Valley Water Storage

- Aquifer Pumped Hydro
- Groundwater storage facility



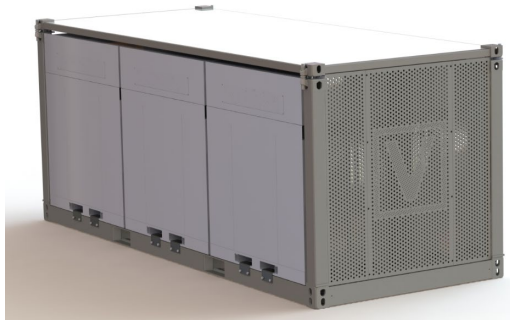
50 KW/10 hours Demonstration Systems ($4.9M EPIC, $2.1 Match)
2020 Energy Storage Solicitation

Pechanga Tribal Microgrid
Long-Duration Storage Project

- 10+ hours of storage will alleviate much of the concern currently surrounding a PSPS event
- Back up critical emergency facility

INVINITY ENERGY SYSTEMS

- Vanadium Redox Flow Battery
- Fire station for the Soboba Band of Luiseño Indians



INVINITY ENERGY SYSTEMS

INDIAN ENERGY LLC

Indian Energy

- Flywheel
- Drinking water for the Viejas Band of Kumeyaay Indians

Kinetic Energy Storage Corporation

50 KW/10 hours Demonstration Systems ($2M EPIC, $0.5M Match)
2020 Energy Storage Solicitation

Antelope Valley Water Storage

- Aquifer Pumped Hydro
- Groundwater storage facility

MADISON FARMS ECHO, OREGON
ASR REGENERATION

200 HP MOTOR WITH VERTICAL LINE SHAFT PUMP – 8" PIPE, AQUIFER LEVEL 520 FEET BELOW LAND SURFACE.

200 HP MOTOR STARTING VFD & 100 HP REGENERATION VFD WITH LOCAL CONTROL PANEL.

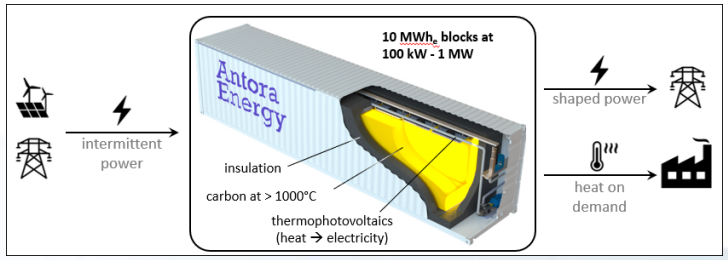
Willow Springs Water Bank

20 hours to 100 Hours Applied Research Systems ($5.3M EPIC, $6M Match)

2020 Energy Storage Solicitation

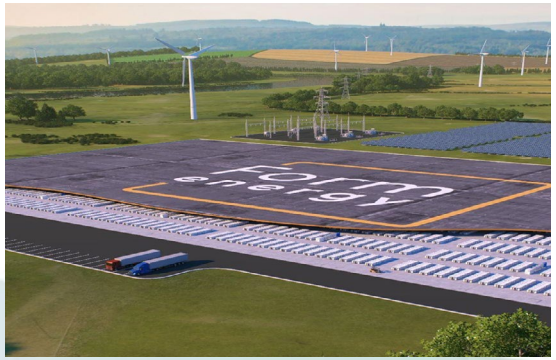
Antora Energy

Solid-state Long Duration Energy Storage for Industrial Applications



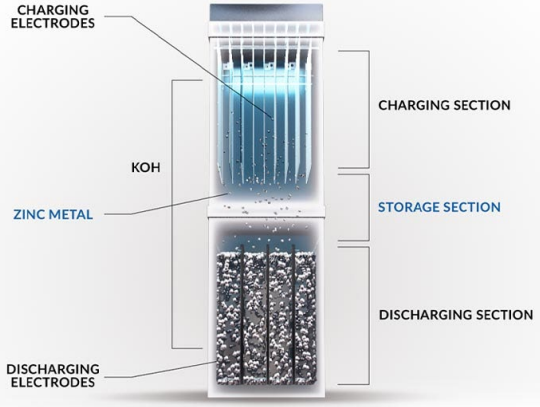
form energy

Aqueous Air-Breathing Energy Storage System for Multi-Day Resiliency



eZINC

Commercialization of Lowest-Cost, Long Duration Energy Storage Systems



Assessing Long-duration Energy Storage Deployment Scenarios to Meet California's Energy Goals ($2.8M EPIC, $821K Match)

2020 Energy Storage Solicitation

UNIVERSITY OF CALIFORNIA MERCED

- Variety of energy technologies in storage, generation, and grid structure
- Utilizing cost modeling to forecast the future costs of long-duration storage

Energy+Environmental Economics

- Developing a new modeling toolkit to assess the long-duration storage needs of California
- Working with UCSD and long-duration energy storage system developers from Form Energy

Questions from Members of the Dais

Long Duration Storage at DOE

April 2022

ENERGY earthshots
U.S. DEPARTMENT OF ENERGY

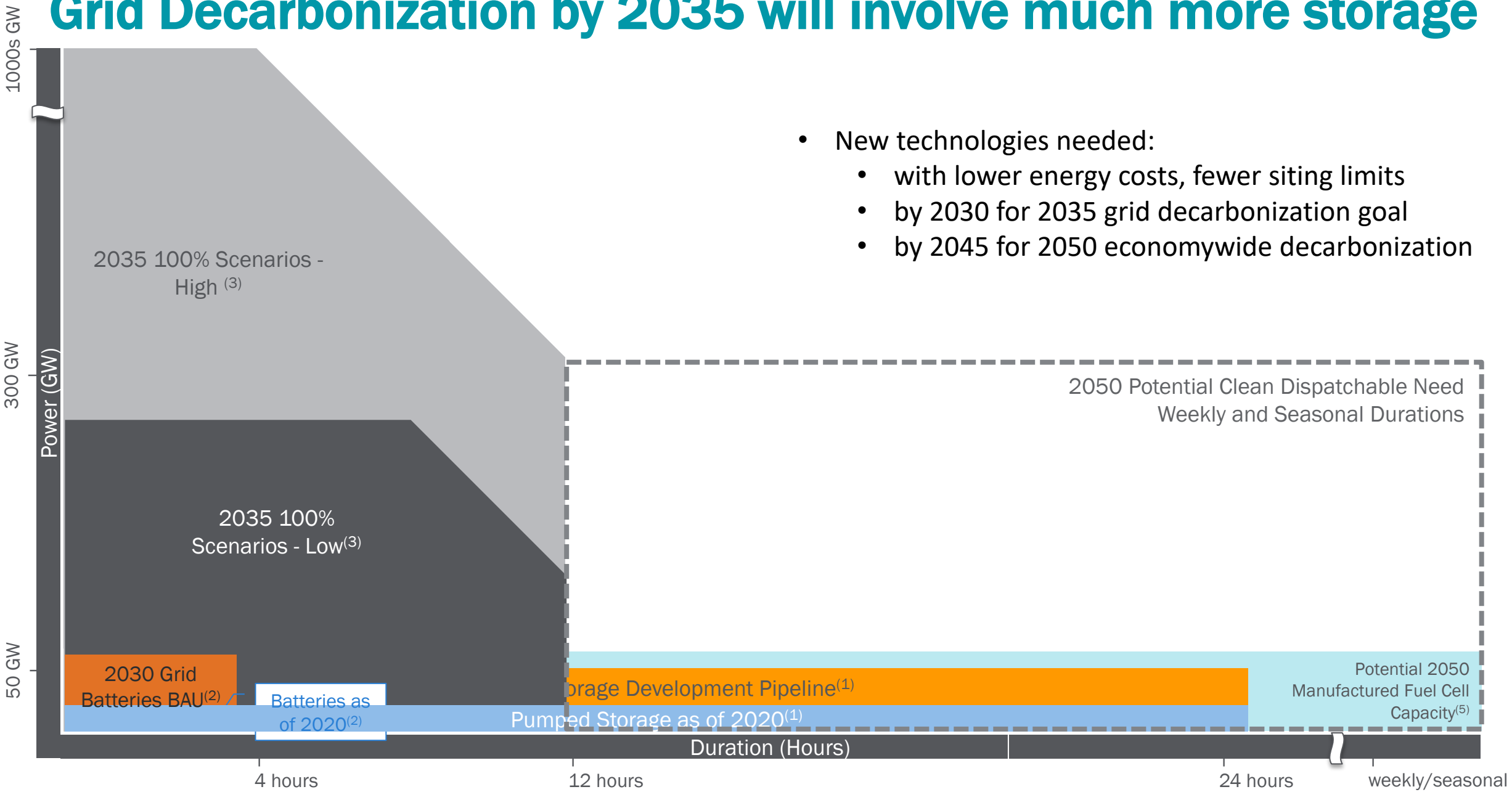
Key Messages

- **2035 goals will require 40x – 110x more grid energy storage**
- **Storage includes a range of functions provided by many technologies**
  - DOE storage work is found across the spectrum of offices and labs
- **Successful storage deployment requires:**
  - Full range of R&D, deployment, manufacturing, and institutional support

- **New targets and opportunities:**
  - Long Duration Storage Shot: tech targets for cost-effective decarbonization
  - Bipartisan Infrastructure Law: opportunity to validate at scale

ENERGY earthshots
U.S. DEPARTMENT OF ENERGY

Grid Decarbonization by 2035 will involve much more storage

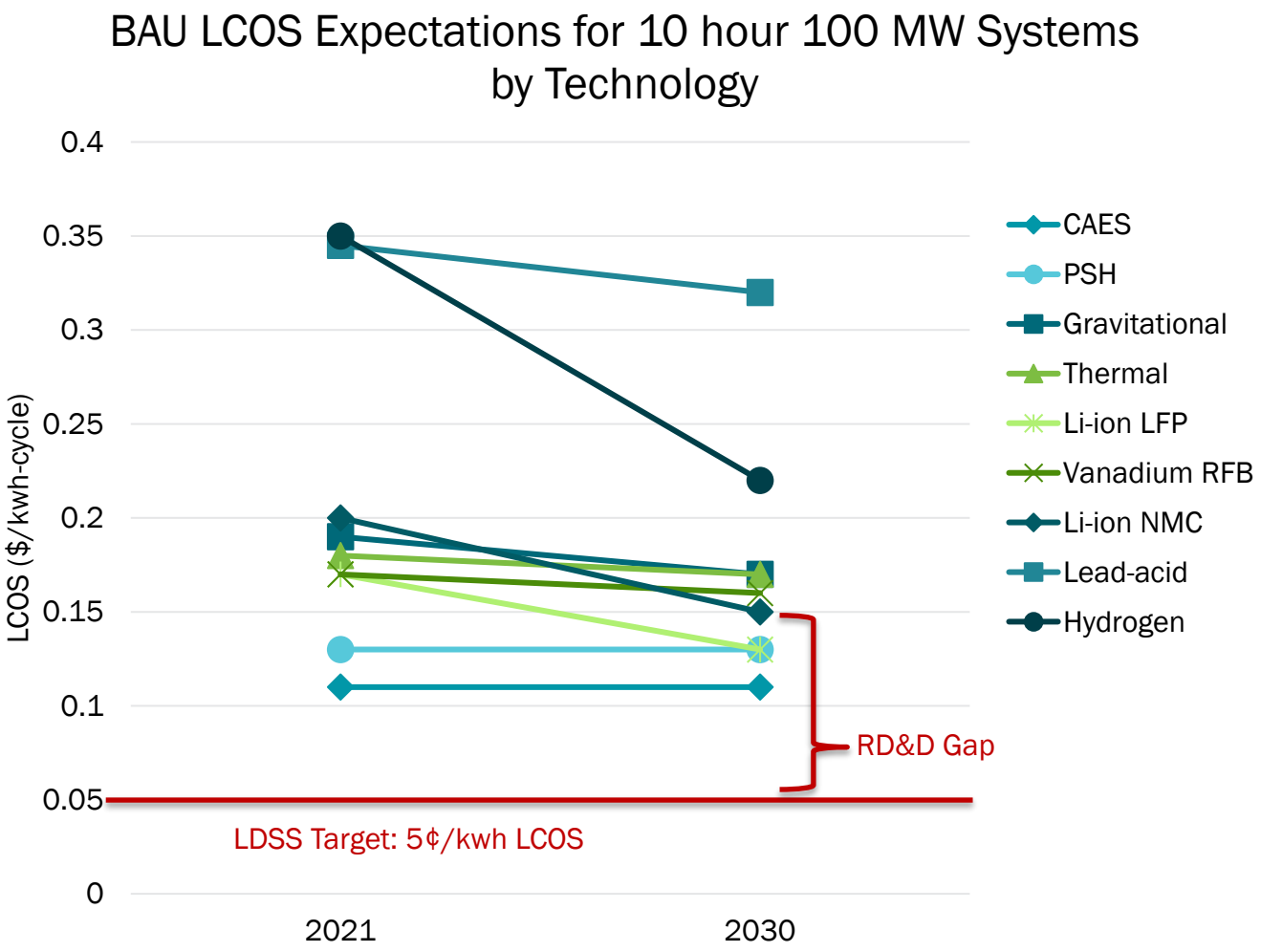


- New technologies needed:
  - with lower energy costs, fewer siting limits
  - by 2030 for 2035 grid decarbonization goal
  - by 2045 for 2050 economywide decarbonization

Sources:

1. DOE U.S. Hydropower Market Report, January 2021
2. IHS, Grid-Connected Energy Storage Market Tracker—First Half 2021, 25 August 2021
3. McKinsey "Net-zero Power," December 2021; Princeton, "Net Zero America," October 2021; The Long-Term Strategy of The United States, November 2021; NREL., Solar Futures Study, 2021
4. IHS, Battery Market Tracker: First Half 2021, 05 Oct 2021
5. DOE, Supply Chain Review: Water Electrolyzers and Fuel Cells, Forthcoming

RD&D Required for Cost-Effective Decarbonization



- 5¢/kwh LCOS enables dispatchable clean energy while minimizing rate increases
- Business as Usual LCOS Expectations will not achieve this goal

Source:
Forthcoming DOE/ESGC Cost and Performance Report

ENERGY earthshots
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ENERGY earthshots U.S. DEPARTMENT OF ENERGY | Storage™

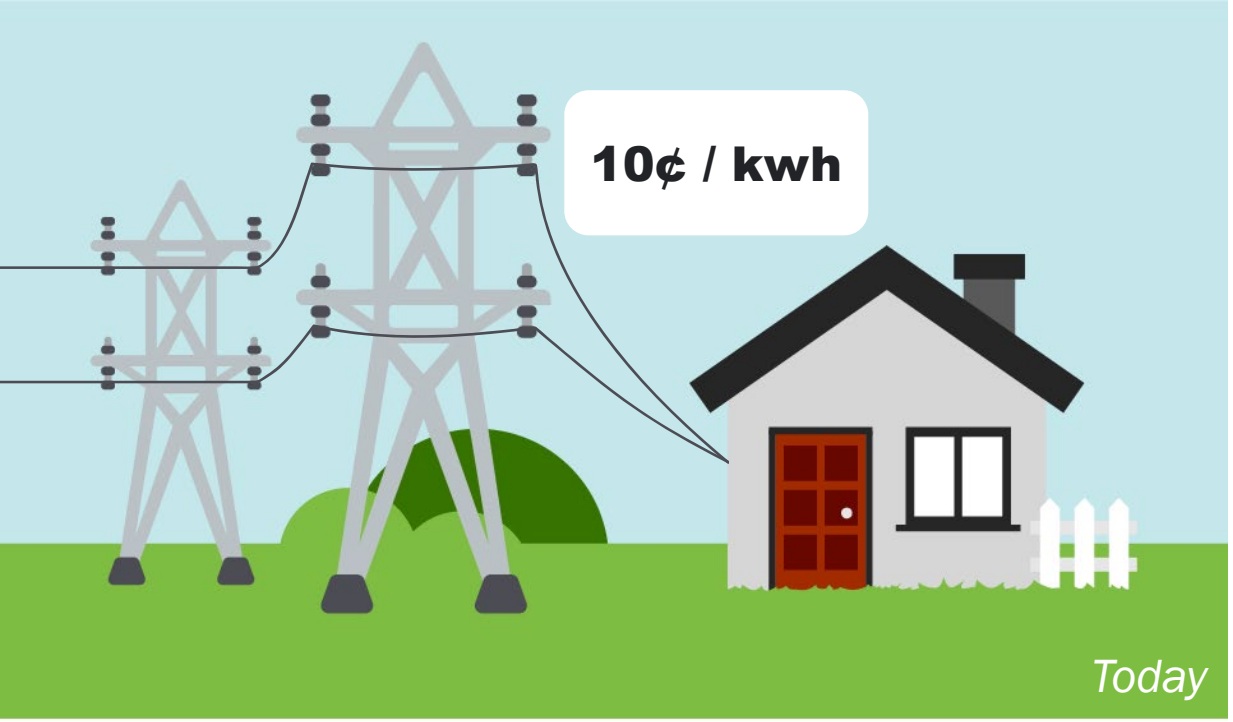
LONG DURATION STORAGE SHOT TARGET

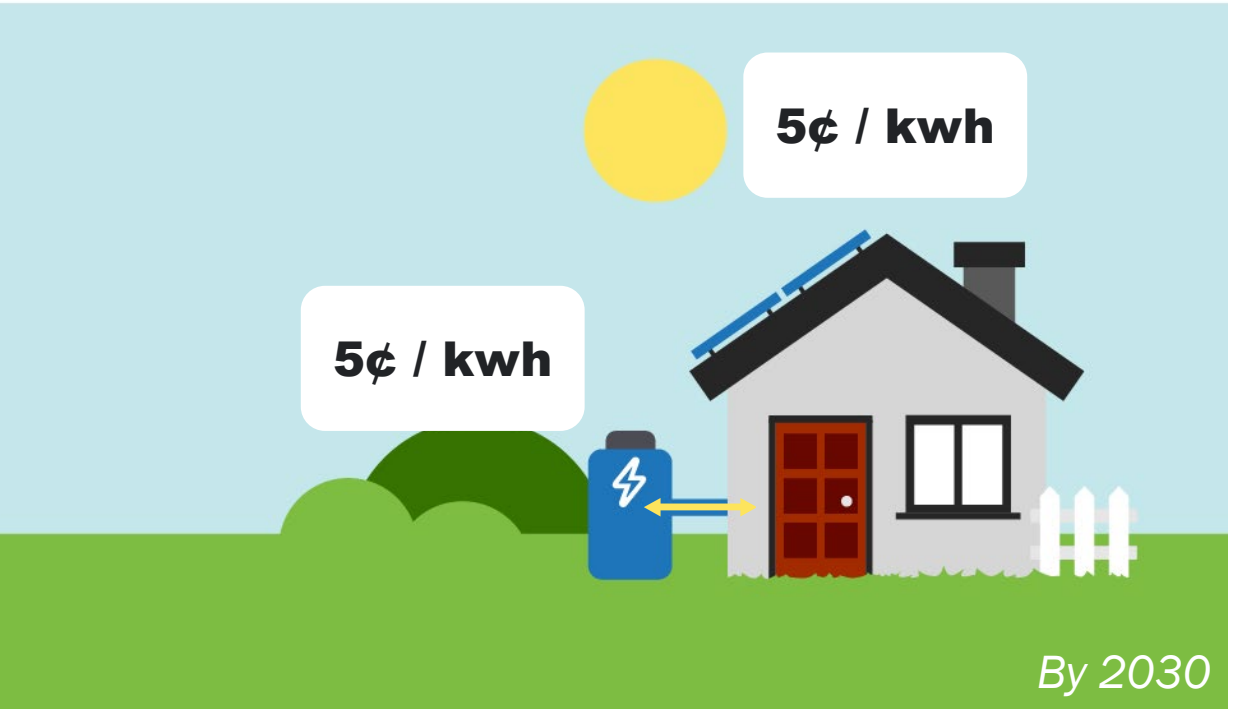
Reduce storage costs by **90%** from a 2020 Li-ion baseline...

...in storage systems that deliver **10+** hours of duration

...in **1** decade

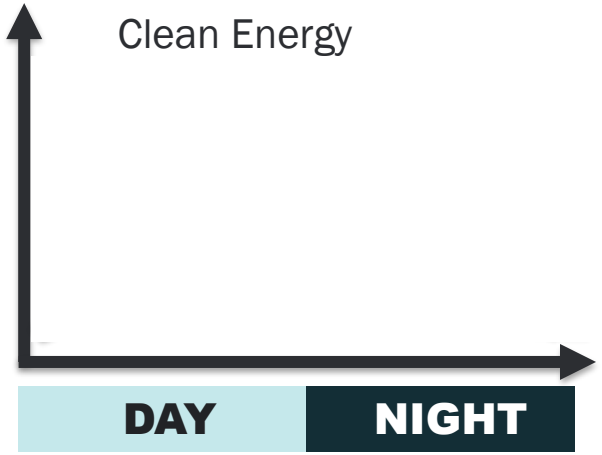
Affordable grid storage for clean power – any time, anywhere





THE LONG DURATION STORAGE SHOT TARGET

With 5¢ / kwh storage, dependable clean energy is competitive with existing electricity sources



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Leveraging the Energy Storage Grand Challenge (ESGC) Use Case Framework

ESGC Use Cases Highlighted by LDSS

Facilitating Grid Decarbonization

- Ensure reliability, resilience, and security in a decarbonized grid

Serving Remote Communities

- Support communities not connected to the bulk power system

Electrified Mobility

- Support electrification of the transportation sector

Independent Network Infrastructure

- Services that use and serve the electric grid

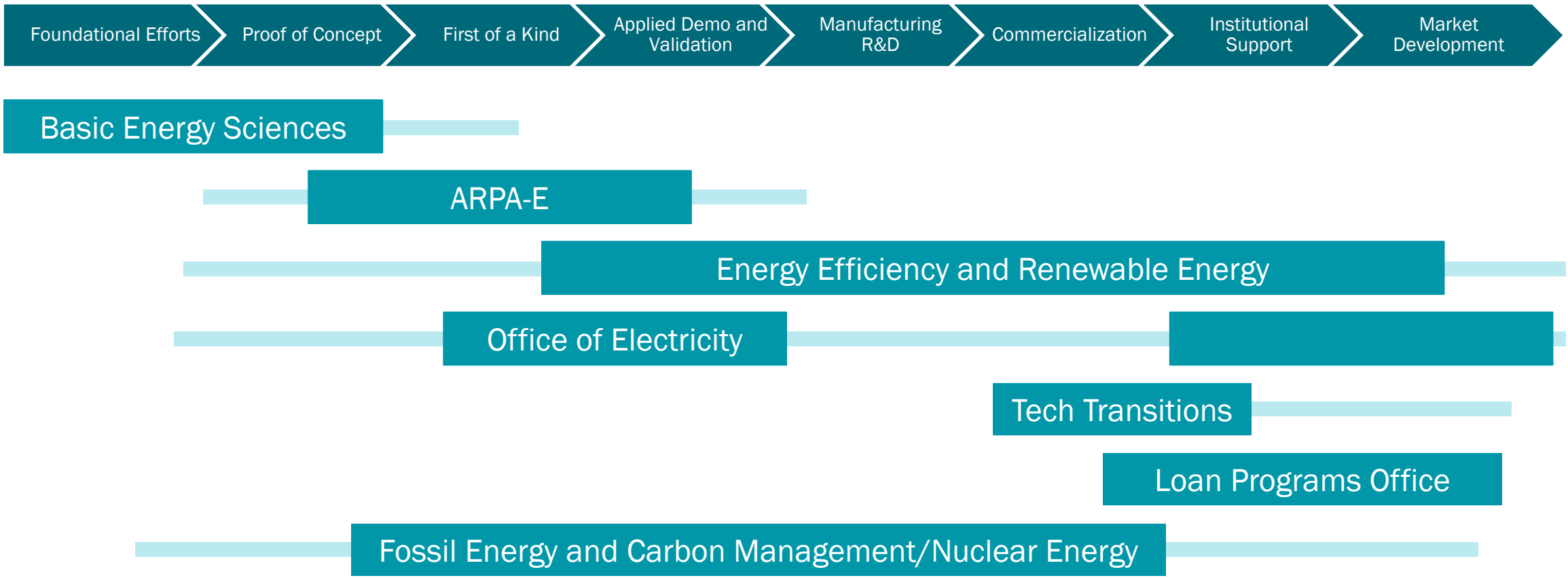
Critical Services

- Maintain operations in facilities critical to public health/safety

Facility Flexibility, Efficiency, and Value Enhancement

- Optimize energy production/usage

Storage Advancement Throughout DOE



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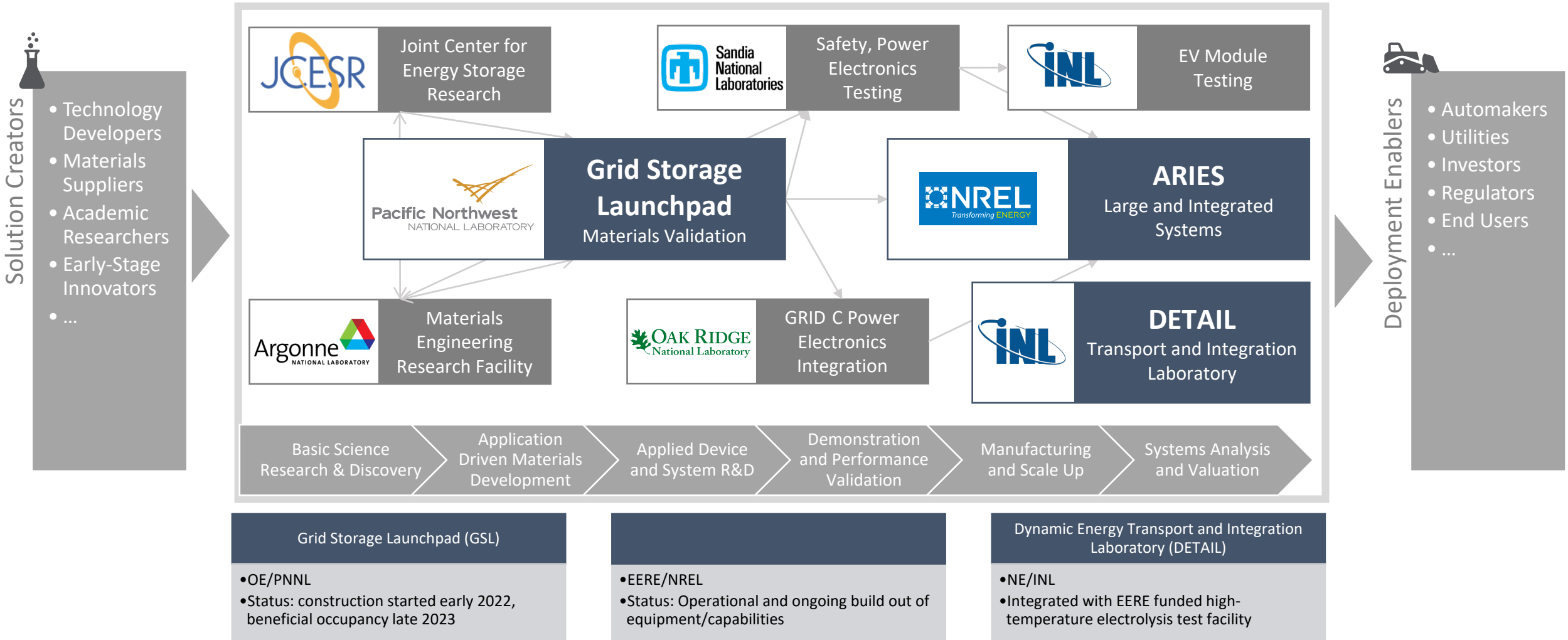
Leveraging National Labs and Consortia to Accelerate Storage



Grid Storage Launchpad (GSL)		Dynamic Energy Transport and Integration Laboratory (DETAIL)
•OE/PNNL •Status: construction started early 2022, beneficial occupancy late 2023	•EERE/NREL •Status: Operational and ongoing build out of equipment/capabilities	•NE/INL •Integrated with EERE funded high-temperature electrolysis test facility

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Energy Storage in the Infrastructure Law

41001A. ENERGY STORAGE DEMONSTRATION PROJECTS AND PILOT GRANT PROGRAM ($355M)

A1 Demonstration Projects
3 energy storage demos
1 weekly-seasonal demo
1 EV battery 2nd life demo

A2 Pilot Grants
State energy office; Indian Tribe; Tribal organization; institution of higher education; an electric utility

41001B. LONG-DURATION DEMONSTRATION INITIATIVE AND JOINT PROGRAM ($150M)

B1 Demonstration Initiative
range of technologies; regional diversity; and bulk, distribution, behind-the-meter, microgrid, and off-grid

B2 Joint Program
Demos at DOE and DOD Facilities

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Thank You!

Integrated Resource Planning (IRP) and the Role of Energy Storage

James McGarry, Senior Analyst, Integrated Resource Planning, California Public Utilities Commission

April 5, 2022

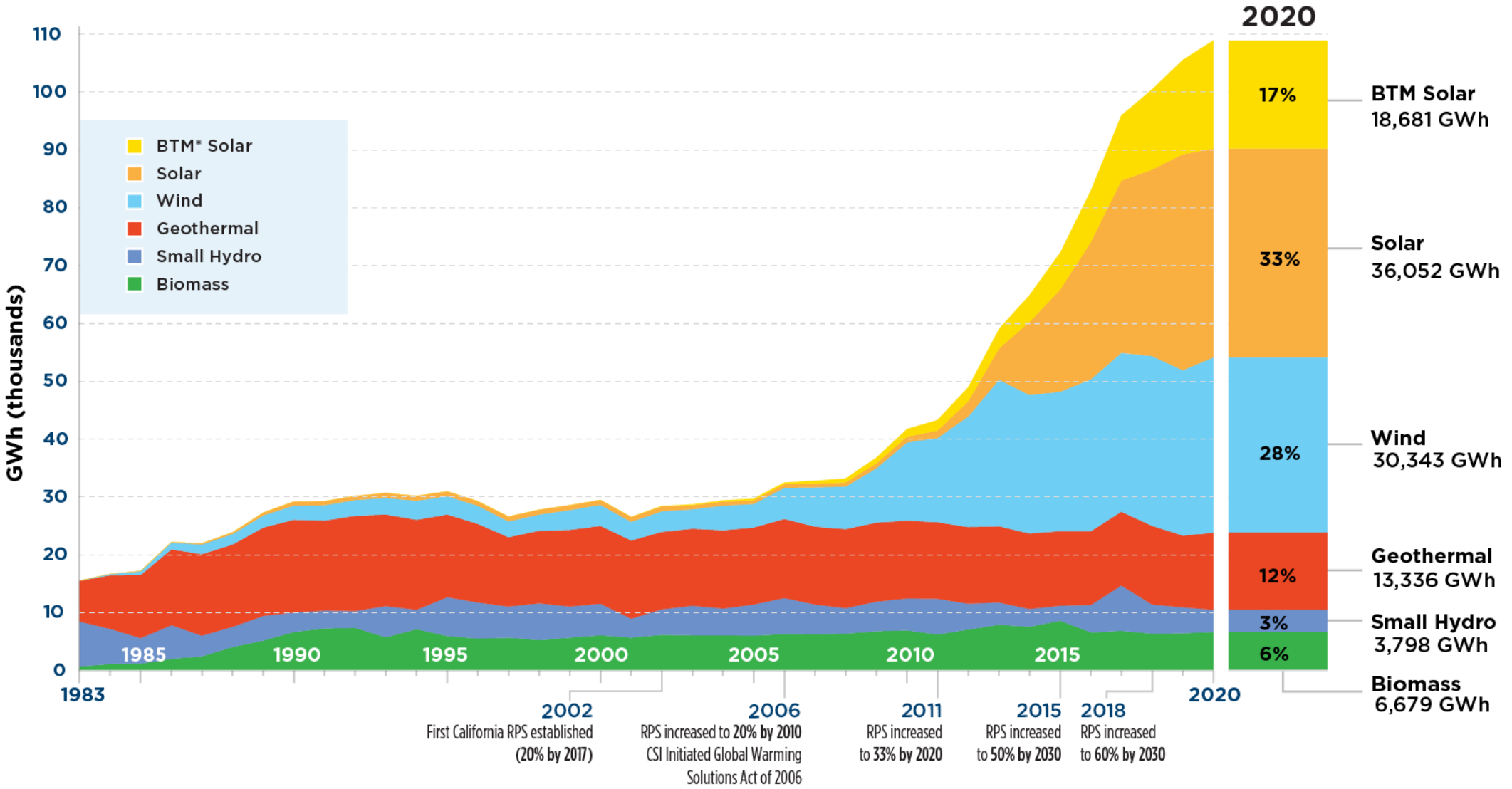
California Public Utilities Commission

Background

Integrated Resource Planning (IRP) in California Today

- The objective of IRP is to reduce the cost of achieving greenhouse gas (GHG) reductions and other policy goals by looking across individual LSE boundaries and resource types to identify solutions to reliability, cost, or other concerns that might not otherwise be found.
- Goal of the 2019-2021 IRP cycle was to ensure that the electric sector is on track to help California reduce economy-wide GHG emissions 40% from 1990 levels by 2030, per SB 32, and to explore how achievement of SB 100 2045 goals could inform IRP resource planning in the 2020 to 2032 timeframe.
- The IRP process has two main components:
  - First, it identifies an optimal portfolio for meeting state policy objectives and encourages the LSEs to procure towards that future.
  - Second, it collects and aggregates the LSEs collective efforts for planned and contracted resources to compare the expected system to the identified optimal system. The CPUC considers a variety of interventions to ensure LSEs are progressing towards an optimal future.

Where we are today: Clean Energy Build-out So Far



Source: CEC staff analysis, October 2021

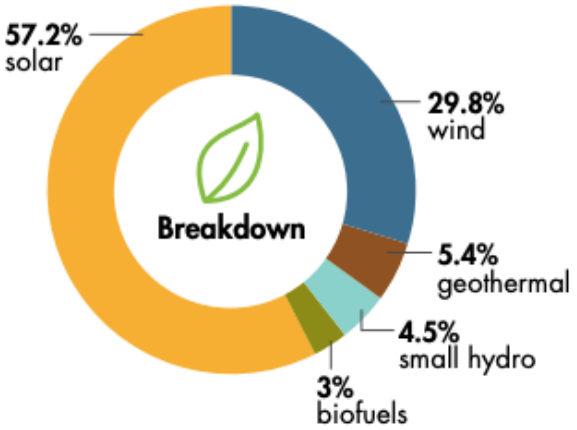
Where we are today: Breaking Clean Energy Records

- In 2020, California's generation mix was approx. 60-65% carbon-free
- Since July 2020, more than **6,800 MW nameplate** (3,000 MW NQC) of new renewables and storage have come online.
- **2021: A record year for renewables in California**

Solar peak
13,205 MW
May 27, 2021 at 11:57 a.m.
Previous record:
13,151 MW, Apr 13, 2021

Wind peak
5,754 MW
May 29, 2021 at 10:12 p.m.
Previous record:
5,753 MW, Apr 22, 2021

Peak renewables serving load
94.5%
Apr 24, 2021 at 2:28 p.m.
Previous record:
92.5%, Mar 13, 2021



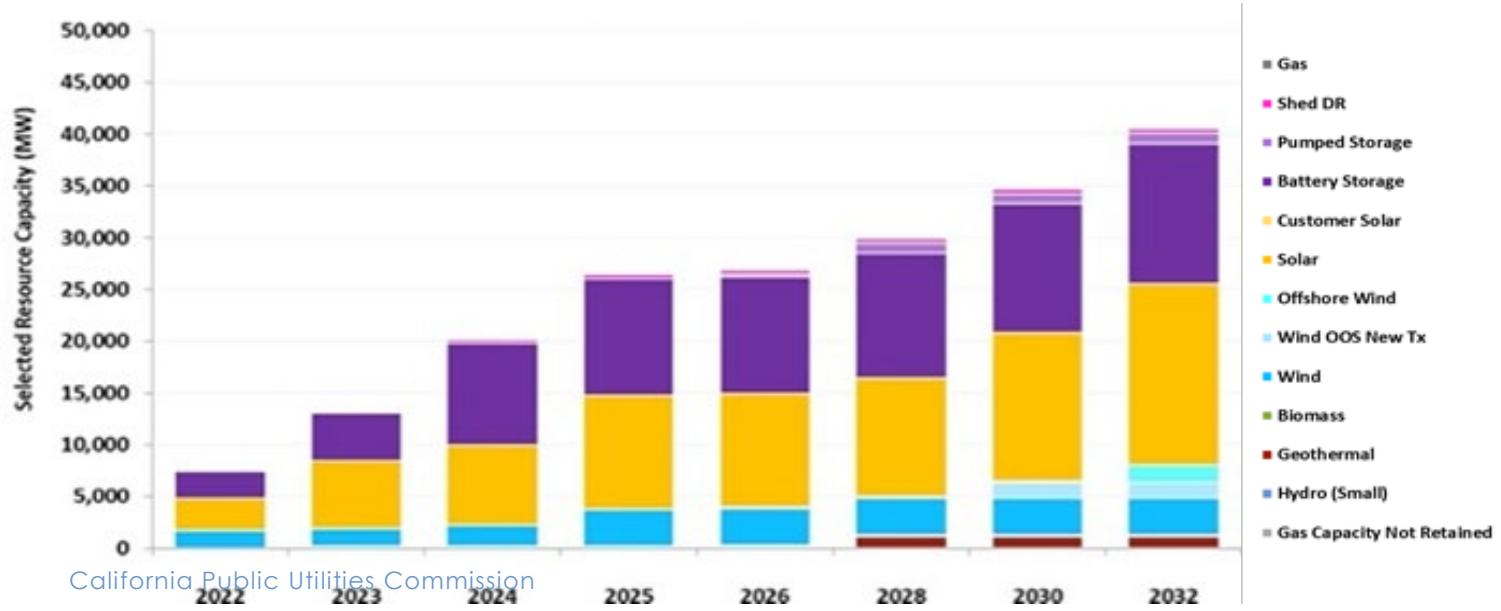
- On April 24, 2021, at 2:28pm, **94.5%** of CAISO load was met by renewables
- As of February 2022, more than **26,000 MW** (nameplate) of renewables have been installed, roughly half the total installed capacity in CAISO territory, and **2,600 MW** (nameplate) of battery storage.

Source: http://www.caiso.com/Documents/Key-Statistics-Jan-2022.pdf

California Long-Term Planning Needs

2021 Preferred System Plan (PSP)

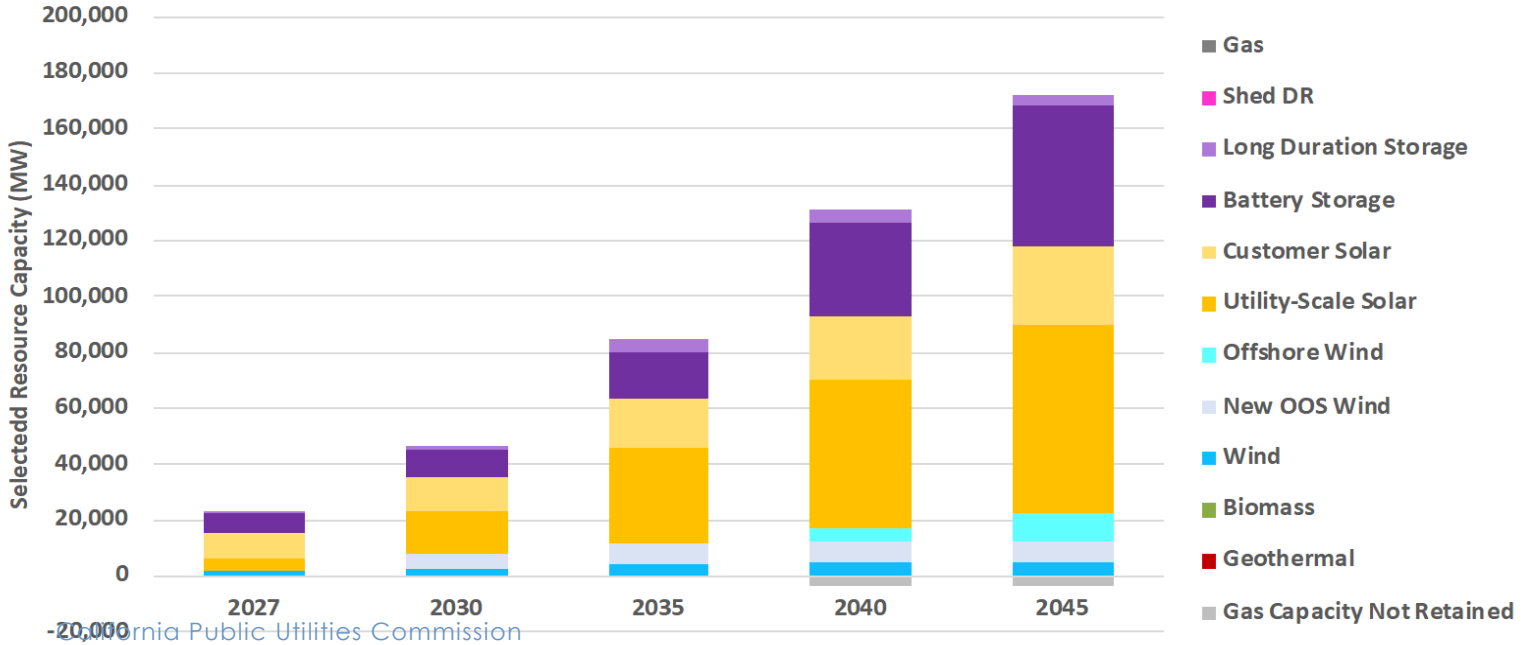
- Decision adopted by the CPUC on February 10, 2022:
  - Lowers the 2030 GHG target to 38 million metric tons (MMT) from the previous 46 MMT target, and sets a 2032 GHG target of 35 MMT. Also tells LSEs to plan for both 38 MMT and 30 MMT targets next cycle.
  - Includes a PSP Portfolio for use in planning, procurement, and to be transmitted to the California Independent System Operator (CAISO) for use in the 2022-23 Transmission Planning Process (TPP).
- PSP portfolio includes approximately 25,500 MW (nameplate) of new supply-side renewables and 15,000 MW of new storage and demand response resources by 2032.
  - Includes aggregated LSE plans and assumes procurement in compliance with the Mid-Term Reliability (MTR) Decision 21-06-035, including 1,000 MW of LDES



Resource Type	MW by 2032
Biomass	134
Geothermal	1,160
Wind	3,531
Wind OOS New Tx	1,500
Offshore Wind	1,708
Utility-Scale Solar	17,506
Battery Storage	13,571
Long-duration Storage	1,000
Shed Demand Response	441
Total	**40,551**

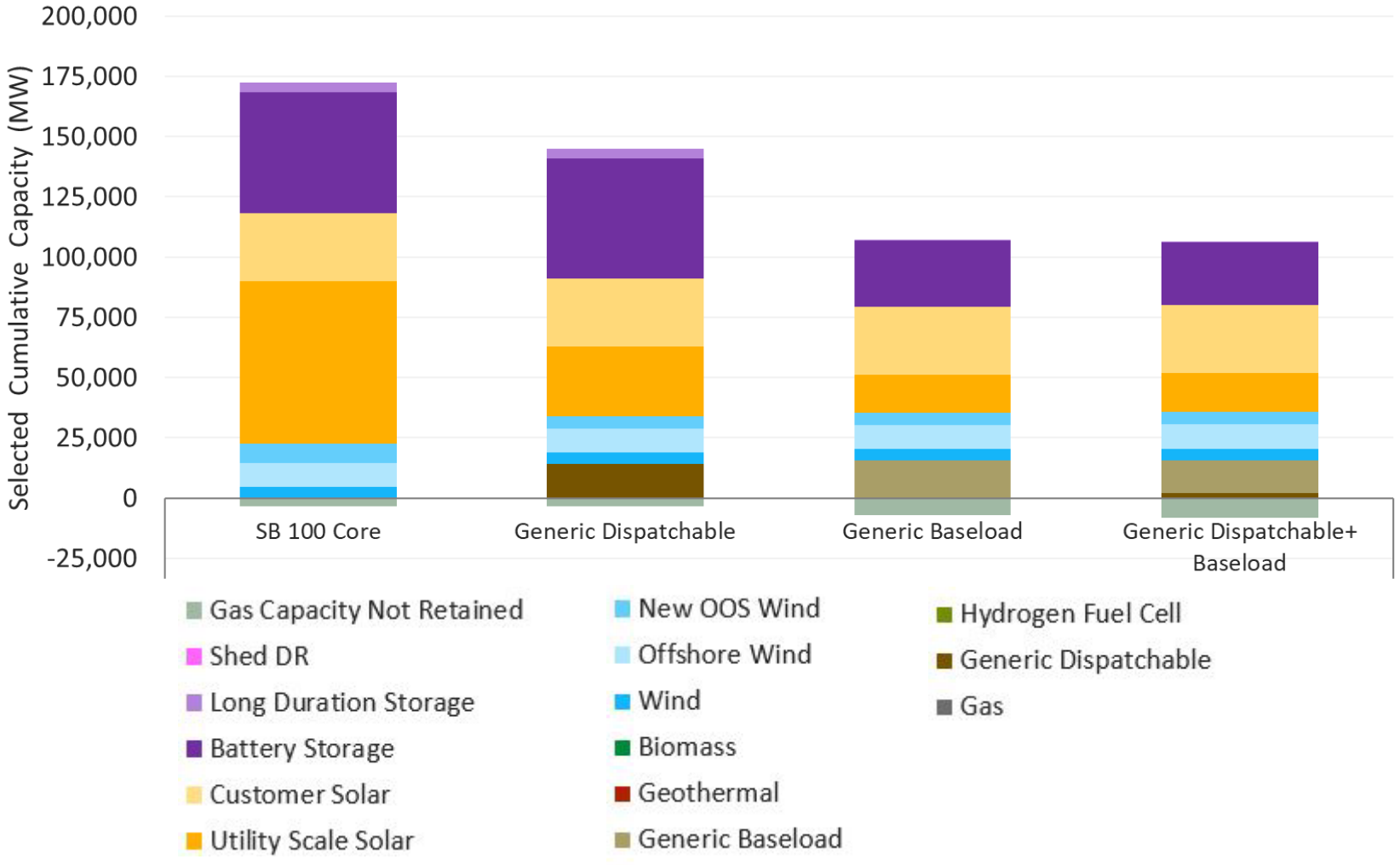
Senate Bill (SB) 100

- SB 100 (De León, 2018) sets a 2045 goal of powering all retail electricity sold in California and state agency electrical needs with renewable and zero-carbon sources
- The 2021 SB 100 Joint Agency Report is an initial assessment of the additional energy resources and resource build rates needed to achieve 100 percent clean electricity, along with associated costs
- The SB 100 portfolio includes approximately 90,000 MW (nameplate) of new supply-side renewables and 54,000 MW of new storage resources by 2032, including 4,000 MW of new long-duration storage by 2045



Resource Type	MW by 2045
Geothermal	245
Wind	4,337
Wind OOS New Tx	8,215
Offshore Wind	10,000
Utility-Scale Solar	67,415
Battery Storage	49,927
Long-duration Storage	4,000
Gas Capacity Not Retained	-3,379
Total Resource Additions	**144,029**

SB 100 Study: Zero Carbon Firm



Scenario	Total Resource Cost ($B)	Average Cost (¢/kWh)
Generic Dispatchable	$64	15.4
Generic Baseload	$64	15.4
Generic Dispatch + Baseload	$64	15.4
SB 100 Core	$66	16.0

Items for Further Consideration

- In its IRP proceeding, the CPUC set a 35 MMT GHG target for 2032, which equates to 73% Renewables Portfolio Standard (RPS) resources and 86% GHG-free resources
  - Achieving this target will require LSEs to collectively procure roughly 13,500 MW of short-duration storage and at least 1,000 MW of long-duration storage—procurement amounts that have been reinforced by a June 2021 CPUC procurement order
- California is planning to power 100% of the retail electricity sold in the state with renewable and zero-carbon sources by 2045
  - Initial assessments find that this target would require the development of approximately 50,000 MW of short-duration storage and 4,000 MW of long-duration energy storage
- A diverse set of new resource types with varied operating characteristics will be increasingly valuable within California's grid, helping to control both the pace and cost of California's clean energy build-out
  - Long-duration storage technologies of all types can provide valuable services for a decarbonized and highly electrified grid such as serving a longer and flatter net load peak and providing energy for multi-day durations or longer when variable renewable output is low

For more information:

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Energy Storage and Grid Management

April 5, 2022

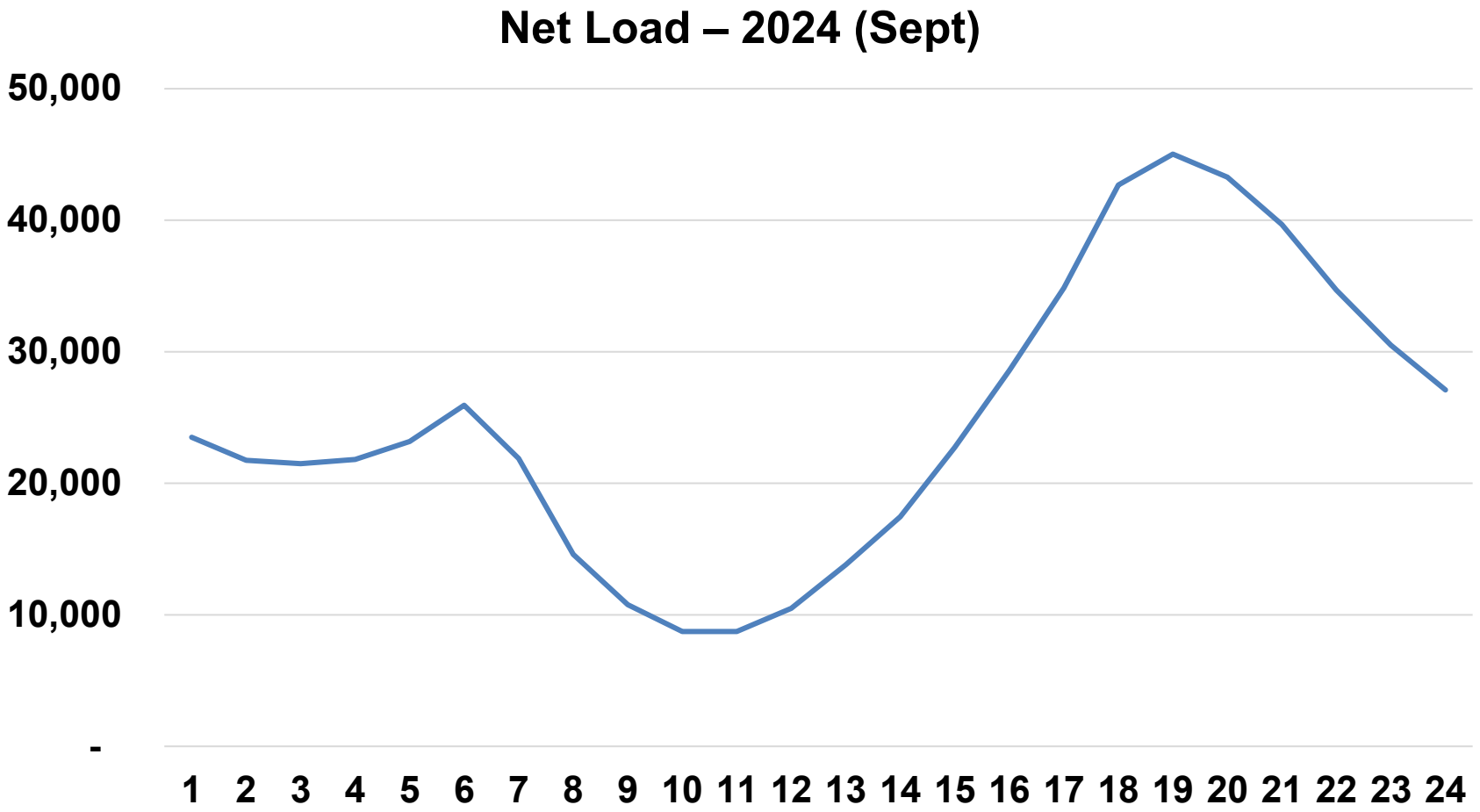
Gabe Murtaugh, Storage Sector Manager

CEC Workshop – Advancing Non-Lithium Ion Long Duration

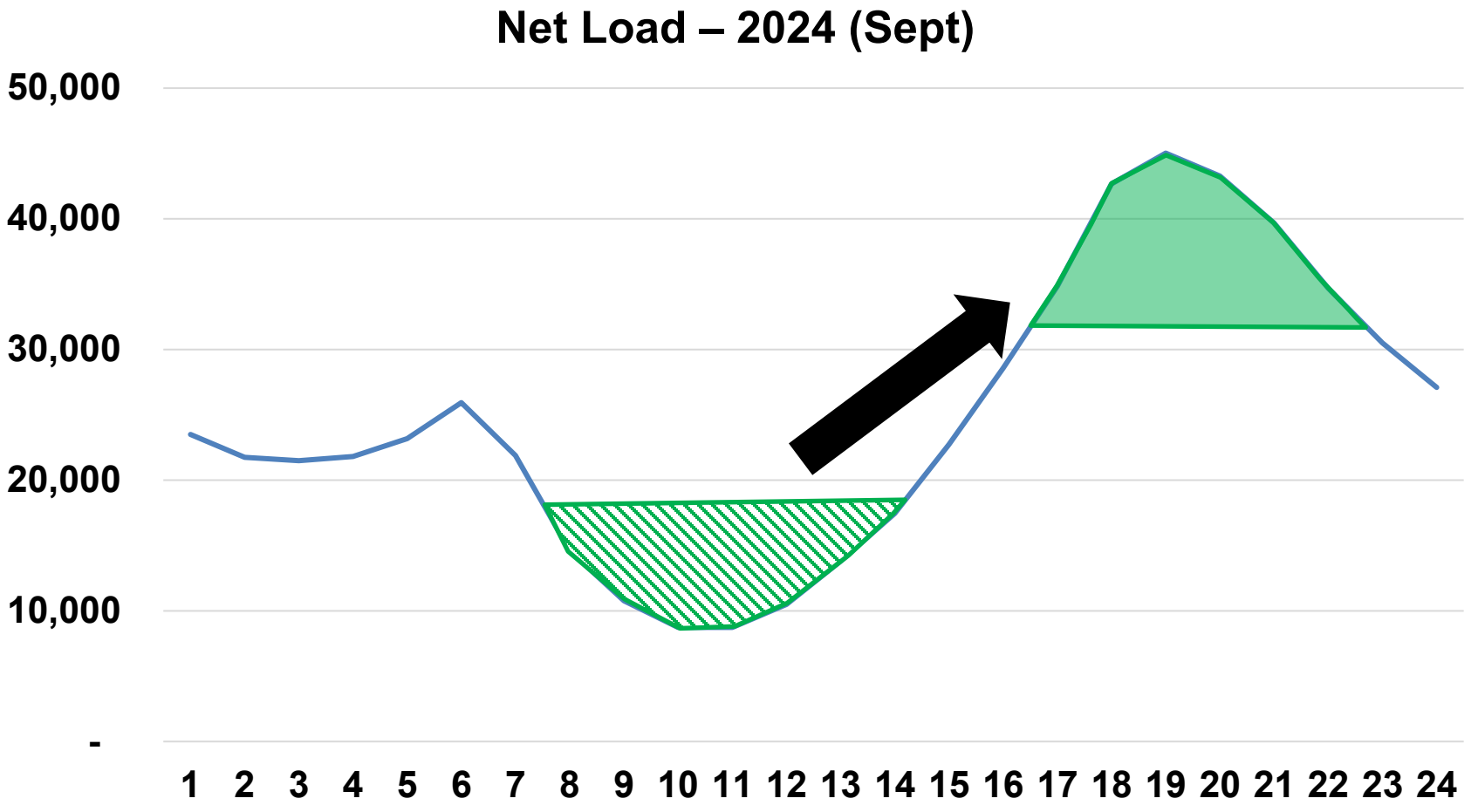
Storage resources are versatile and help the ISO manage peak loads and operational uncertainty today

- The ISO models state of charge for storage resources and ensures operations within physical limitations
- Lithium-ion resources can ramp very quickly and can deliver energy from minimums to maximums within a 5-minute period
- Lithium-ion resources have no start-up time and can be dispatched very quickly
- Lithium-ion resources are typically 85+% efficiency

Forecast peak loads increase in the future and new generation will need to be built to serve load



Storage resources move energy from the hours of least need to the hours of greatest need



Zero emission grid may eventually require (very) long duration storage to maintain operational grid reliability

- In the long run, the most challenging months to operate the grid will be in the winter
  - Multi-day periods of low solar and low wind will require storage solutions
- The ISO must retain state of charge in the event these conditions occur
  - ISO does not currently evaluate the day-ahead market beyond a 24-hour period
  - ISO is contemplating additional tools, outside of exceptional dispatch, to charge storage resources and have them hold state of charge
  - The ISO is developing other compensation mechanisms for storage resources simply holding state of charge
- The ISO continues to engage in work to evolve storage resource modeling on our grid, and is actively working on the energy storage enhancements initiative

LONG DURATION ENERGY STORAGE ASSOCIATION OF CALIFORNIA

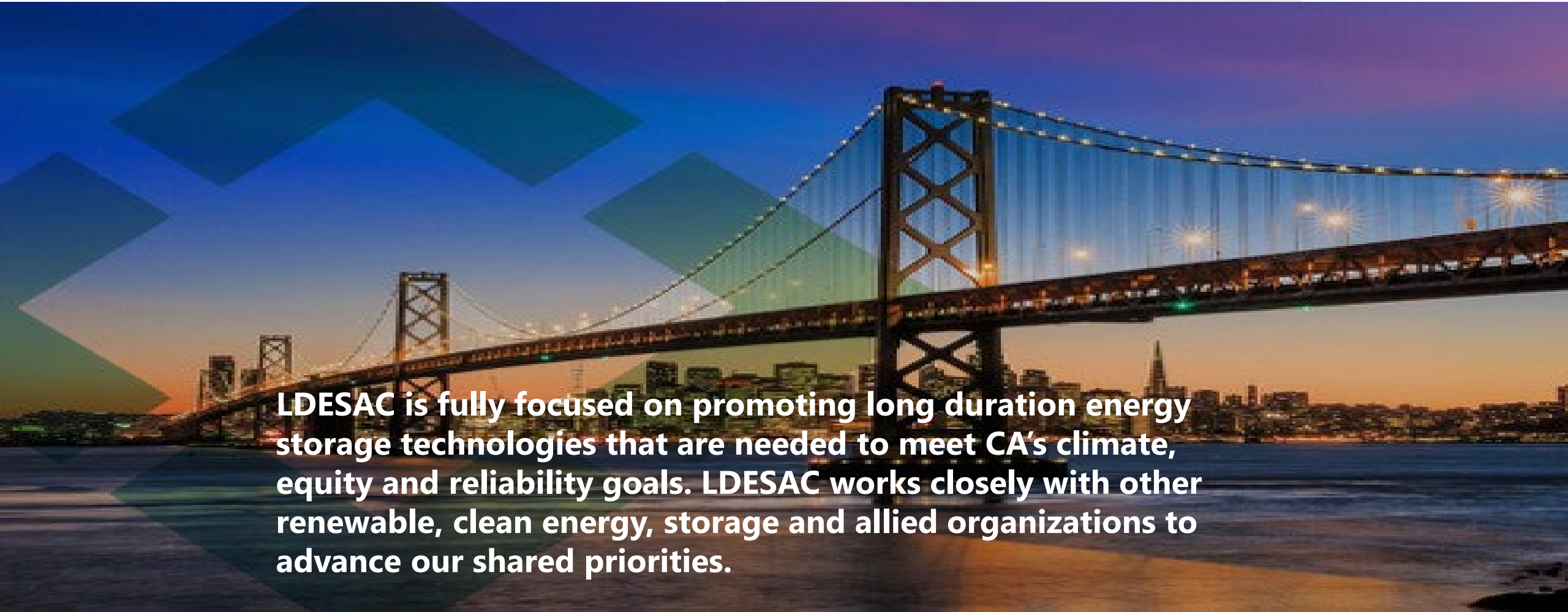
Workshop on Advancing Non-Lithium-Ion Long Duration Energy Storage Technologies

California Energy Commission

April 5, 2002

LONG DURATION ENERGY STORAGE ASSOCIATION OF CALIFORNIA

LDESAC



LDESAC is fully focused on promoting long duration energy storage technologies that are needed to meet CA's climate, equity and reliability goals. LDESAC works closely with other renewable, clean energy, storage and allied organizations to advance our shared priorities.

LONG DURATION ENERGY STORAGE ASSOCIATION OF CALIFORNIA

Membership

www.storeenergyca.org

LDES Plays a Critical Role in Meeting the State's Energy Policy Goals

CEC
Storage/ EPIC
Integrated Energy Planning
Resource Midterm Reliability

CARB
Public Scoping Plan
Emissions Tracking

CPUC
Various Proceedings

CAISO
Storage Initiative
Transmission Planning
Markets / Resource Adequacy

STUDIES
UC Merced
LBNL
US DOE

Diversity of LDES Technologies and Attributes

LDES Provides Community Benefits

LDES Procurement

LDES Solutions

Diversity of LDES Technologies and Attributes

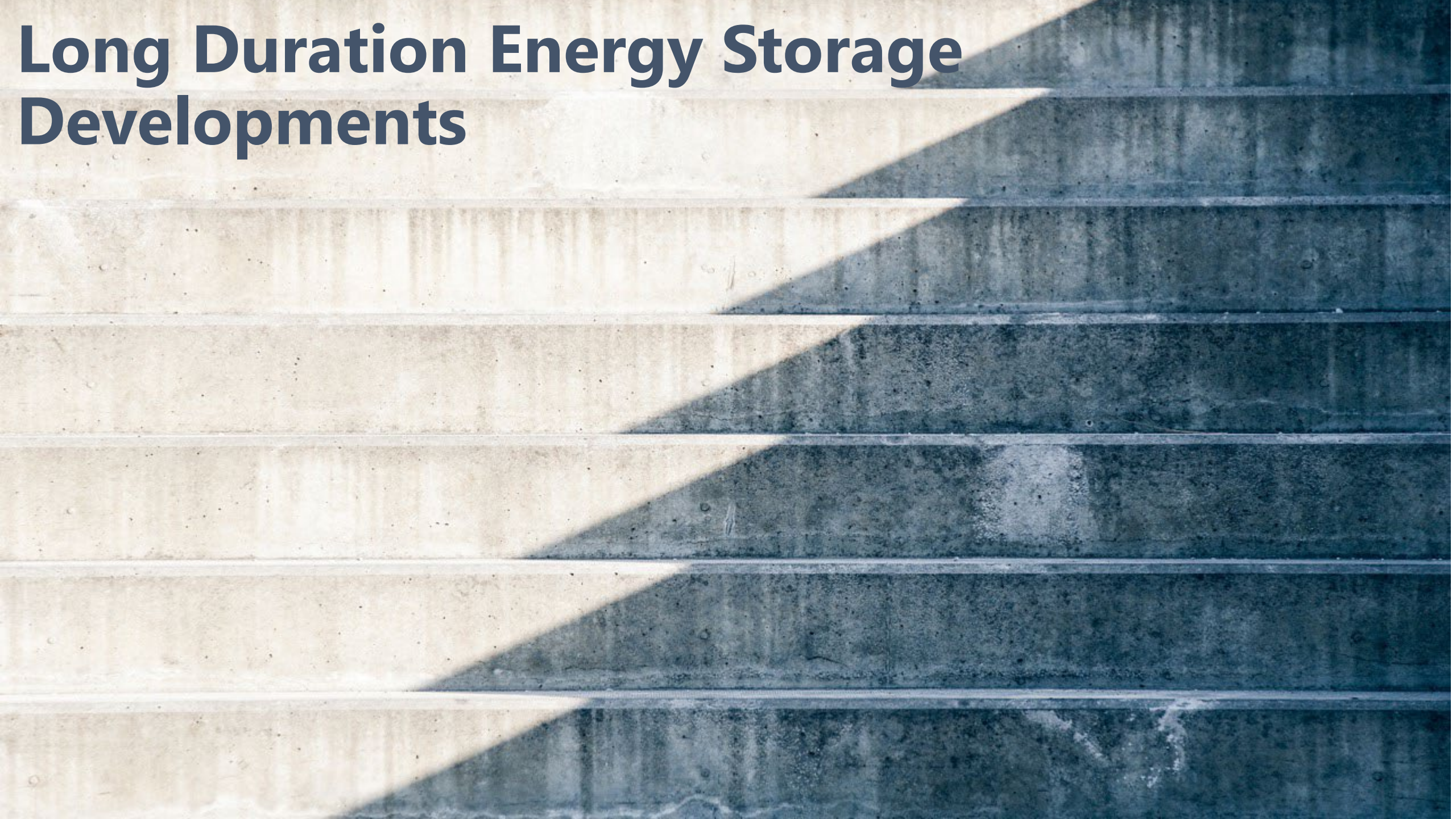
Long Duration Energy Storage: Inclusive Problem Solver

- Resiliency
- Community Benefits
- Just & Equitable Transitions
- Reliability
- Resource Adequacy
- Lower Costs
- Clean Energy Jobs
- Diverse Supply Chains
- Facilitates 24/7 Clean Energy Operations
- Promotes Equity and Affordability
- Helps Meet Climate Goals
- Operates for 8 hours +

What is Working to Advance LDES?

- Administration Vision
- Retirement of Fossil Fuel Generation
- Roadmap Aligned with Public Policies
- Acknowledgement of LDES Need
- Growing Procurement Opportunities
- Funding for LDES Projects

Long Duration Energy Storage Developments



Long Duration Energy Storage

All technologies promote renewable energy generation and manage surplus energy

Technology Type	Capacity	Avg. Duration	Avg. Life Cycle	Ancillary Services	Resource Attributes
Green Hydrogen	1-100MW	10-100hrs	20 yrs	Discharge time, response time	Refuel and recharge
Liquid Air	50-200MW	8-24hrs	30 yrs	Black start, regulation up, regulation down, spinning reserves, non-spinning reserves, voltage support. Future services: synchronous inertia, short-circuit level	No geographical constraints, above-ground construction, small footprint, no degradation
Compressed Air	100-500MW	8+ hrs	50 yrs	Regulation service-up, regulation service-down, responsive reserve service, non-spinning reserve service	Efficiency at max generation, Emissions free, unimpacted by temperature, future scalability in size and duration, no degradation, flexible siting locations
Pumped Storage	10-2400MW	8-121hrs	100 yrs	Black start, frequency regulation, voltage support, spinning reserves and operating reserves, synchronous condensers, fault ride thru add all services available in charging and discharging mode	Secure power supply, scalable, synchronous machines with large Inertia, high cycle efficiency, ultra-fast ramp rates and response times, high proven reliability
Concentrating Solar Thermal	50-250MW	10-24hrs	35 yrs	Synchronous generation thus provides spinning reserve, frequency regulation, fast ramping and other ancillary services	High conversion efficiencies. Can be designed to meet a fixed demand during specific times of day or night, including evening and morning peaks.

Long Duration Energy Storage

All technologies promote renewable energy generation and manage surplus energy

Technology Type	Capacity	Avg. Duration	Avg. Life Cycle	Ancillary Services	Resource Attributes
Flow Battery	1-25MW	10-24hrs	25 yrs	Frequency control	Scalable, power and duration can be sized independently
Flywheel	5-25MW	10-24hrs	35 yrs	Rotational energy, fast response time	Instant start and load following
Thermal Battery	200kWe & up	6-20hrs	30 yrs	Grid stabilization, frequency control, spinning reserves, rate arbitrage	No geographical constraints, scalable, close load following, no degradation
Gravity	40kW-8MW	5-24hrs	30 yrs	Resource adequacy, spinning reserve, sub-second response time (but not well suited for frequency response)	Scalable, distributed, reuse infrastructure, zero self-discharge
Zinc Batteries	1-10MW	10+ hrs	30 yrs	Frequency control	High energy density, 2% discharge rate

Power and Duration can be sized independently

LDES Essential Building Blocks

Proposed Administration Funding – $380 Million	1GW of Procurement	Acknowledgement of Resource Adequacy Value
Acknowledgement of LDES Need/ Value -SB 100	CEC Updated Data Inputs support 4+ GW	CEC Projects& Grants / Federal Funding

Funding Diverse Long Duration Energy Storage Technologies –small and large, behind the meter and utility scale is critical to decreasing emissions.

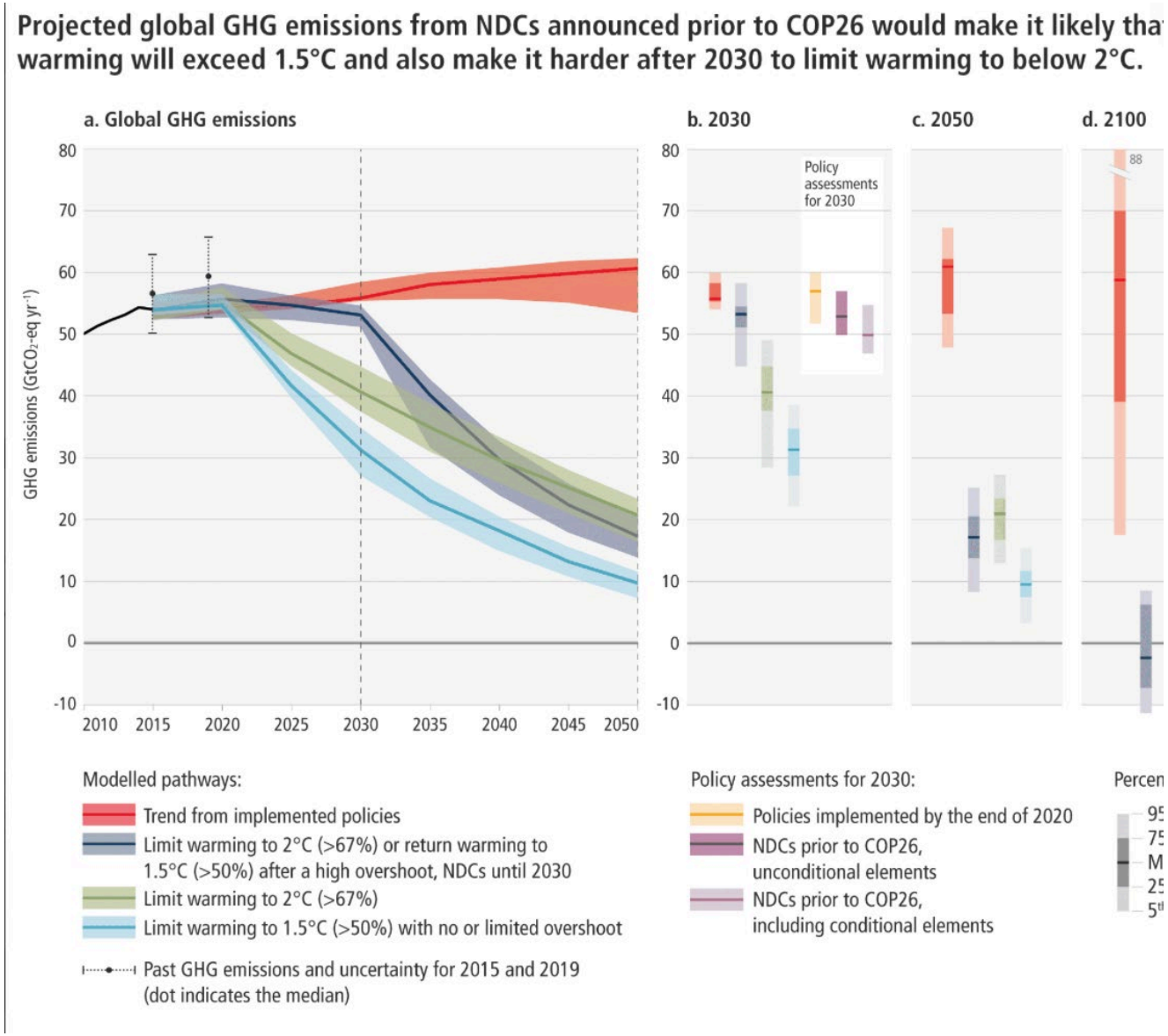


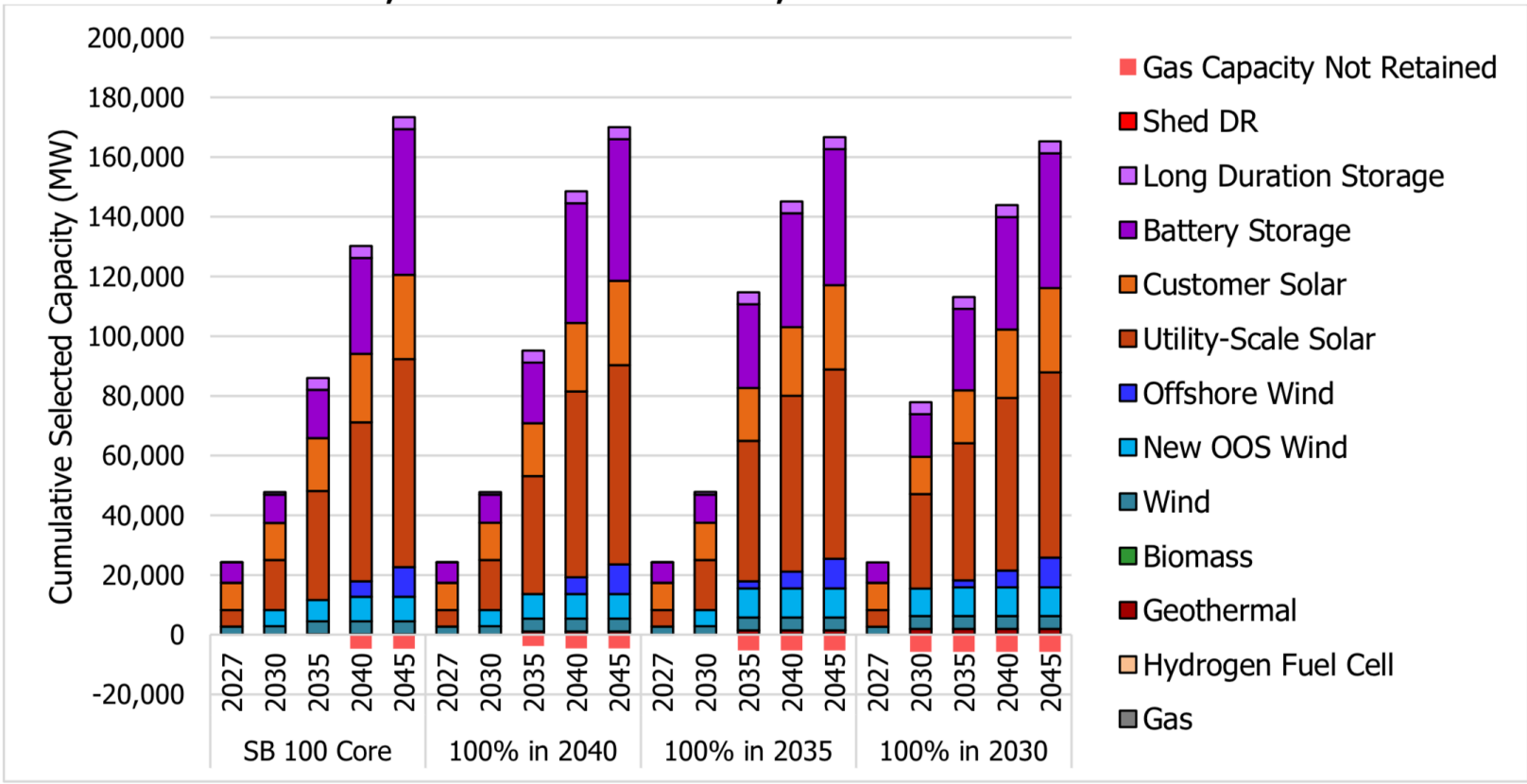
Figure SPM4: Global GHG emissions of modelled pathways (funnels in Panel a. and associated bars in Panels b, c, d) and projected emission outcomes from near-term policy assessments for 2030 (Panel b)

https://www.ipcc.ch/report/ar6/wg3/

“Moving to a clean electric grid is a foundational step that will unlock and support economywide opportunities to achieve carbon neutrality and address the most catastrophic impacts of climate change.”

[CA Joint Agency SB 100 Report]

Figure 9: Cumulative Capacity Additions for the SB 100 Core (2045 SB 100), 100 Percent in 2040, 100 Percent in 2035, and 100 Percent in 2030 Scenarios



Source: CEC staff and E3 analysis

Funding for Long Duration Energy Storage is Critical, as noted in the Report to the Governor on Priority SB 100 Actions to Accelerate the Transtion to Carbon-Free Energy…

“Consider funding sources other than ratepayer monies for zero-carbon emerging technologies, including long-duration energy storage and renewable hydrogen production, to accelerate the deployment and scale up of these resources."

https://www.energy.ca.gov/sites/default/files/2021-09/CEC-200-2021-008.pdf

Accelerated and equitable climate action in mitigating, and adapting to, climate change impacts is critical to sustainable development. Climate change actions can also result in some trade-offs. The trade-offs of individual options could be managed through policy design.

Effective and equitable climate governance builds on engagement with civil society actors, political actors, businesses, youth, labor, media, Indigenous Peoples and local communities.

https://www.ipcc.ch/report/ar6/wg3/

Thank you!

LONG DURATION ENERGY STORAGE ASSOCIATION OF CALIFORNIA

Julia Souder
Executive Director
julia@storeenergyca.org
202-246-3025

Advancing Non-Lithium-Ion Long-Duration Energy Storage Technologies

Jin Noh, Policy Director
California Energy Storage Alliance (CESA)

April 5, 2022

About CESA

The California Energy Storage Alliance is **the definitive voice of energy storage in California.**

At 100+ members strong, CESA is committed to advancing the role of energy storage in the electric power sector.

CESA is a 501c(6) membership-based advocacy group. CESA is technology and business model-neutral and is supported solely by the contributions and coordinated activities of its members.

Our CESA Members

CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

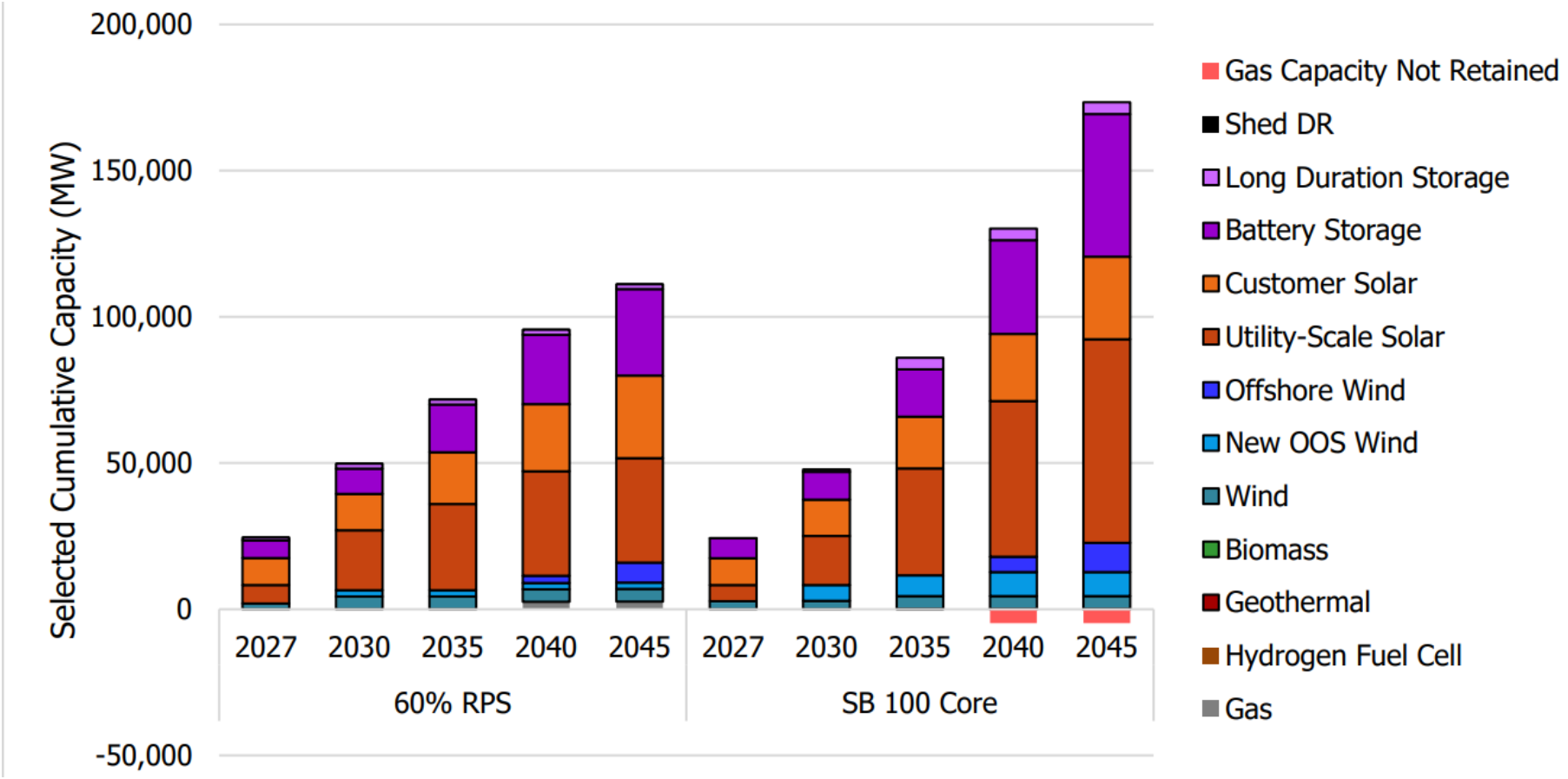
8minute Solar Energy
aes
Burns McDonnell
Fluence — A Siemens and AES Company
Hydrostor
LG Energy Solution
Lockheed Martin
NextEra Energy Resources
OnwardEnergy
ORMAT
Quidnet Energy
Recurrent Energy — A subsidiary of Canadian Solar
REV Renewables
RWE
Southern Power
sunrun
Tenaska
Terra-Gen
Tesla
Trane
Wellhead

AMERESCO — Green • Clean • Sustainable
American Fire Technologies — A Division of The Viking Companies, Inc.
Antora Energy
Arevon
aypa
BayWa r.e.
B2U
Borrego Solar
Boston Energy Trading and Marketing — A Subsidiary of Mitsubishi Corporation
Broad Reach Power
Carrier
Chelion America
conEdison
Cupertino Electric Inc.
Customized Energy Solutions — Analyze. Simplify. Implement.
EDF renewable energy
Elsys
enel
Energport
Energydome — Ground-Breaking Energy Storage
ESRG — Energy Storage Response Group
Energy Vault — Enabling a Renewable World
Enervenue
ENGIE
Enlighten
Enphase
ESS Inc
esVolta
Forefront Power
form energy
Gridwiz
Gore
GSR Energy
H2
Hecate Energy
Highview Power
Innergex
Jupiter Power
Largo CleanEnergy
Li-ion Tamer
Malta
Nuvation Energy
PXiSE Energy Solutions
Qcells
redflow — sustainable energy storage
Reimagine Power
Samsung
Samsung C&T
Sempra Infrastructure
Solas Energy Consulting
NGK
Nostromo
nexamp
Poly Joule
stem
Stoel Rives LLP
Storworks Power
Strata Clean Energy
Sumitomo Electric
sunnova
swell
TRC
UBS
UL
Vesper Energy
VRB Energy — Vanadium Redox Battery Solutions
Wärtsilä
ZELOS
Zitara

CPA Clean Power Alliance — Locally powered energy innovation.
MCE — My community. My choice.
City of Glendale Water & Power — Your Trusted Community Utility
San Jose Clean Energy — A Program of the City of San José
Silicon Valley Clean Energy
Peninsula Clean Energy

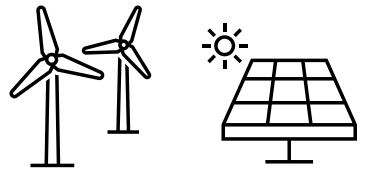
Energy Storage Future

Cumulative Capacity Additions for SB 100 Core Scneario and 60 Percent RPS Reference Scenario



Source: CESA analysis of public procurement data via compliance filings (data as of February 16, 2022)

To Achieve Clean Energy

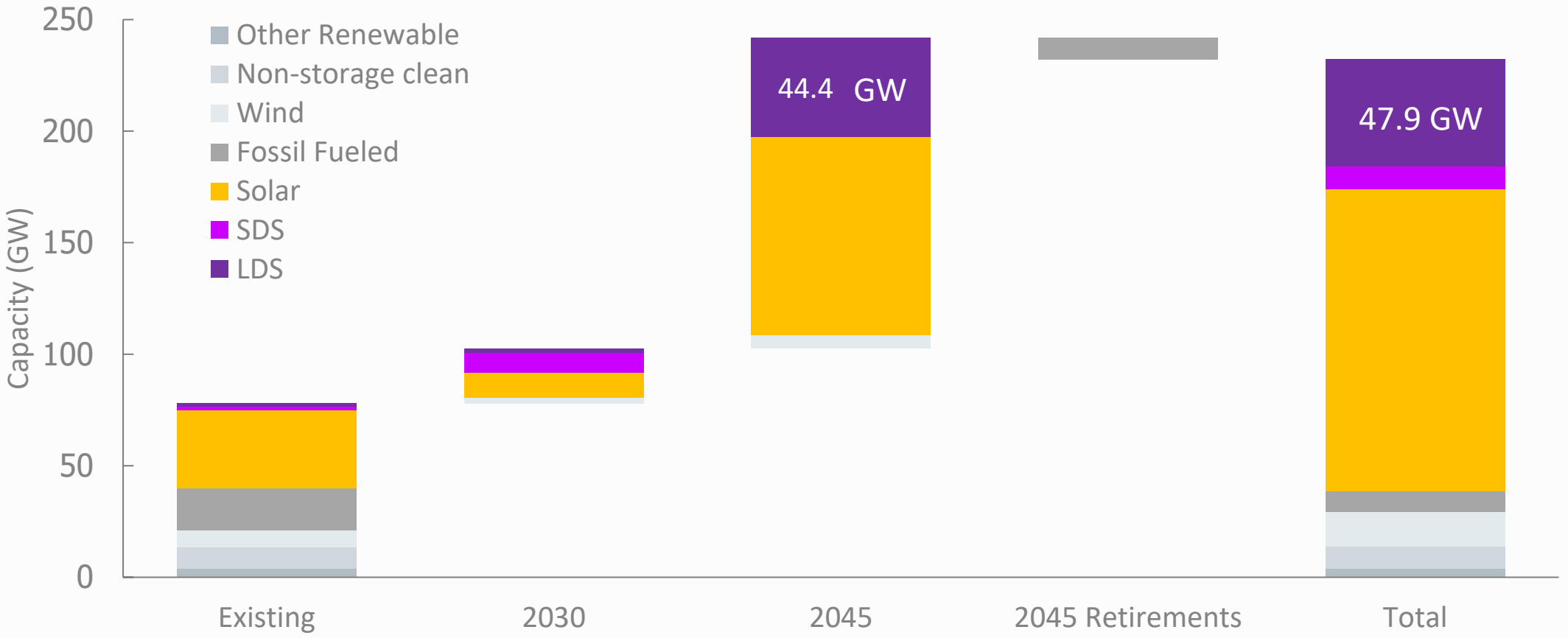


Solar and wind build rates need to **nearly triple**

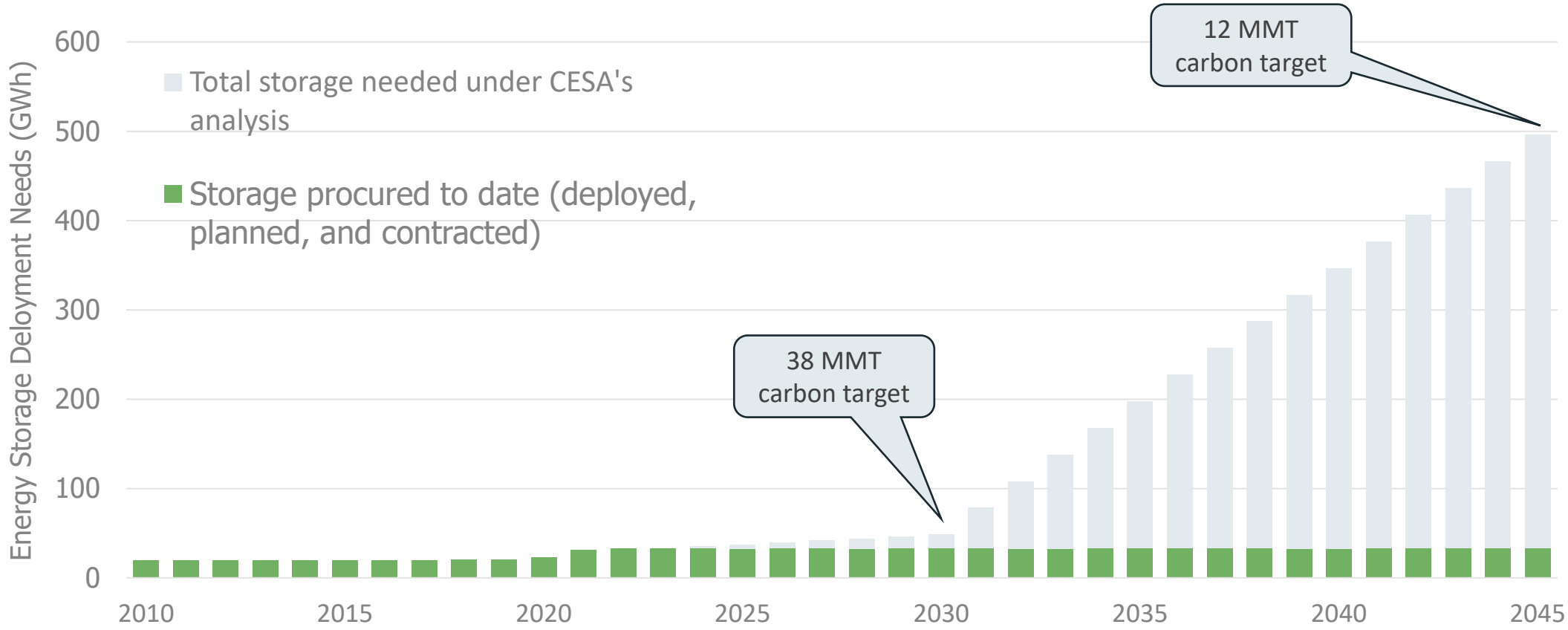
Battery storage build rates need to **increase by nearly eightfold**

**Based on 10 Year Average*
***Based on 2020*

Energy Storage Future



Energy Storage Future

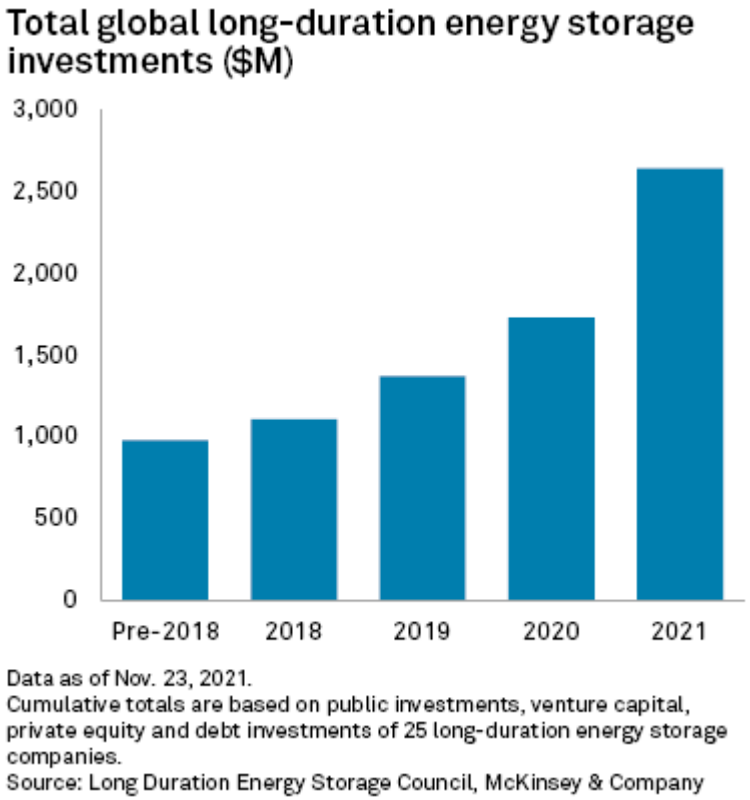


Clear Need for LDES

- **See IRP, SB 100, and CESA analysis on system need for decarbonization, reliability, and ratepayer costs:**
  - IRP Mid-Term Reliability (MTR) procurement order for 1,000 MW of LDES by 2025
  - Non-proxy inputs and multi-day reliability studies may show need for more
- **LDES can support a number of important use cases and applications:**
  - CAISO Local Capacity Requirement (LCR) studies show limits to 4-hour storage and longer durations to replace local gas generation
  - Greater range of T&D deferral applications can be met with longer durations
  - Microgrid resiliency applications looking at 24-72 hour capabilities
  - Some LDES technologies can provide inertia in a high inverter-based resource future
- **Non-lithium LDES can support diversification of supply chains**

LDES Technologies & Companies Are Ready

- **Significant private investments are being made to LDES technologies and pipeline development**
- **Many projects are reportedly in the pipeline in California**
- **LDES companies and technologies are being bid in California RFOs and RFPs:**
  - CC Power reported 9,000 MW of LDES across over 200 unique offers, representing close to 20 distinct technologies
  - SCPPA has received offers and is continuing to look at LDES options for in-basin needs
  - 3CE recently procured 32 MW (226 MWh) vanadium redox flow battery



CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

Proposed LDES Budget Will Address Barriers

- Serve as “tipping point” for technologies on verge of commercialization
- Ease first-mover burden (sweat equity) to procure non-lithium LDES technologies
- Support some larger projects where some tech requires a minimum scale and some LSEs set high minimum MW bid/offer requirements
- Support MTR needs and requirements (buydown, interconnection, permitting)
- Bridge current gaps in grid value, such as in RA capacity
- Position for future long-term growing needs (bankability, supply chain and tech diversity, experience requirement)

Please contact us at: info@storagealliance.org | www.storagealliance.org

Advancing Non-Lithium-Ion Long-Duration Energy Storage Technologies

April 5, 2022

Workshop Starts at 10 AM

Workshop is on a Break

and will Resume shortly

Balki Lyer, CEO
Eos Energy

INVINITY ENERGY SYSTEMS

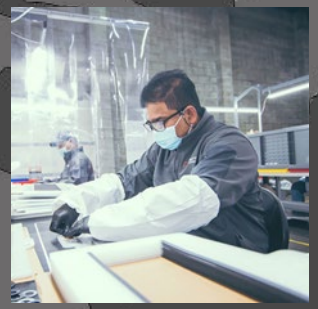
COMPANY OVERVIEW

CALIFORNIA ENERGY COMMISSION—LONG DURATION ENERGY STORAGE WORKSHOP

APRIL 5TH, 2022

INVINITY ENERGY SYSTEMS

- Utility-grade energy storage using vanadium flow technology
- Founded in 2020 through merger of Avalon Battery and redT Energy
- Public (LSE:IES)
- Over 50 projects with more than 33 MWh installed or signed



VANCOUVER/CANADA
Design & Manufacturing

SAN FRANCISCO/US
Sales & Exec

BATHGATE/UK
Solutions Engineering

LONDON/UK
Sales & IR

SUZHOU/CHINA
Manufacturing

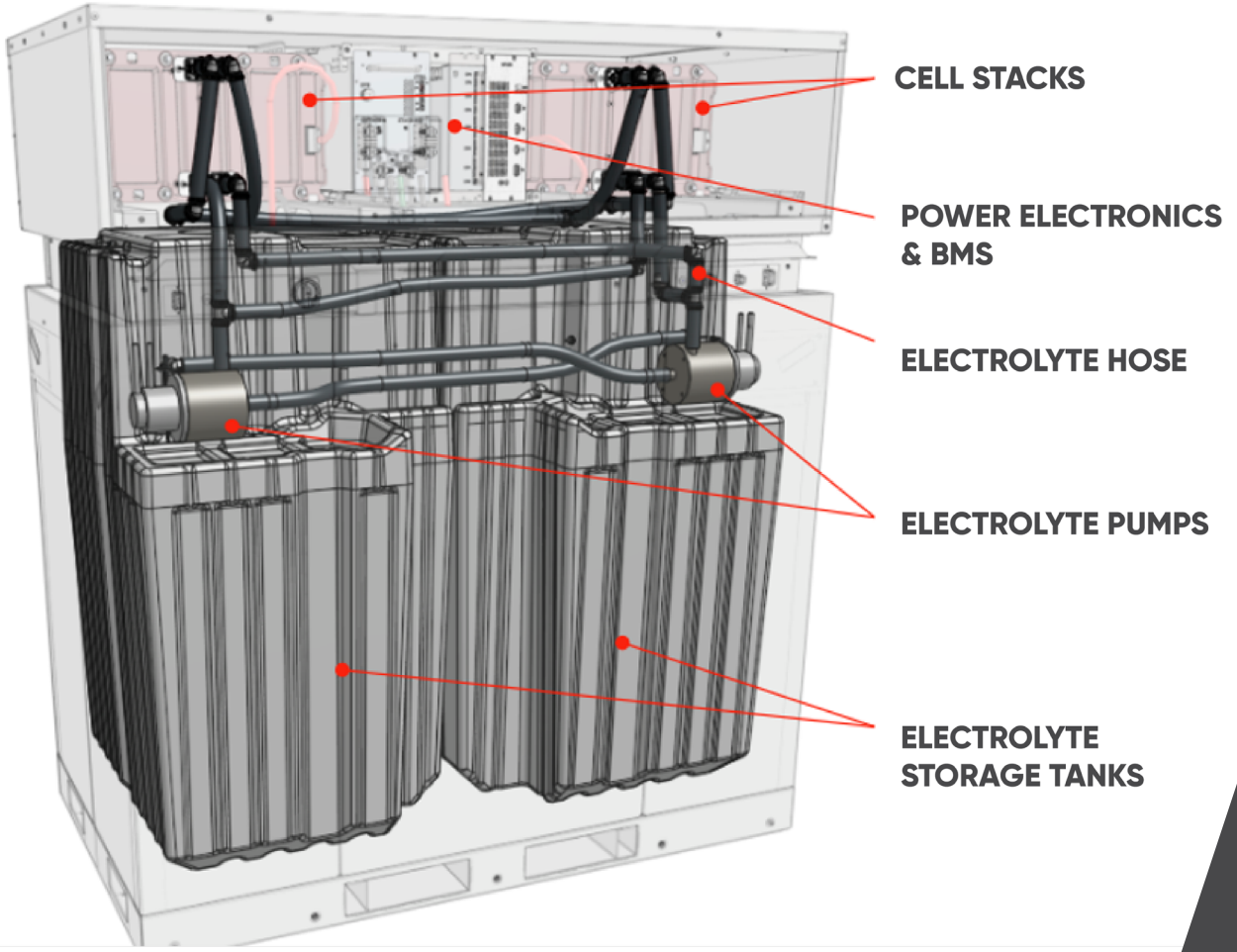
INVINITY ENERGY SYSTEMS

What makes energy storage utility-grade?

SAFE	Must have no risk of thermal runaway or significant safety risk near residential areas
LONG-LIFE	Match the lifespan of solar & wind assets; 25+ years of constant cycling
ECONOMICAL	Low LCOS; the price per MWh stored & discharged over the lifetime of the battery
PROVEN	Demonstrated performance in commercial applications in the field

INVINITY ENERGY SYSTEMS

Inside a VFB



VANADIUM

AVAILABLE

Element 23, readily available and more abundant in the Earth's crust than copper. Accessible reserves in Australia, South Africa, United States, Canada

REUSABLE

Virtually unlimited working life. 97% proven recovery rate from used electrolyte

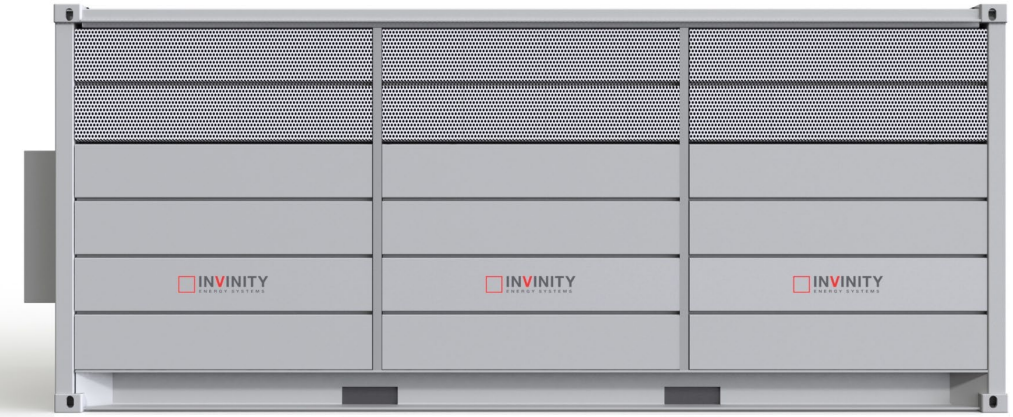
SAFE

Vanadium electrolyte is mild battery acid. Mixing fully charged electrolyte leads to a small temperature increase.

INVINITY ENERGY SYSTEMS

Invinity VS3

Safe. Long Life.
Economical. Proven.



RATED POWER: CONTINUOUS
78
kW

ENERGY STORAGE: NOMINAL
220
kWh

ENERGY STORAGE: DURATION
2-12
HOURS

LIFETIME:
25
YEARS

RECOMMENDED DEPTH OF DISCHARGE:
100%

CYCLE LIFE:
UNLIMITED

INVINITY ENERGY SYSTEMS

Energy Superhub Oxford

THE UK'S LARGEST FLOW BATTERY

2 MW / 5 MWH

Scottish Water Perth

DECARBONIZING WATER TREATMENT

0.8 MWH + 1 MW SOLAR

Chappice Lake Solar-Storage

CANADA'S LARGEST VANADIUM FLOW BATTERY

- 8.4 MWh flow battery system + 21 MWp solar array
- Generating clean energy on demand to serve the daily needs of more than 7,000 Albertans
- Order to be fulfilled with 38 Invinity VS3 batteries
- Operational in late 2022

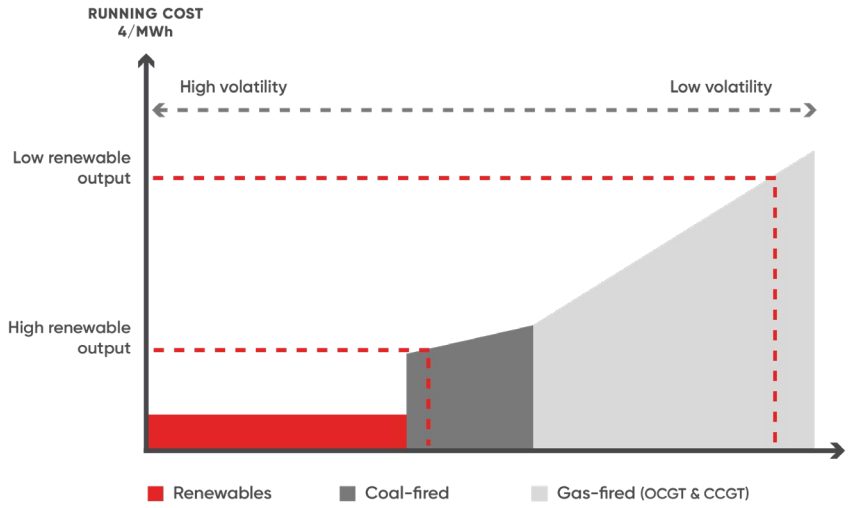
INVINITY ENERGY SYSTEMS elemental energy COLD LAKE FIRST NATIONS EMISSIONS REDUCTION ALBERTA

Yadlamalka Solar + Storage

WORLD'S LARGEST SOLAR-POWERED VFB

- 8 MWh Invinity Battery System + 6 MWp Solar PV
- Manufacturing starting H1 2021
- 41 Invinity VS3s
- Australia's largest flow battery
- Delivery 2022

DISPATCHABLE SOLAR TO DISPLACE THERMAL GENERATION



INVINITY ENERGY SYSTEMS

Soboba Fire Station

CLEAN POWER FOR CRITICAL INFRASTRUCTURE

- California Energy Commission-funded project
- 0.5 MWh flow battery system integrated with onsite solar PV
- 10-hours storage duration, supplying resiliency in a region heavily affected by wildfires
- Project to go live in San Jacinto in 2022

INVINITY ENERGY SYSTEMS

GRID ALTERNATIVES

SOBOBA BAND OF LUISEÑO INDIANS
EST. JUNE 19, 1883

STATE OF CALIFORNIA
ENERGY COMMISSION

Air Station Miramar

US MARINE CORPS AIR STATION IN CALIFORNIA

- Ensuring round-the-clock energy resiliency while reducing overall energy costs
- 0.5 MWh flow battery system integrated for grid-connected or off-grid modes
- 10-hours storage duration, supplying resiliency in a region heavily affected by wildfires
- Project to go live in 2022

INVINITY ENERGY SYSTEMS

WEBCOR

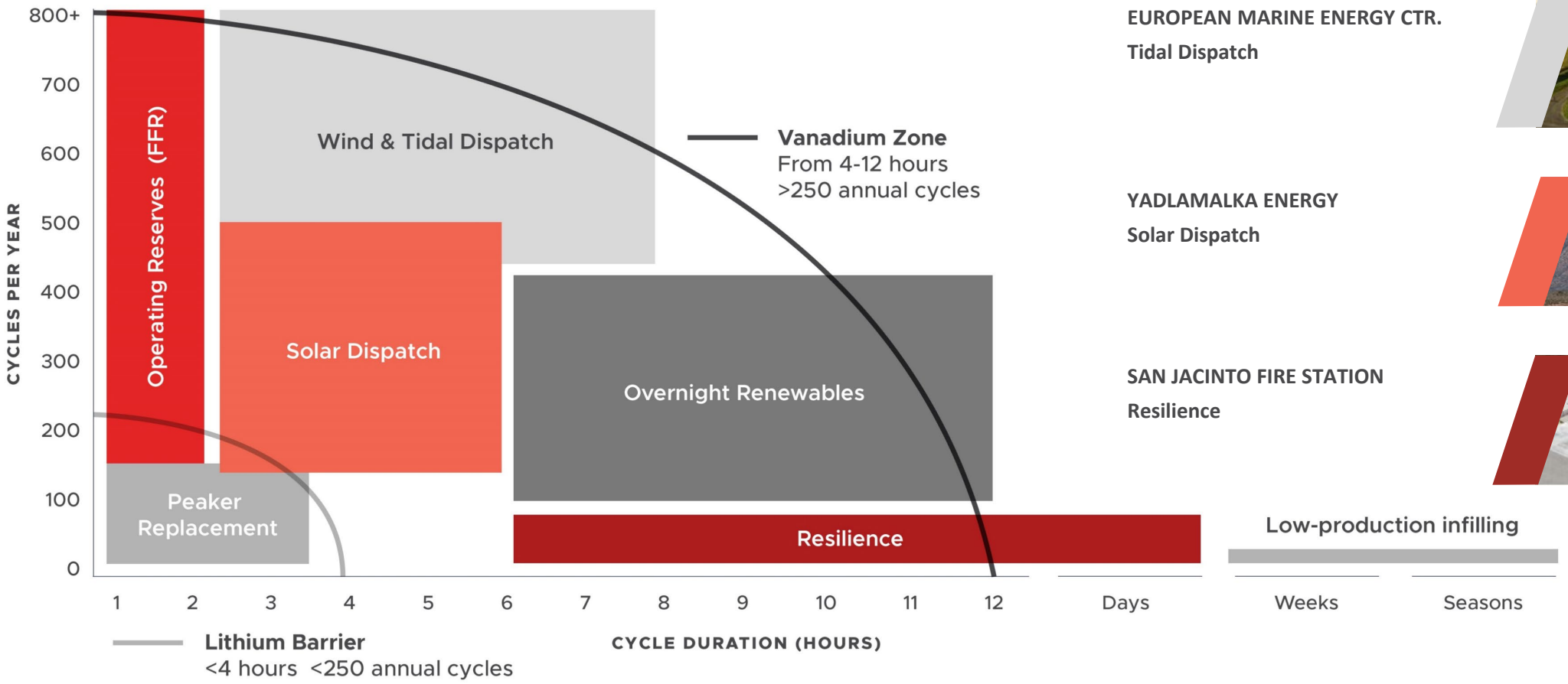
INDIAN ENERGY LLC

STATE OF CALIFORNIA ENERGY COMMISSION

INVINITY
ENERGY SYSTEMS

INVINITY
ENERGY SYSTEMS

VFB Use Cases



ENERGY SUPERHUB OXFORD
Operating Reserves

EUROPEAN MARINE ENERGY CTR.
Tidal Dispatch

YADLAMALKA ENERGY
Solar Dispatch

SAN JACINTO FIRE STATION
Resilience

INVINITY ENERGY SYSTEMS

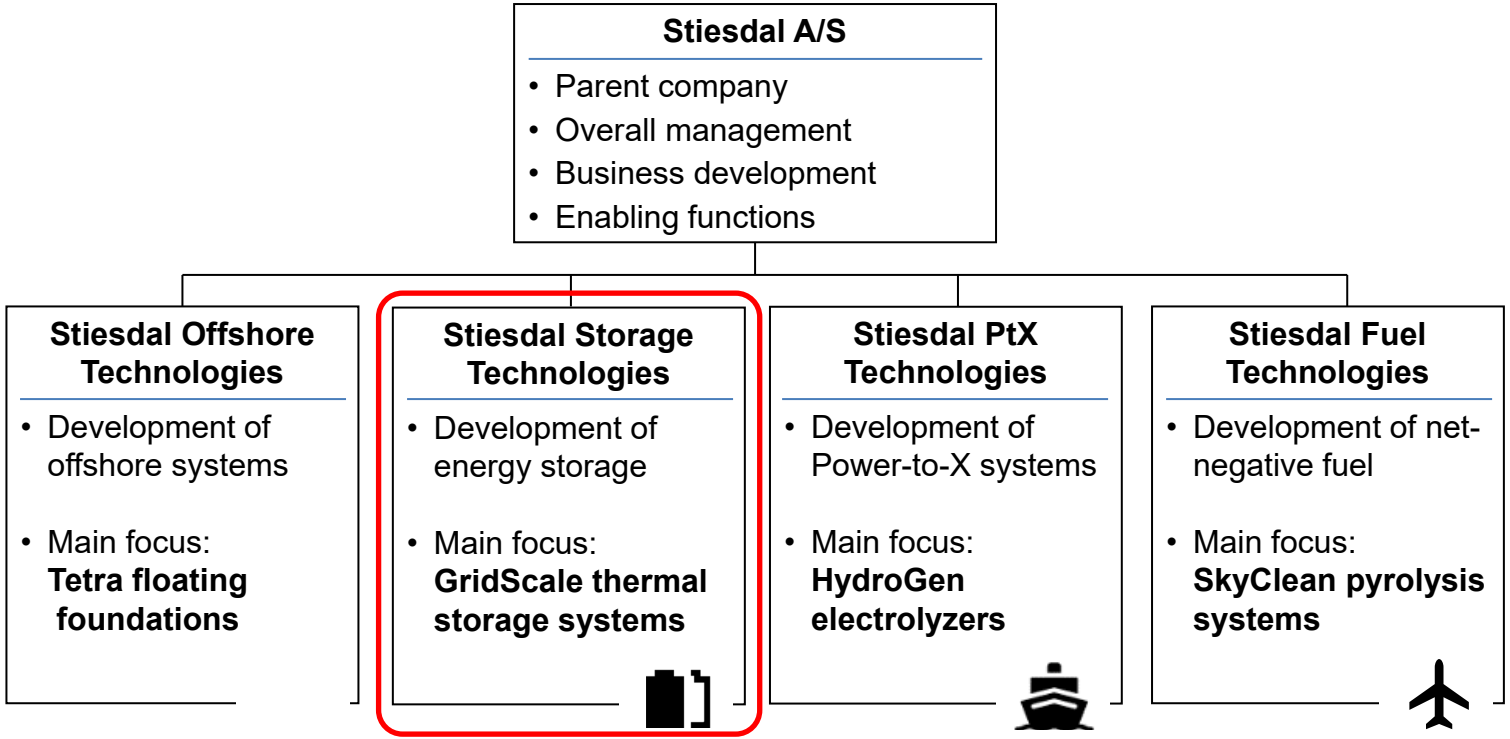
Mateo Jaramillo, CEO
Form Energy

Stiesdal Storage Technologies

GridScale Battery

Henrik Stiesdal, April 5, 2022

Company structure



The heat pump principle of the GridScale Thermal Battery

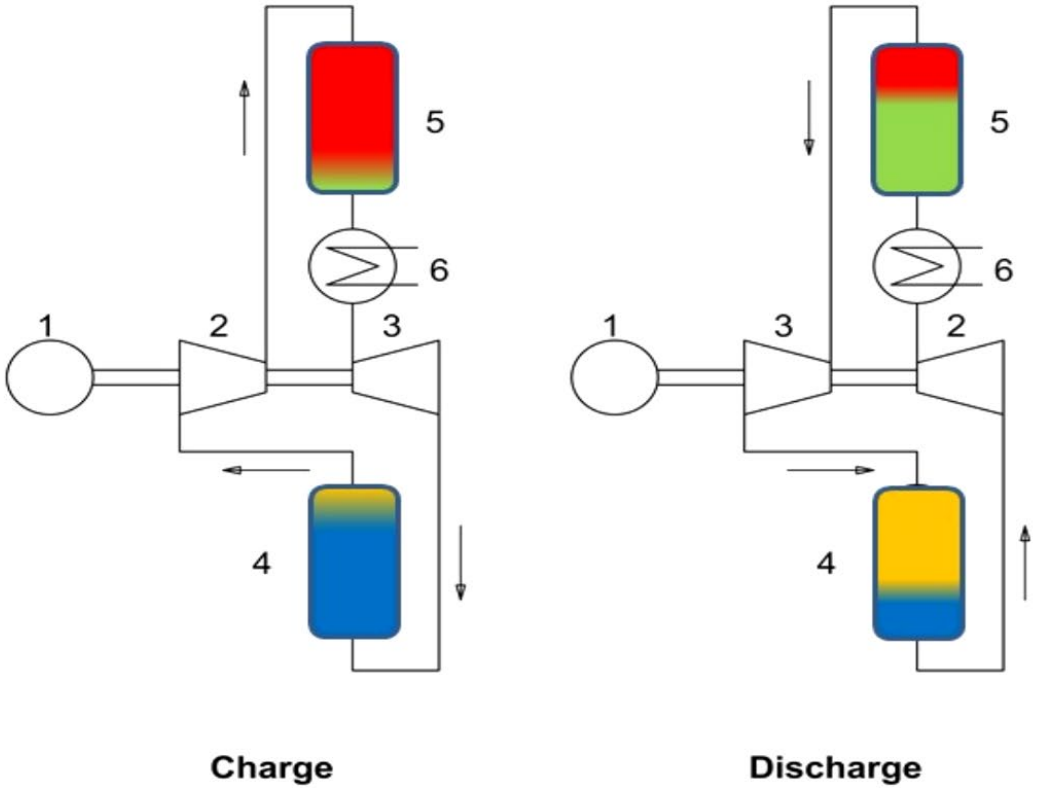
1 Motor
2 Compressor
3 Turbine
4 Cold storage tank
5 Hot storage tank
6 Cooler

600 deg.C

385 deg.C

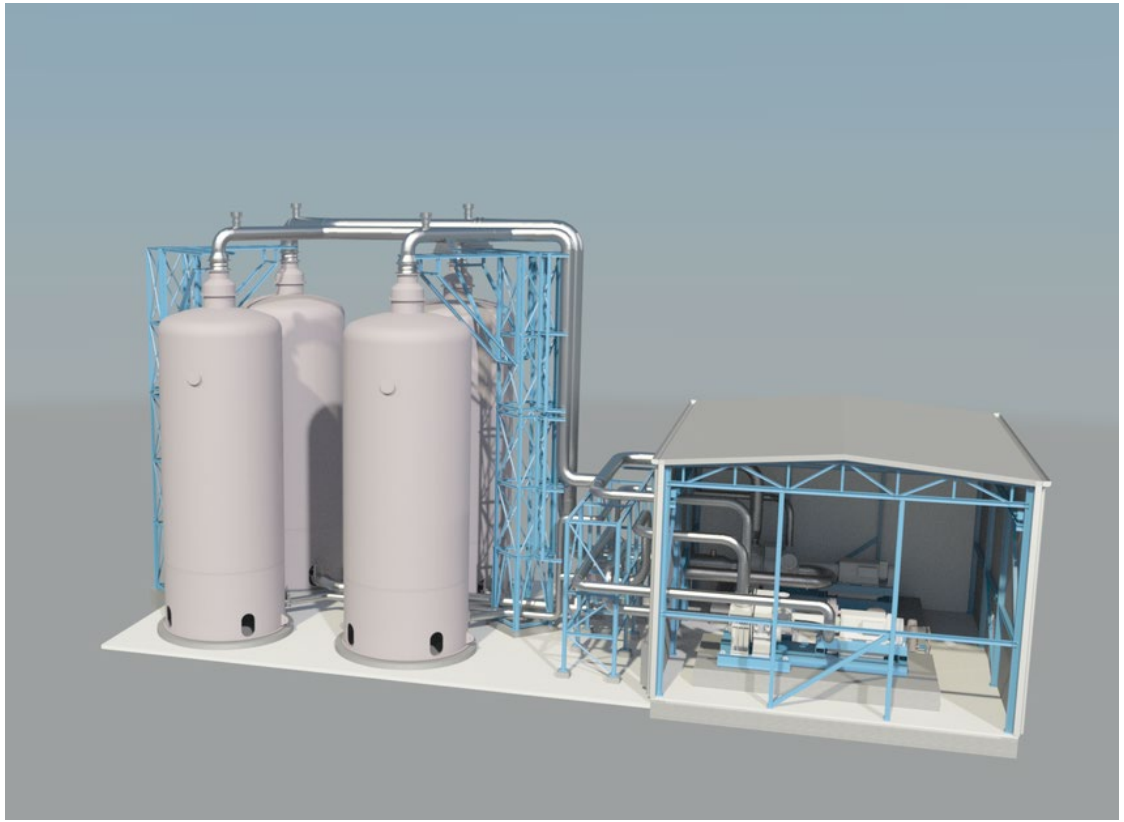
75 deg.C

-30 deg.C

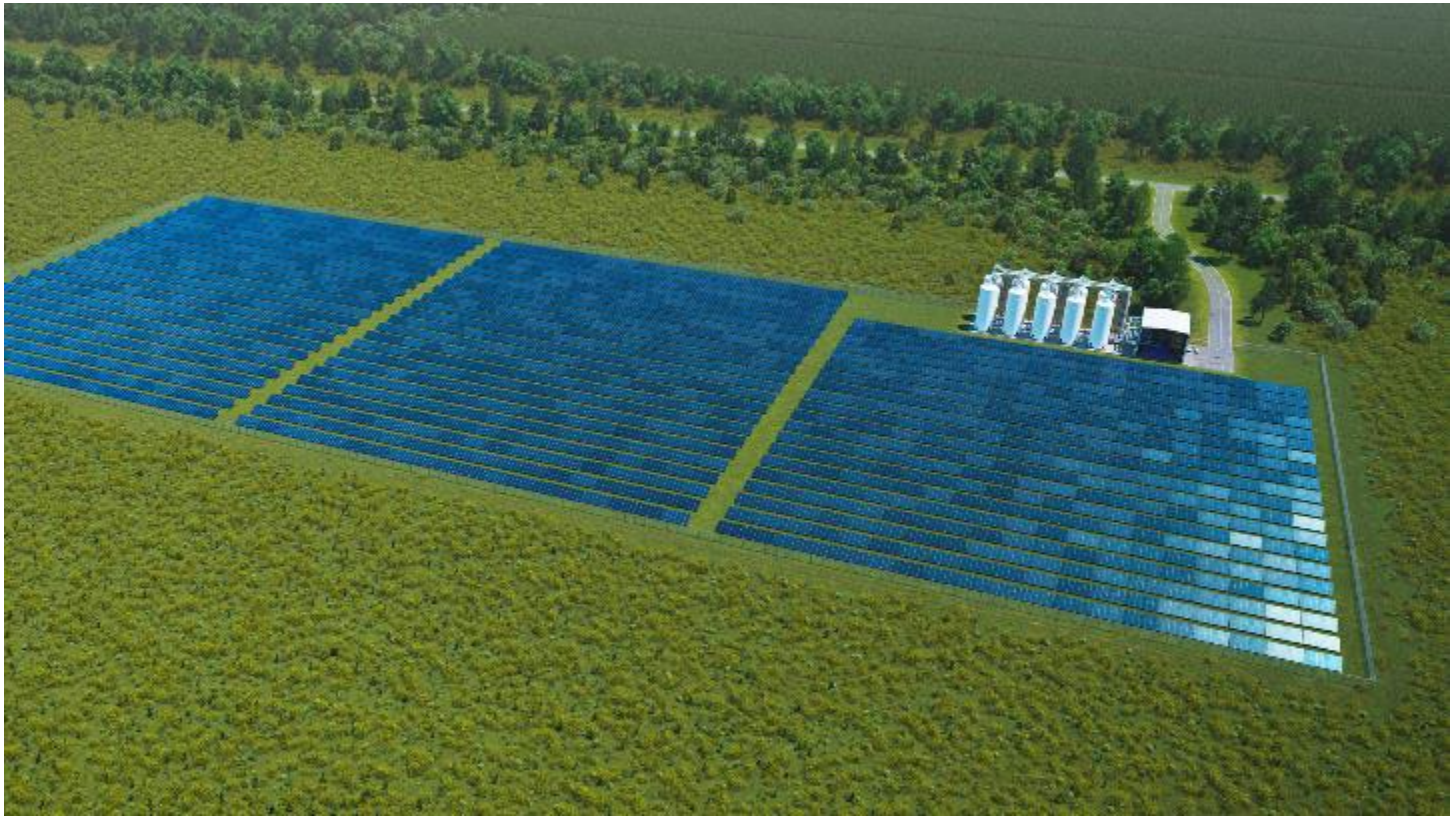


Testing of storage tank concept

The first full scale project with Danish utility Andel



Potential behind-the-meter application for 24/7 solar power



Thanks for your attention

Henrik Stiesdal
hst@stiesdal.com

Public Comment

Advancing Non-Lithium-Ion Long-Duration Energy Storage Technologies

Written comments must be submitted to the Docket Unit **by 5:00 p.m. on April 26, 2022**.

The CEC encourages use of its electronic commenting system. Visit the e-commenting page https://efiling.energy.ca.gov/EComment/EComment.aspx?docketnumber=19-ERDD-01

at https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=19-ERDD-01, which links to the comment page for this docket. Enter your contact information and a comment title describing the subject of your comment(s). Comments may be included in the "Comment Text" box or attached as a downloadable, searchable document in Microsoft® Word or Adobe® Acrobat®. The maximum file size allowed is 10 MB.

Written comments may be submitted by email. Include docket number 19-ERDD-01 and Workshop on Advancing Non-Lithium-Ion Long Duration Energy Storage Technologies in the subject line and email to docket@energy.ca.gov.

A paper copy may be sent to:

California Energy Commission
Docket Unit, MS-4
Docket No. 20-EPIC-01
715 P Street
Sacramento, California 95814

Public Comments

Zoom:

- Use the “raise hand” feature to make verbal comments

Telephone:

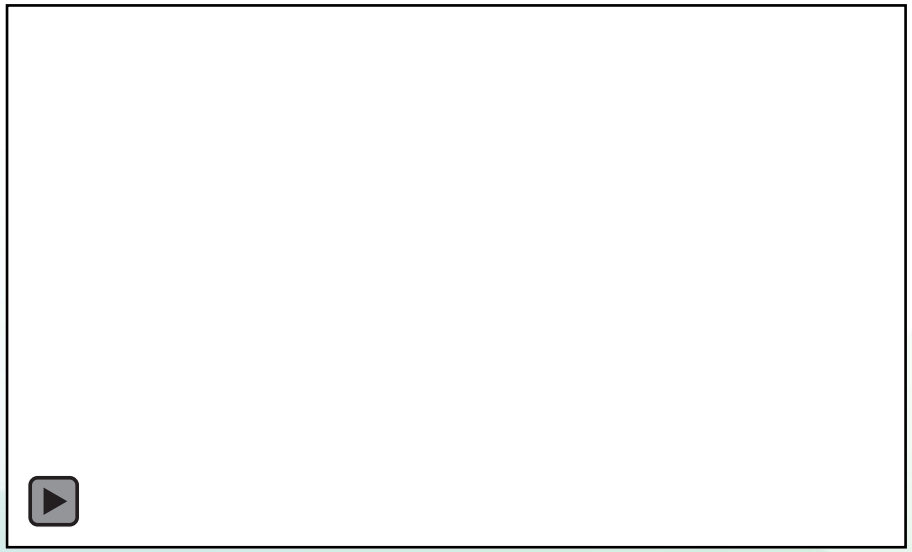
- Dial *9 to raise your hand
- *6 to mute/unmute your phone line. You may also use the mute feature on your phone.

When called upon:

- Your microphone will be opened
- Unmute your line
- Spell your name for the record, then start your comments

Limited to 1 minute per person and 1 representative per organization.

1-MINUTE TIMER



Public Comment

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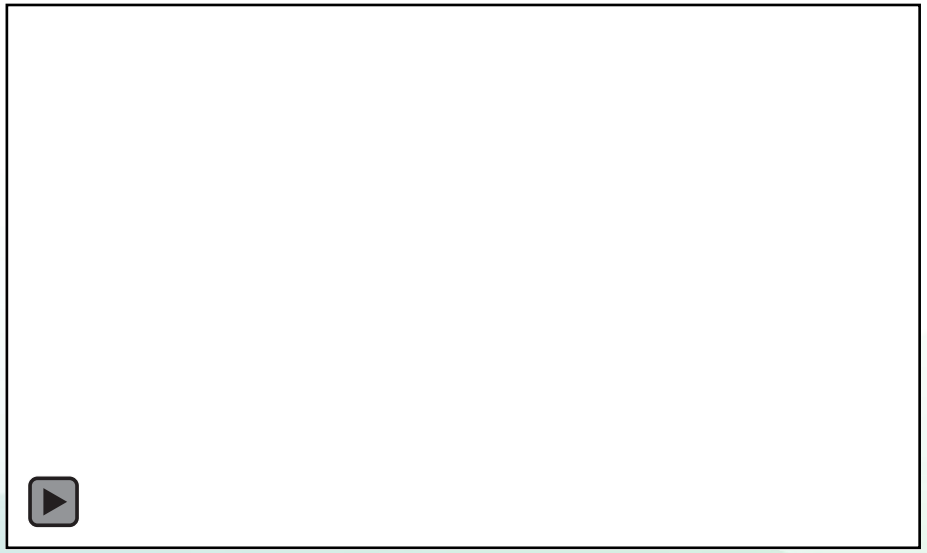
- *6 to mute/unmute your phone line. You may also use the mute feature on your phone.

When called upon:

- Your microphone will be opened
- Unmute your line
- Spell your name for the record, then start your

Limited to 1.5 minutes per person and 1 representative per organization.

1.5 MINUTE TIMER



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Telephone:

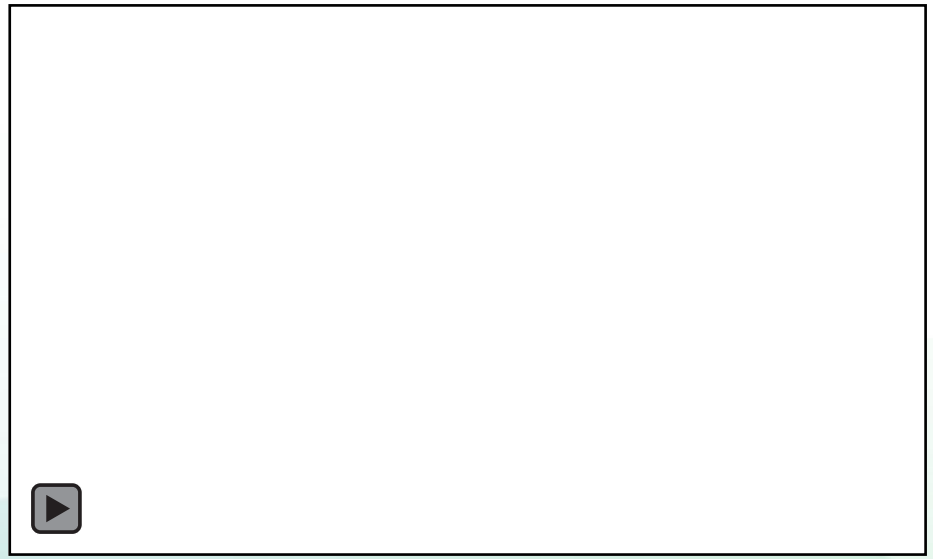
- Dial *9 to raise your hand
- *6 to mute/unmute your phone line. You may also use the mute feature on your phone.

When called upon:

- Your microphone will be opened
- Unmute your line
- Spell your name for the record, then start your comment

Limited to 1 representative per organization.

3-Minute TIMER



Closing Remarks

Submit written comments to the ERDD docket page:

- Comments are due April 26, 2022

Break

The IEPR Commissioner Workshop on Natural Gas Market and Demand Forecasts

will Resume at X:00 PM

We Appreciate Your Patience