DOCKETED	
Docket Number:	20-EPIC-01
Project Title:	Development of the California Energy Commission Electric Program Investment Charge Investment Plans 2021-2025
TN #:	238944
Document Title:	Presentation - July 20, 2021 - (EPIC 4) Investment Plan Workshop
Description:	Full presentation from the July 20, 2021 EPIC Energy Storage Workshop
Filer:	Harrison Reynolds
Organization:	California Energy Commission
Submitter Role:	Commission Staff
Submission Date:	7/20/2021 1:08:56 PM
Docketed Date:	7/20/2021

Electric Program Investment Charge: 2021-2025 (EPIC 4) Investment Plan Workshop

Technology Advancements for Energy Storage

July 20, 2021

EPIC 4 Investment Plan Process, Timeline, and Public Participation

Mike Petouhoff, CEC

EPIC 4 Investment Plan Research Themes

Decarbonization

Reduce GHG emissions and use of fossil fuels.

Resilience and Reliability

Provide firming and shaping to balance increasing amounts of intermittent renewable generation to help match load and generation to keep the grid stable

Support Resilience for PSPS events

Entrepreneurship

Support clean energy entrepreneurs developing breakthrough technology solutions from idea to market.

Affordability

Improve the affordability of energy services for all electric ratepayers.

EQUITY is an overarching theme for EPIC investment planning. Initiatives will include funding set-asides for projects in under-resourced communities and other equity-targeting elements.

EPIC 4 Plan Schedule

Task / Event	Date(s)
Public workshops series to solicit stakeholder input on specific topics	May – July 2021
Public workshop to get input and feedback on the CEC's draft research initiatives being considered for the Overall EPIC 4 Investment Plan	August 4, 2021
EPIC 4 Investment Plan considered at CEC Business Meeting for approval	September 2021 (tentative)
EPIC 4 Investment Plan submitted to CPUC	October 1, 2021 (tentative)
CPUC Decision on EPIC 4 Plan expected	Spring-2022 (tentative)
The first EPIC 4 solicitations released	Summer-Fall 2022

Ways to stay involved!

To stay involved in EPIC 4:

Visit CEC's website for workshop info, presentations, docket, e-commenting, and EPIC listserv sign up:
www.energy.ca.gov/epic4

Submitting Written Comments:

The Stakeholder Input Form and Workshop Comments may be submitted using CEC's **e-commenting** system through July 30th
https://efiling.energy.ca.gov/Ecomment/Ecomment.aspx?docketnumber=20-EPIC-01

See this event's **notice** for **e-mail and U.S. Mail** commenting instructions:
https://efiling.energy.ca.gov/getdocument.aspx?tn=238093

For all comments, please include docket # **20-EPIC-01** and "EPIC 4 Investment Plan" in the subject line and on the cover page. Comments for this workshop are due **July 30, 2021.**

California
Energy Commission
Research & Development

Technology Advancements for Energy Storage

Electric Program Investment Charge Workshop

Energy Research and Development Division

Mike Petouhoff, Mike Gravely, Haresh Kamath, Quenby Lum, Jeffrey Sunquist

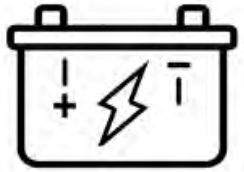
July 20, 2021

Planning for California's SB-100 Goals To Achieve Clean Energy

Solar & Wind

3X

Solar and wind build rates need to nearly triple*



Battery

8X

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

For reference:

- The 2018 August CPUC committed System RA resources totaled 47 GW.
- Demand: High Electrification; Resource Options: All; Year: 2045

We Are Looking For Your Input to Guide These Efforts

- Short Duration Storage Technology
    - Lithium Ion
    - Non Lithium Ion
- Long Duration Storage Technology
- Exploring Storage Use Cases

….Also, Potential Funding for Research for H2 Storage and Firm Dispatchable Generation, and other forms of Long Duration Storage Under Consideration by the CA State Legislature.

Workshop Agenda

Time	Topic
9:30 AM	Introductions and Opening Remarks Mike Petouhoff, Manager, CEC Energy Systems Research Office
9:45 AM	CEC EPIC History—Advancing the Commercialization of Emerging Energy Storage Technologies Mike Gravely, CEC Energy Systems Research Office
10.00 AM	Panel 1: Global Industry View on the Opportunities and Challenges Facing Emerging Energy Storage Technologies Moderator: Mike Gravely, CEC Energy Systems Research Office Jason Burwen, CEO of the U.S. Energy Storage Association Alex Morris, Executive Director, California Energy Storage Alliance
10:30 AM	Panel 2: Lithium-Ion Technology Batteries—Current Status and Future Outlook to Support California's Storage Needs Moderator: Haresh Kamath, Director of Distributed Energy Resources and Energy Storage, Electric Power Research Institute Paul Beach, President of Octillion Power Systems, representing lithium-ion technology systems Jonathan Weisgall, Berkshire Hathaway Energy, representing the Lithium Valley Commission and the lithium extraction industry

Workshop Agenda

Time	Topic
11:00 AM	Panel 3: Addressing the 4 Hour or Less Energy Storage Market—Opportunities and Gaps Moderator: Quenby Lum, CEC Energy Systems Research Office Andrew Hughes, Manager of Sales & Business Development, Eos Energy Ryan Brown, CEO and Co-Founder, Salient Energy Seth Sanders, Chief Technology Officer and Co-founder, Amber Kinetics
11:30 AM	Panel 4: Addressing Long Duration Energy Storage Market—Opportunities and Gaps Moderator: Jeff Sunquist, CEC Energy Systems Research Office Matt Harper, Chief Commercial Officer, Invinity Energy Systems David Bierman, Co-Founder and Chief Technology Officer,Antora Energy Jason Houck, Manager, Policy and Regulatory Affairs, Form Energy, Inc.
12:00 PM	Public Comments • 3 minutes per commenter, 1 commenter per organization • Please clearly state your name and affiliation • Use the raise hand function in Zoom and wait to be called upon to unmute. Type questions/comments into the Q/A window.
12:30 PM	Closing Remarks Mike Gravely, CEC Energy Systems Research Office Workshop Comments are due July 30, 2021.

100% Clean, Nimble, Reliable, Cost Optimized Grid of the Future

HELP US GET THERE!

An EPIC CEC History- Advancing the Commercialization of Emerging Energy Storage Technologies

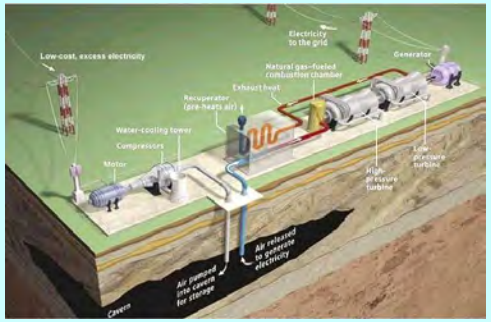
MIKE GRAVELY, CEC ENERGY SYSTEMS RESEARCH OFFICE, SENIOR TECHNICAL LEAD

California Energy Commission EPIC Research Program

Electric Program Investment Charge (EPIC)—Administered by the CPUC

- Ratepayer-funded program to benefit ratepayers
- Administered by the Energy Commission and three Investor-Owned Utilities (PG&E, SCE, and SDG&E)
- Energy Commission Program ~ $130 M/year

California Energy Commission has a Long History of Energy Storage Research



Diverse Combination of Microgrid Demonstration Projects by End Use

Critical Facilities

Shelter

Medical Center

Fire Stations

City Hall, Police HQ, and Community Centers

Waste Water Treatment Plant

Airport

Ports

Military

Communities

Industrial

Digester

Distribution Center

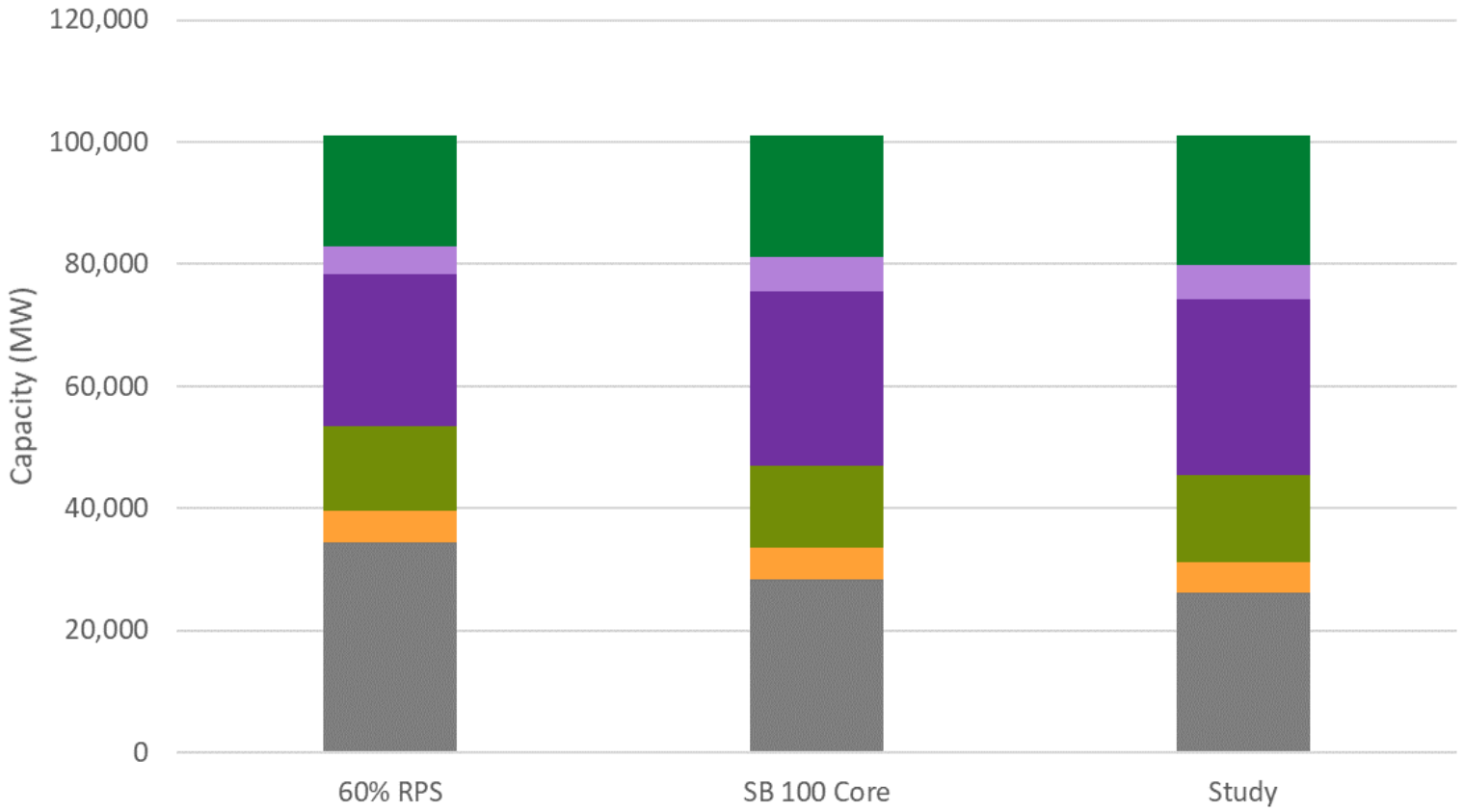
Growing Need for Energy Storage in California

(CPUC Integrated Resource Plan)

Table 5. New Resource Buildout of 2019-2020 RSP (Cumulative MW)

Resource Type	2020	2021	2022	2023	2024	2026	2030
Wind	-	34	1,950	1,950	2,737	2,737	2,837
Wind on New Out-of-State Transmission	-	-	-	-	-	-	606
Utility-Scale Solar	2,000	4,000	6,000	8,000	8,000	8,000	11,017
Battery Storage	152	2,453	2,453	2,453	3,299	6,127	8,873
Pumped (long-duration) Storage	-	-	-	-	-	973	973
Shed Demand Response	-	222	222	222	222	222	222
Natural Gas Capacity Not Retained	-	-	-	-	-	-	(30)

Planning for California's SB-100 Goals Latest Modeling Results: System Resource Adequacy



Solar Marginal ELCC: 2%
Wind Marginal ELCC: 19%

"Variable renewable" resources include wind and solar.
"Zero carbon firm" resources include hydro, nuclear, geothermal, hydrogen, biomass.

For reference, the 2018 August CPUC committed System RA resources totaled 47 GW.

2021 is a Pivotal Year for Critical Energy Storage Research

- Over $100 Million Invested in Energy Storage in 2020 (EPIC Funds and Awardee Provided Match Funding)
- Evaluating the Performance of Lithium Ion and Non-Lithium-Ion Energy Storage Technologies in a Variety of Microgrid Applications
- Supporting New and Emerging non-Lithium-Ion Technologies
- Field Demonstrations of non-Lithium Ion Longer Duration Energy Storage
- Validating Capability of Second-Life Batteries to Cost-Effectively Integrate Solar Power for Small-Medium Commercial Building Applications
- Assessing Long-duration Energy Storage Deployment Scenarios to Meet California's Energy Goals

Panel 1: Global Industry View on the Opportunities and Challenges Facing Emerging Energy Storage Technologies

Moderator: **Mike Gravely**, CEC Energy Systems Research Office

Panelists

Jason Burwen

CEO of the U.S. Energy Storage Association

Alex Morris

Executive Director, California Energy Storage Alliance

Panel 1: Global Industry View on the Opportunities and Challenges Facing Emerging Energy Storage Technologies

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Panel 1: Global Industry View on the Opportunities and Challenges Facing Emerging Energy Storage Technologies

Panel Questions

1. Each of you represent many diverse energy storage companies with a wide range of technologies and capabilities. What is the biggest challenge these companies face to becoming commercially successful?

2. What is the biggest opportunity you see both in California, the US and the World that provides the energy storage companies optimism that there is a commercial market for them to pursue.

3. What do you think are the obstacles to investing in storage companies and projects? Are the issues related to more to technology uncertainty and the certainty of the cash flow from the offtake agreements like PPA's or other factors?

4. What do each of you see the Federal Government doing to advance the growth of the energy storage market and how can the EPIC program leverage that federal funding to help in this advancement?

5.How do each of you see California impacting the energy storage growth market over the next decade?

Lightning round: What is the most important thing CEC and EPIC can do to help the broad energy storage sector?

Panel 2: Lithium-Ion Technology Batteries – Current Status and Future Outlook to Support California's Storage Needs

Moderator: **Haresh Kamath**

Director of Distributed Energy Resources and Energy Storage, Electric Power Research Institute

Panelists

Paul Beach

President of Octillion Power Systems, representing lithium-ion technology systems

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Berkshire Hathaway Energy, representing the Lithium Valley Commission and the lithium extraction industry

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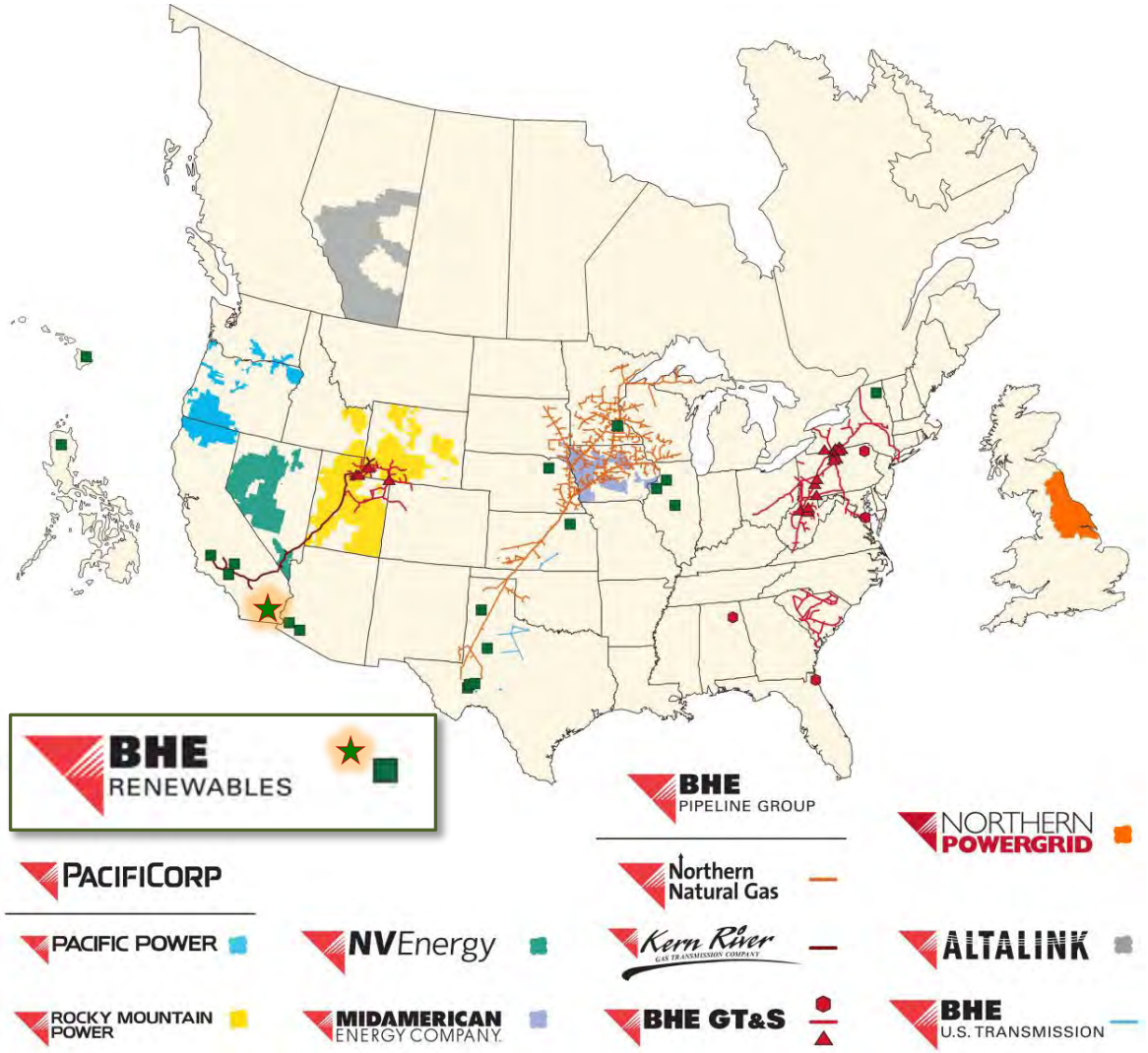
Paul Beach

President of Octillion Power Systems, representing lithium-ion technology systems

Lithium Recovery Update
July 2021

Jonathan Weisgall
Vice President, Government Relations
Berkshire Hathaway Energy

Berkshire Hathaway Energy Overview



- 12 million customers worldwide
- Top-rated service provider within the industry

- Top 10% industry OSHA Recordable Incident Rate of 0.51

- 42% renewable/non-carbon generation capacity
- 37% reduction in carbon intensity since 2005

- Balanced and informed outcomes
- Earning allowable returns

- $125b in total assets
- Exceptional cyber and physical protection

- Net income approximately $3.5b
- Operating cash flows approximately $6.5b

CalEnergy Geothermal Operations – Imperial County

Power Production

- 10 power plants
- 350 MW Capacity

23 Production Wells:

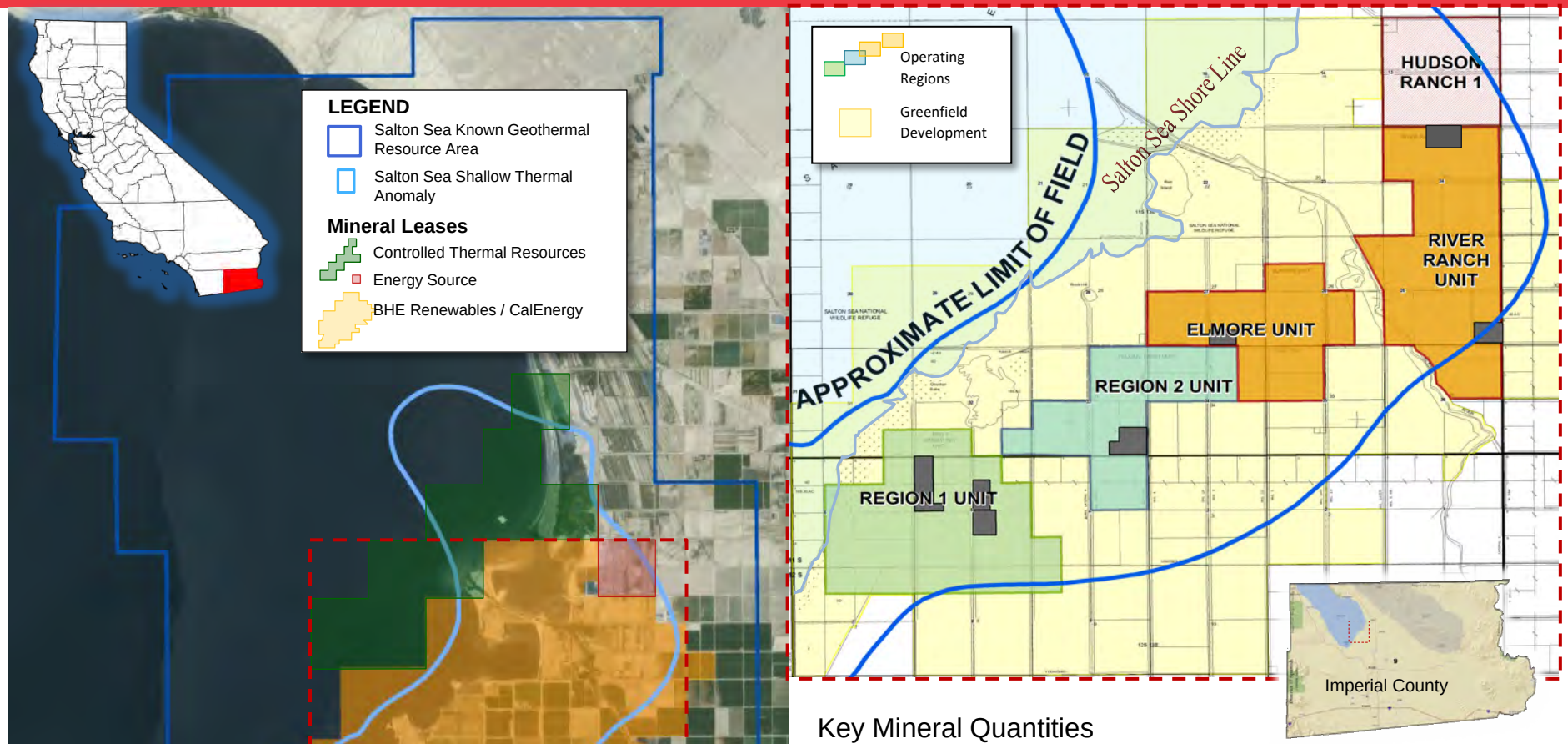
- 2,900 to 8,700 feet deep
- 450 to 480 degrees Fahrenheit at wellhead
- 310 to 500 psi pressure
- Total flow 53,676 gpm
  or
  1.8 million barrels per day

22 Injection Wells:

- 2,650 to 9,200 feet deep
- 205 to 230 degrees Fahrenheit at wellhead
- Total 41,785 gpm
  or
  1.4 million barrels per day

CalEnergy 50 MW Elmore Facility

Salton Sea Geothermal and Mineral Resources



Key Mineral Quantities

CalEnergy Resources	Power MW	Potential Annual Mineral Production			
		Li_2CO_3 (ktpa)	Zn (ktpa)	Mn (ktpa)	KCl (ktpa)
Operating	350	90	32	98	2,480
Greenfield	700	210	100	310	5,370

Status and Timelines

- California Energy Commission grant May 2020
  - $6 million: demonstration project to recover lithium from geothermal brine
  - Match with at least $4 million of corporate funds
  - Groundbreaking late April 2021
  - Goal to be in service March 2022
  - Knowledge transfer: UC Riverside and LBNL
- Department of Energy grant January 2021
  - $14.9 million: (1) demonstration project to convert lithium chloride into battery-grade lithium hydroxide; (2) fund engineering for full-scale commercial operations
  - Match with $14.9 million of corporate funds
  - Sign contract Summer 2021
  - Goal to be in service fall 2022

Hard Rock Mining (Western Australia)

Photo credit: FollowCN

Hard Rock Mining (Western Australia)

Photo credit: John Banagan

Lithium Brine Pools in Atacama Desert, Chile

Photo credit: Matjaż Krivic

Lithium Brine Pools in Atacama Desert, Chile

Photo credit: Reuters

Berkshire Hathaway Energy

Panel 2: Lithium-Ion Technology Batteries – Current Status and Future Outlook to Support California's Storage Needs

Moderator: **Haresh Kamath**

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Panel 2: Lithium-Ion Technology Batteries – Current Status and Future Outlook to Support California's Storage Needs

Panel Questions

1. Given Lithium-Ion Batteries represent most of the energy storage systems being fielded today, do you think the market can keep up with this pace?
2. What are the biggest challenges facing the Lithium-Ion supply market given the projected growth of the stationary and electric vehicle markets.
3. What do you feel is California's role in driving the energy storage market?
4. What are the obstacles for California's Lithium Valley to becoming a worldwide producer of critical energy storge system minerals like lithium, zinc and magnesium?

Lightning round: What is the most important thing CEC and EPIC can do to help the broad energy storage sector and the supply chain needed to support the growth of the Lithium-Ion Market?

Panel 3: Short Term Energy Storage – Addressing the 4-hour or Less Energy Storage Market

Moderator: **Quenby Lum**, CEC Energy Systems Research Office

Panelists

Andrew Hughes
Manager of Sales & Business Development, Eos Energy

Ryan Brown
CEO, Salient Energy

Seth Sanders
Chief Technology Officer and Co-founder, Amber Kinetics

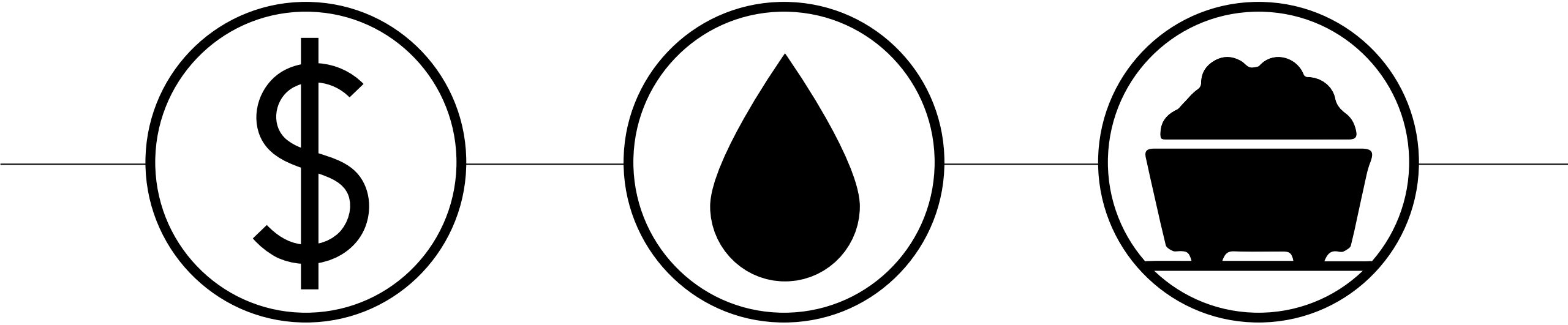
Panel 3: Short Term Energy Storage – Addressing the 4-hour or Less Energy Storage Market

Andrew Hughes
Manager of Sales & Business Development, Eos Energy

Salient's Zn-ion battery replaces Li-ion in the grid

- Worked from the atom up to make a **completely new battery**
- Raw materials are orders of magnitude more abundant
- Direct substitute for Li-ion
- Scalable through use of standard manufacturing

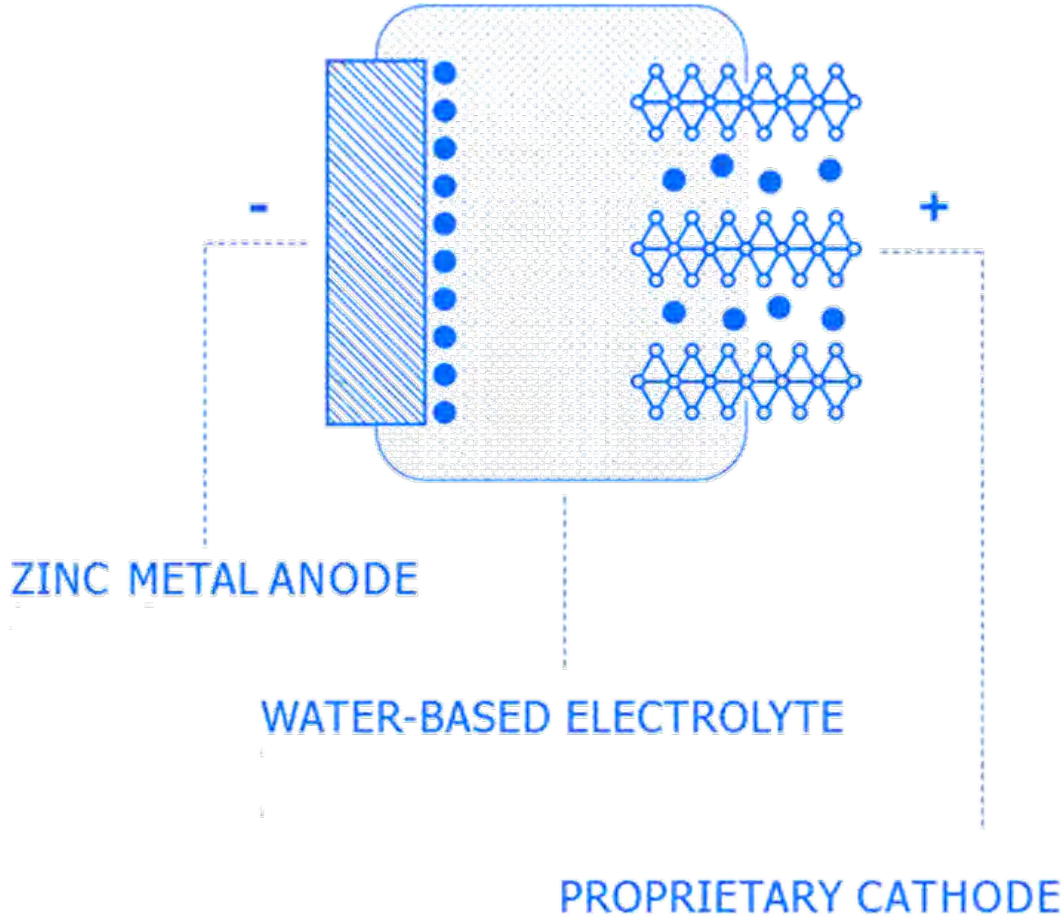
Zn-ion solves Li-ion's toughest challenges



Reduced Cost **Intrinsic Safety** **Secure Supply Chain**

Our technology is built on scientific breakthroughs

- First battery where zinc ions react at both electrodes (intercalation)
- Order of magnitude improvements in density and service life vs traditional zinc
- Salient is first to commercialize Zn-ion and has secured critical IP



Zn-ion is compatible with Li-ion manufacturing

- Growth of Li-ion manufacturing locks out most other battery tech
- Zn-ion's high density enables manufacturing compatibility
- Manufacturing scale-up can be accomplished using existing processes and expertise

The Next Frontier in Energy Storage

July 20, 2021

AMBER KINETICS

AMBER KINETICS

Our History

2009:
Amber Kinetics founded by Dr. Seth Sanders and Ed Chiao

2010:
Awarded $3.6M DOE Grant

2012:
Amber completes 5 kWh long-duration KESS prototype

2013:
Amber completes Series A round

2014:
Amber's 25kWh long-duration KESS operational in Alameda, CA test facility, funded with $1.8M CEC Grant

2015:
Amber signs agreement with Elemental Excelerator, based in Honolulu, HI

2016:
Amber signs supply agreements with HECO, Emerging Power, and EEI

2016:
Amber completes Series B round; awarded second, $2.0M CEC Grant

2016:
Amber deploys two KESS units with customers in the Philippines

2017:
First commercial supply agreements with multiple global customers

2017:
Two-year cooperation agreement with Enel

2018:
Hawaii Electric and China Solar + Flywheel projects operational

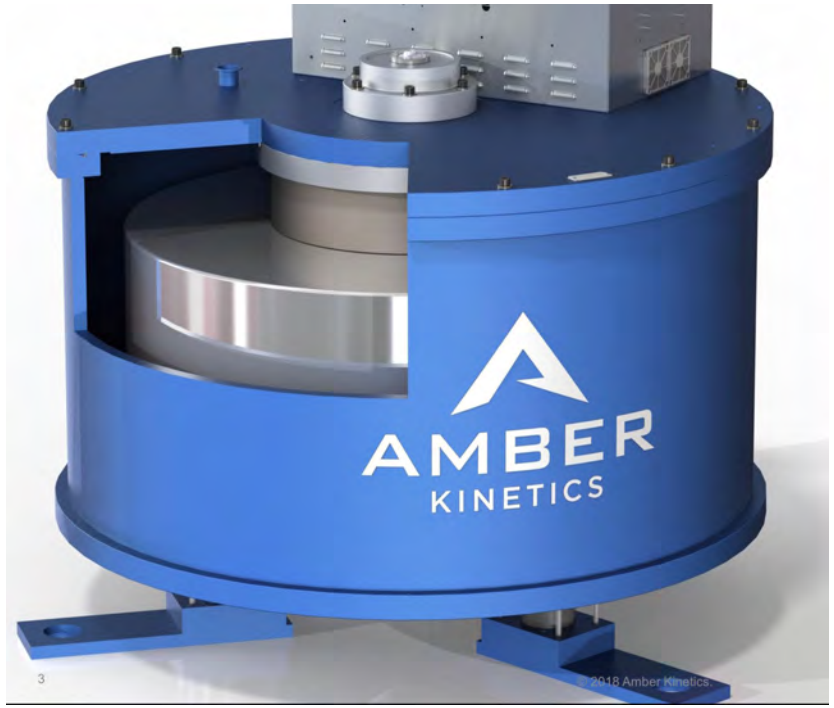
2020:
Flywheel fleet reaches 255,000+ hours of cumulative field of operations globally

AMBER KINETICS

Functional Assets

- Incorporated in US, Philippines, Australia, and Singapore.
- R&D headquarters in Union City, CA. Operations now exceeding capacity.
- California test facility #1 at Alameda Point, Alameda, CA.
- California test facility #2 in King City, CA
- Philippine corporate headquarters in Makati district of Manila, Philippines.
- Batangas manufacturing plant #1 in Philippines. Annual capacity 800 units (M32 product).
- Batangas manufacturing plant #2. Annual capacity of 3200 units, beginning 2022.
- Energy Storage Demonstration center at De La Salle University Laguna campus in Philippines
- 130 employees globally
- 60 employees work out of the Union City, CA office.

First Commercial 4-Hour Discharge Flywheel

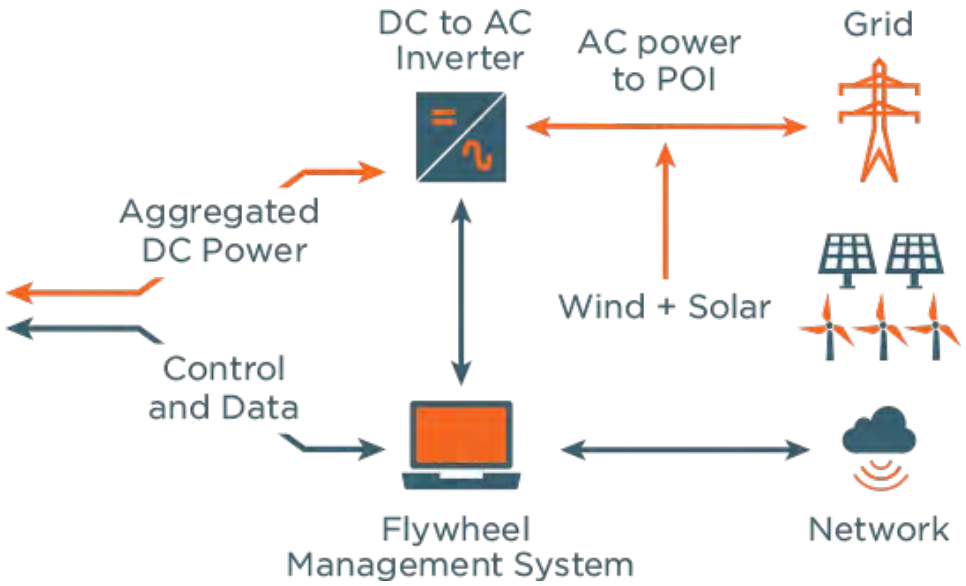


- Minimal O&M
- No chemical reaction
- No GHG emissions
- Performs in heat & humidity
- 100% recyclable materials
- No water or active cooling
- No noise
- No fire risk

MODEL 32	
Power	8 kW
Energy	32 kWh
Duration	4.0 hours
Cooling	Passive
Round-trip Efficiency (DC) (includes coasting loss)	>86%
Cycle Life	11,000 (no daily limitation)
Design Life	30 years
Environmental	-20 to 50 C; 100% humidity
Electrical	
DC Bus Voltage	550-750 Vdc
Full Power Response Time	< 1 sec
Average Coasting Loss	< 65 watts

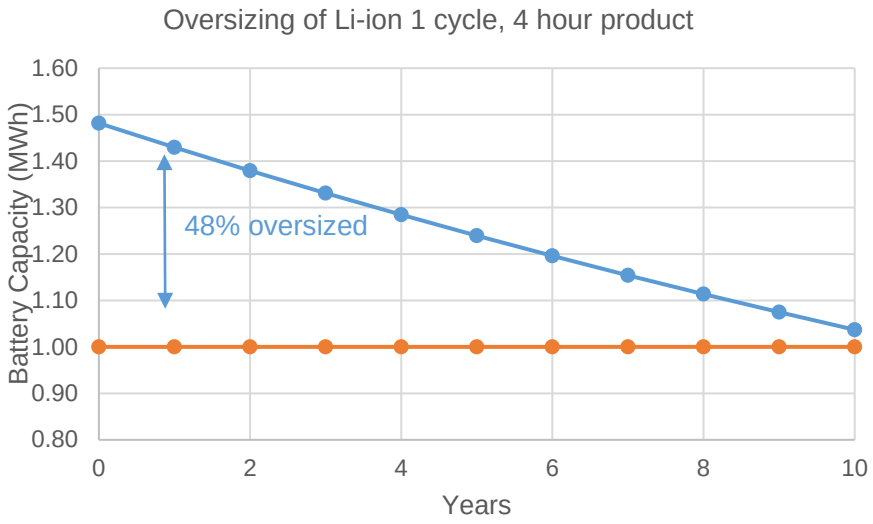
AMBER KINETICS

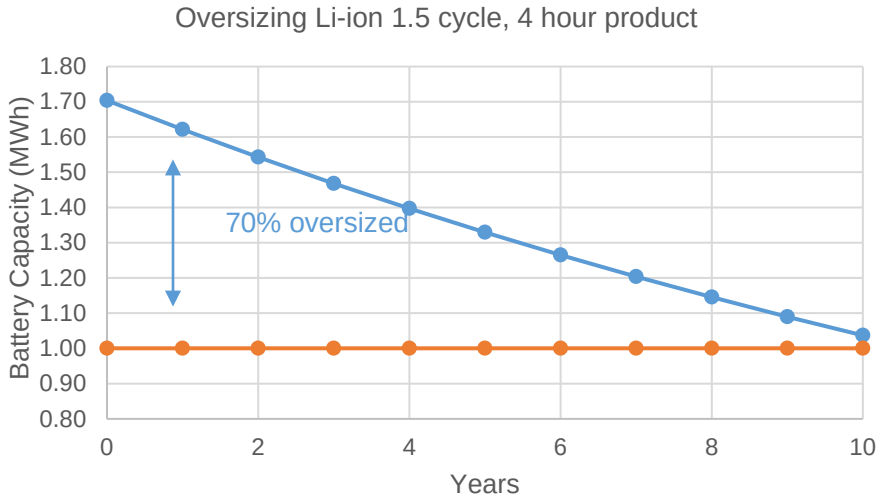
Grid Modernization

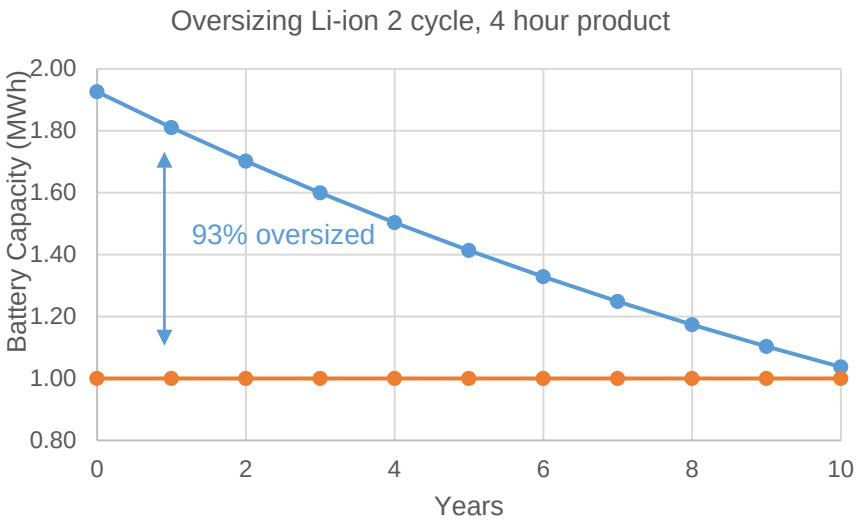


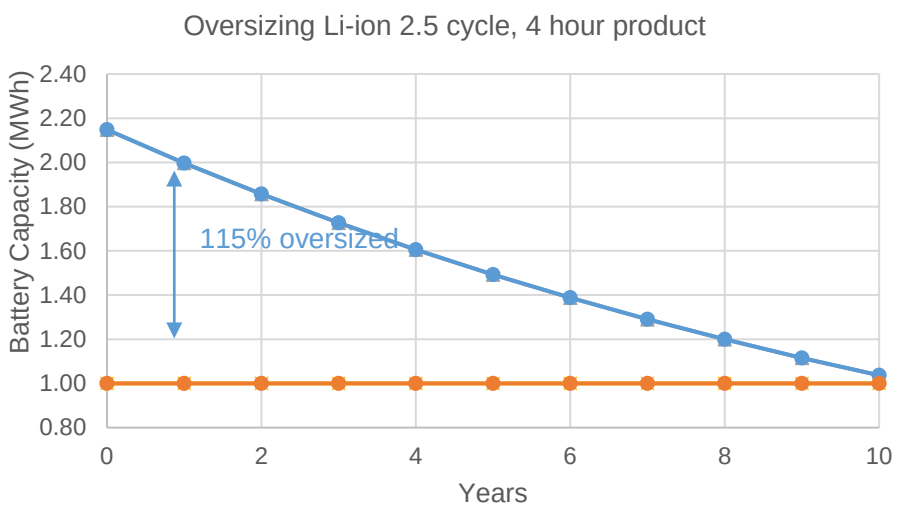
AMBER KINETICS

Daily Cycling with Lithium Ion Batteries









Lithium Ion batteries degrade faster with multiple, daily cycling. This increases overall project cost as the project needs to be oversized to maintain capacity

AMBER KINETICS

The Amber Advantage

Stable & predictable supply chain

No degradation in capacity

100% depth of discharge

Operational excellence in harsh environments

High roundtrip efficiency

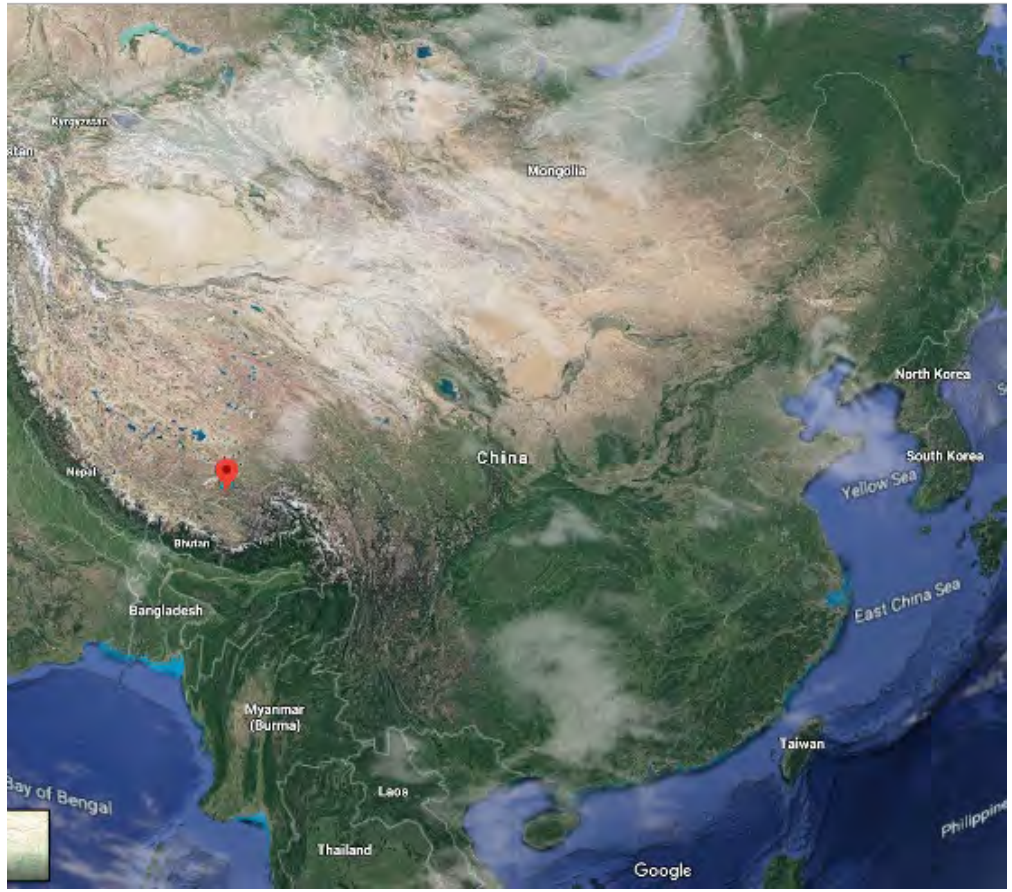
No daily cycling limitations

AMBER KINETICS


Thank you!

HIGHLY RUGGEDIZED TECHNOLOGY

Built for Harsh Environments



Extreme Temperature Ranges

Deployed in remote areas of the world, our flywheels are designed to require minimal maintenance while operating in extreme temperature ranges.

Humidity, Dust and Elevation

Harsh conditions do not impact our flywheel performance or efficiency

AMBER KINETICS

CASE STUDY

Only Ruggedized Energy Storage Solution

CHALLENGE

- Harsh weather conditions
- Remote site (a challenge for both installation and maintenance)
- Extremely high altitude

SOLUTION

Amber Kinetics' highly ruggedized flywheel technology made it the ideal solution to address the challenges surrounding the high altitude and harsh environment.

Successfully commissioned in July 2018, this installation provides energy firming, curtailment capture and power smoothing/ramp rate control seamlessly.

CASE STUDY

Utility of the Future

CHALLENGE

With the traditional utility model rapidly changing, regulatory drivers, utilities are faced with unpredictable weather patterns, natural disasters, rolling power outages and outdated transmission and distribution networks.

SOLUTION

West Boylston Municipal Lighting Plant (WBMLP) partnered with Amber Kinetics to install a 128kW/512kWh flywheel energy storage system in Massachusetts.

The flywheels are located next to an existing ground mounted solar array at a distributed energy generation facility. The flywheels were designed for energy arbitrage to reduce peak load and increase grid reliability.

THE WORLD'S ONLY

Flywheel Innovation Hub

Commissioned in early 2020, Amber Kinetics officially launched its New Product Introduction (NPI) installation on the campus of the De La Salle University (DLSU) in the Philippines. The Philippines is also home to Amber Kinetics' state-of-the-art manufacturing, testing and final configuration facility.

In addition to being an innovation hub for flywheels, DLSU is able to reap the benefits of this installation as it helps to reduce electricity costs by performing demand charge management when electricity demand is high.

TIER 1 VENDORS

Amber Kinetics has built a rigorous supplier qualification guide to ensure only the highest performance of our product.

INDUSTRY-LEADING

Achieving Operational Excellence

SUPPLY CHAIN

Amber Kinetics has built a world-class operations organization to ensure the stability of our global supply chain to mitigate risk.

HEALTH, SAFETY, ENVIRONMENT

Amber Kinetics is committed to adhering to transparent HSE practices for the safety of our employees and the sustainability of our product.

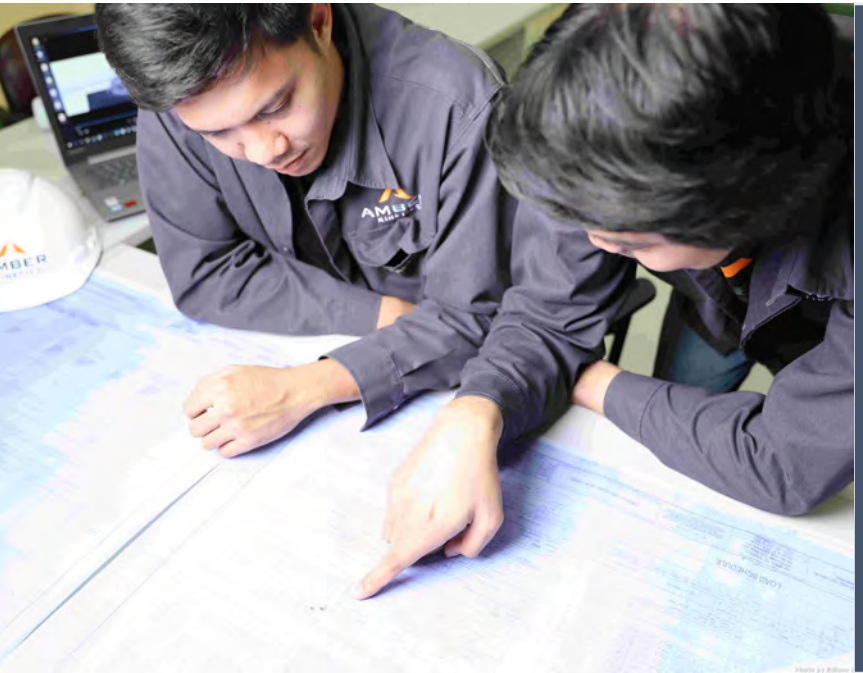
We have developed standard safety, failure and stress tests to ensure each flywheel meets our strict standards prior to deployment. In addition to final safety testing of our flywheels, we have developed proprietary safety procedures for shipping and transportation of our technology—eliminating risk during manufacturing, transport, installation, operation and maintenance.

AMBER KINETICS

COMMITTED TO SAFETY

Rigorous & Transparent Safety Practices

We have developed standard safety, failure and stress tests to ensure each flywheel meets our strict standards prior to deployment. In addition to final safety testing of our flywheels, we have developed proprietary safety procedures for shipping and transportation of our technology—eliminating risk during manufacturing, transport, installation, operation and maintenance.



- No fire risk (i.e. non-flammable materials, no risk of thermal runaway)
- Our flywheels do not contain or produce hazardous materials
- Absolutely no harmful emissions to air, land or water

Panel 3: Short Term Energy Storage – Addressing the 4-hour or Less Energy Storage Market

Moderator: **Quenby Lum**, CEC Energy Systems Research Office

Panelists

Andrew Hughes
Manager of Sales & Business Development, Eos Energy

Ryan Brown
CEO, Salient Energy

Seth Sanders
Chief Technology Officer and Co-founder, Amber Kinetics

Panel 3: Short Term Energy Storage – Addressing the 4-hour or Less Energy Storage Market

Background on EPIC work

Storage Guidebook
– streamline and standardize permitting process for behind-the-meter customers

Residential Solar + Storage
– building energy efficiency standards: Title 24 and Joint Appendix 12
– research on the role of storage to support these residential systems

Diversify technologies
– storage technologies
– battery chemistries

Panel 3: Short Term Energy Storage – Addressing the 4-hour or Less Energy Storage Market

Panel Questions

1. What are the most pressing challenges facing the short duration, 4-hour or less storage market?

– technology, economics, policy, manufacturing, other

2. What are the key hurdles that short duration energy storage faces in manufacturing scale-up?

3. What is the best way to incentivize companies to conduct life-cycle analyses and integrate cradle-to-cradle design and manufacturing into their product plan?

4. What are the key hurdles we need to overcome for energy storage to be more accessible to a wider customer base?

Lightning round: What is the most important thing CEC can do to help the short duration energy storage sector?

Panel 4: Addressing Long Duration Energy Storage Market—Opportunities and Gaps

Moderator: **Jeff Sunquist**, CEC Energy Systems Research Office

Panelist

Matt Harper
Chief Commercial Officer, Invinity Energy Systems

David Bierman
Co-Founder and Chief Technology Officer, Antora Energy

Jason Houck
Manager, Policy and Regulatory Affairs, Form Energy, Inc.

INVINITY
ENERGY SYSTEMS

COMPANY & TECHNOLOGY OVERVIEW

EPIC 4 Scoping Workshop / July 20 2021

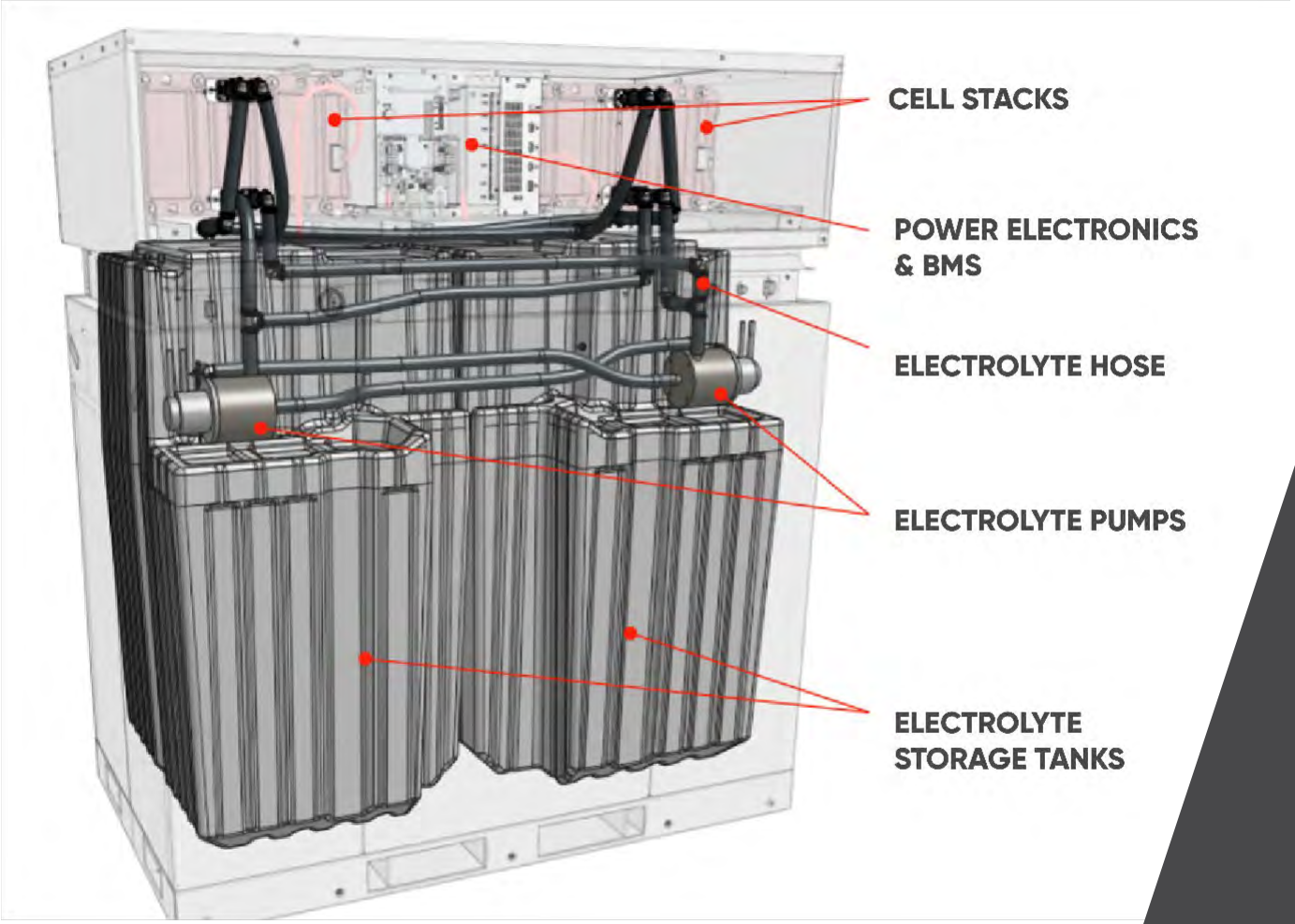
Invinity Energy Systems

- The leading global manufacturer of Vanadium Flow Batteries (VFB)s
- Customers include industry, utilities and electricity networks
- Largest installed VFB base:
  Over 25 MWh installed or pending across 14 countries

INVINITY ENERGY SYSTEMS

Inside VFB

Durable/Reliable/Economical/Proven



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, Russia.

REUSABLE

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

SAFE

Electrolyte is ~70% water, non-flammable with no risk of thermal runaway

INVINITY ENERGY SYSTEMS

Invinity VFB Value Proposition

COMPELLING ECONOMICS

Superior levelized cost of storage (LCOS)

MORE DURABLE

No degradation from heavy cycling
25 year lifetime

SAFER

Non-flammable
No risk of thermal runaway

LONGER DURATION

Optimized for requirements of 3 to 10 hours

SUSTAINABLE MATERIALS

No conflict minerals
All components easily recyclable

FACTORY BUILT

Standardized product drives price down & quality up

THE RESULT:

Energy storage superior to and complementary with lithium systems

INVINITY ENERGY SYSTEMS

Invinity VS3-022

Safe. Dependable.
Economical.

RATED POWER: CONTINUOUS
78kW

ENERGY STORAGE: NOMINAL
220kW

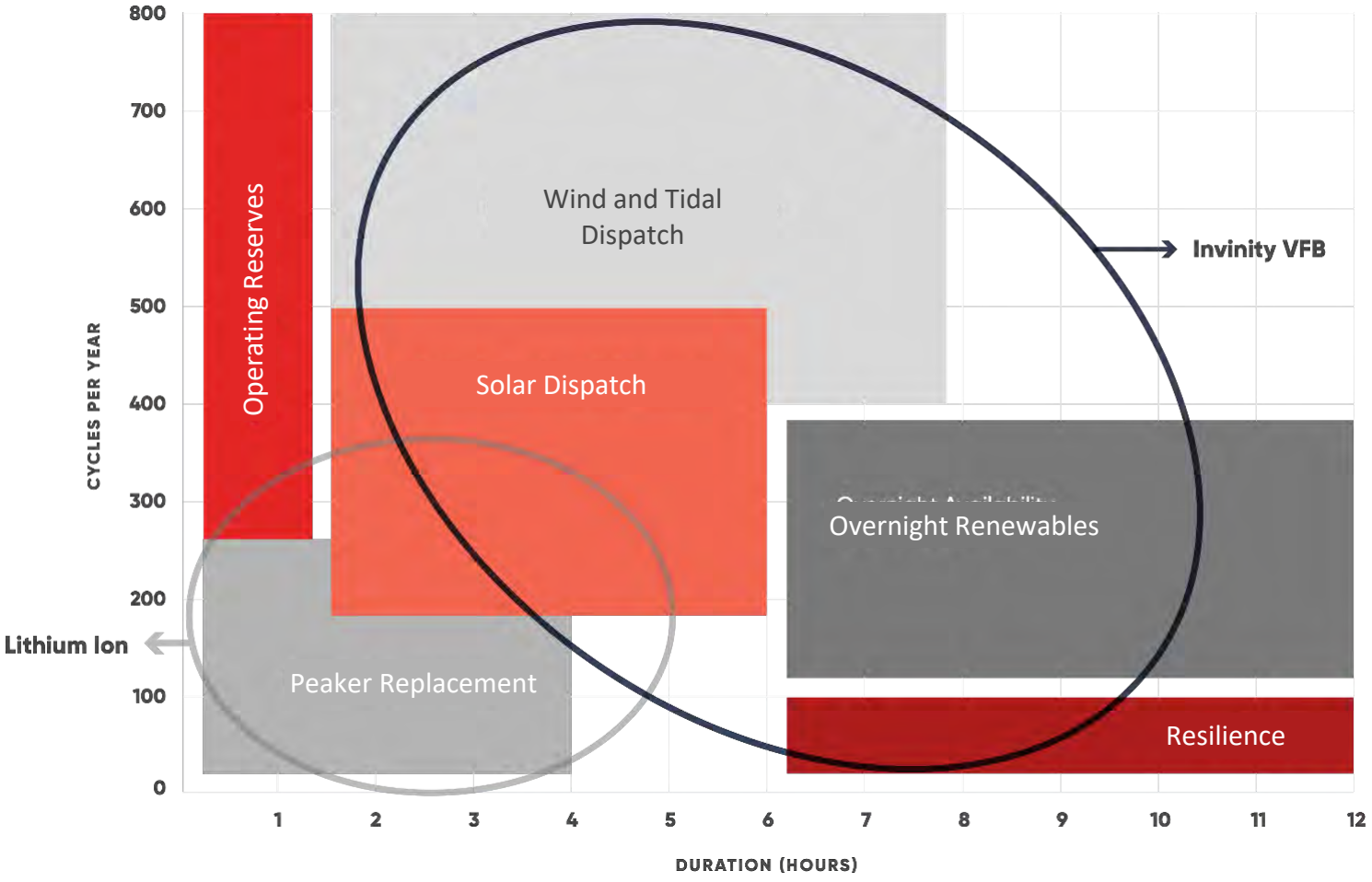
ENERGY STORAGE: DURATION
2-12 HOURS

LIFETIME
25 YEARS

RECOMMENDED DEPTH OF DISCHARGE:
100%

CYCLE LIFE:
UNLIMITED

VFB Use Cases



ENERGY SUPERHUB OXFORD
Operating Reserves

EUROPEAN MARINE ENERGY CTR.
Tidal Dispatch

YADLAMALKA ENERGY
Solar Dispatch

SOBOBA FIRE STATION
Resilience

INVINITY ENERGY SYSTEMS

Roadmap

2015

SMALL SCALE C&I

2018

SMALL SCALE C&I
SOLAR + STORAGE

2020

DISTRIBUTED GRID ASSETS

2023

CENTRALIZED
GRID ASSETS / 50MW+

INVINITY ENERGY SYSTEMS


INVINITY
ENERGY SYSTEMS

Antora Energy

Enabling Deep Decarbonization of the Power Sector Through Affordable Multi-day Energy Storage

David Bierman

EPIC Workshop for Energy Storage
7/20/2021

info@antora.energy

Antora Energy

Mission: To improve human lives by developing technology to promote deep decarbonization.

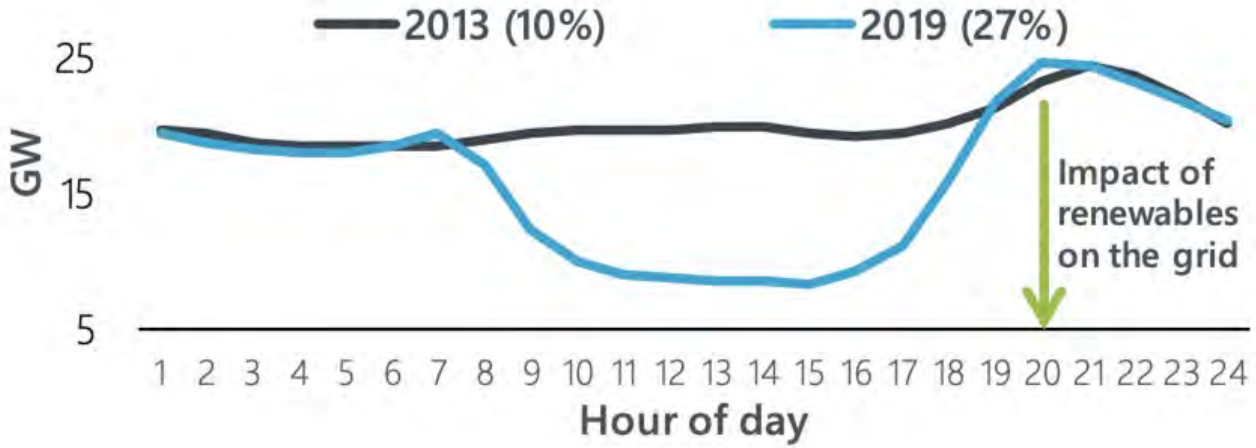
Seed-stage hardware technology start-up

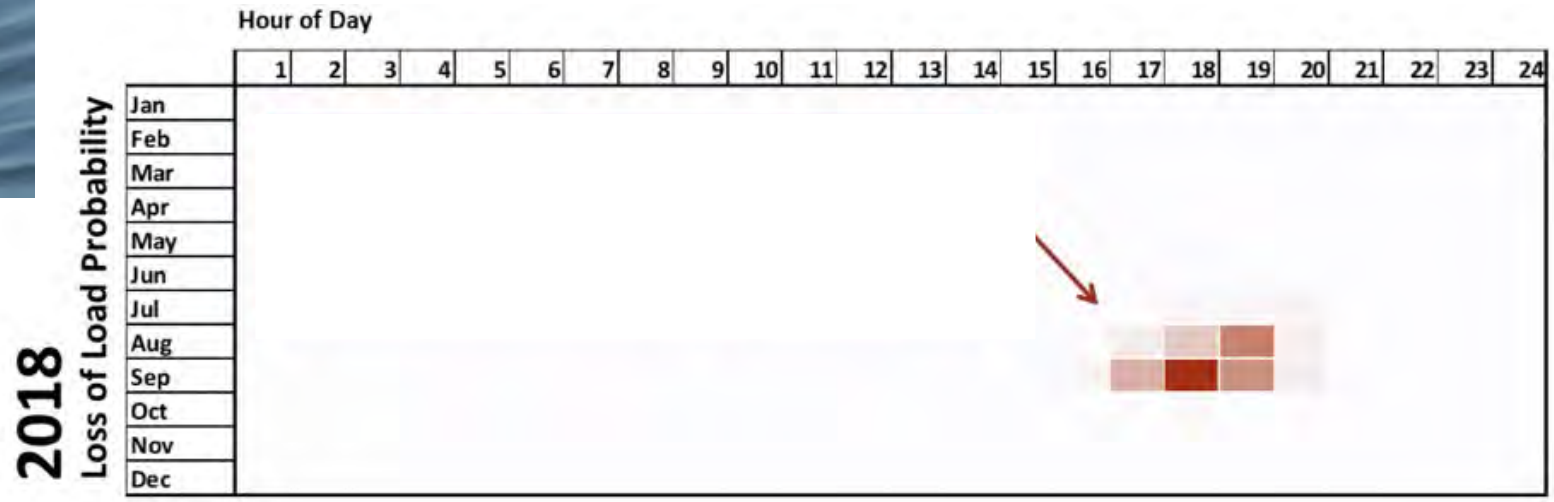
- Founded in 2018, based in Sunnyvale, CA
- Commercializing new class of energy storage that is 20x less expensive than Li-ion
- World-record efficiency solid-state heat engine
- Early funding from CEC, ARPA-E, NSF, EERE-AMO to support early development

Core team with deep experience and track record of success

- 15 FTEs (7 PhDs in photovoltaics and thermal sciences, Stanford, Caltech, Berkeley, UCSB)
- >30 additional collaborators from 5 different organizations
- Participated in Cyclotron Road, Creative Destruction Labs, StartX, GCxN, Third Derivative
- Strong technical and business advisory board

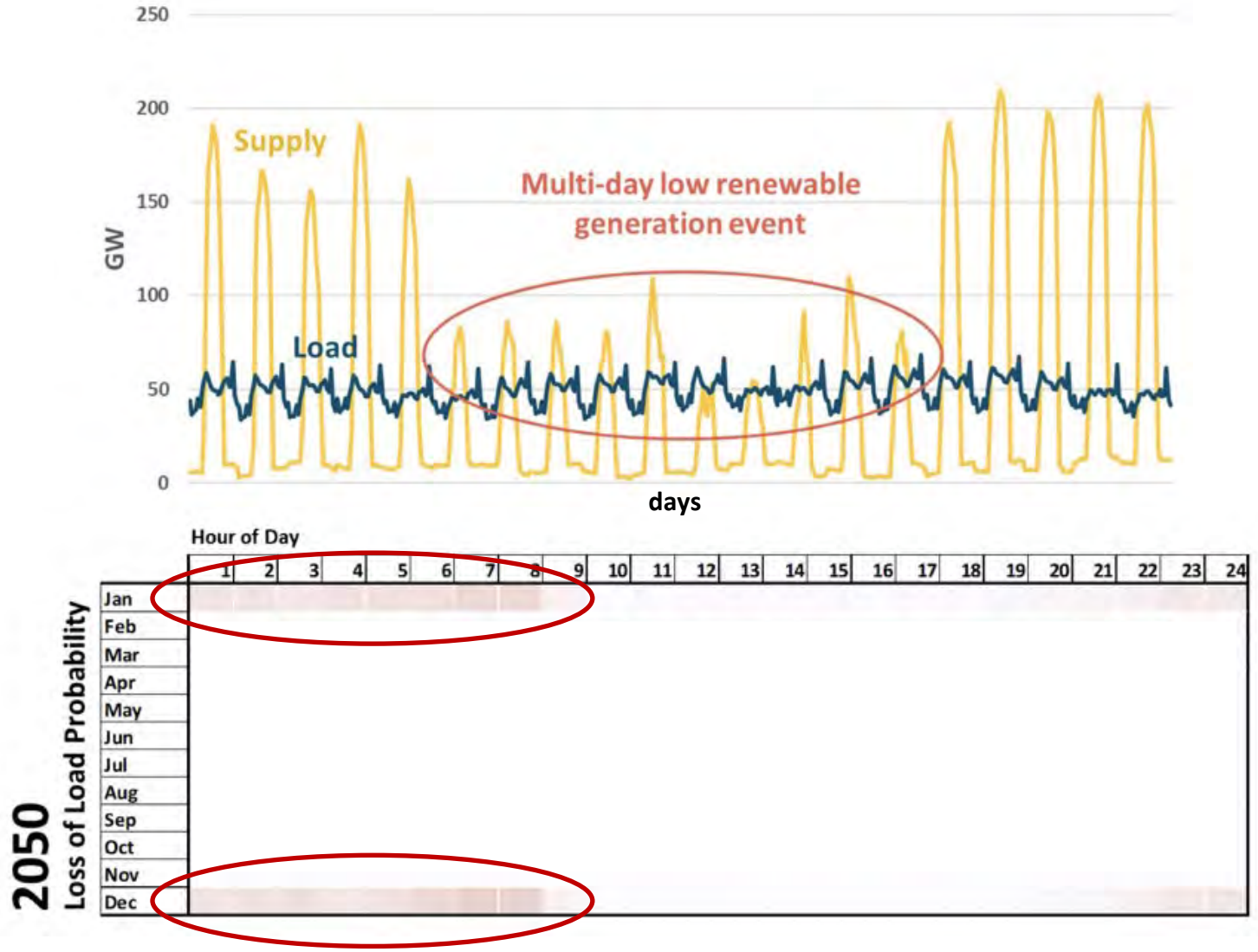
Energy storage solves grid reliability problems





E3, *Long-run resource adequacy under Deep Decarbonization Pathways for California*

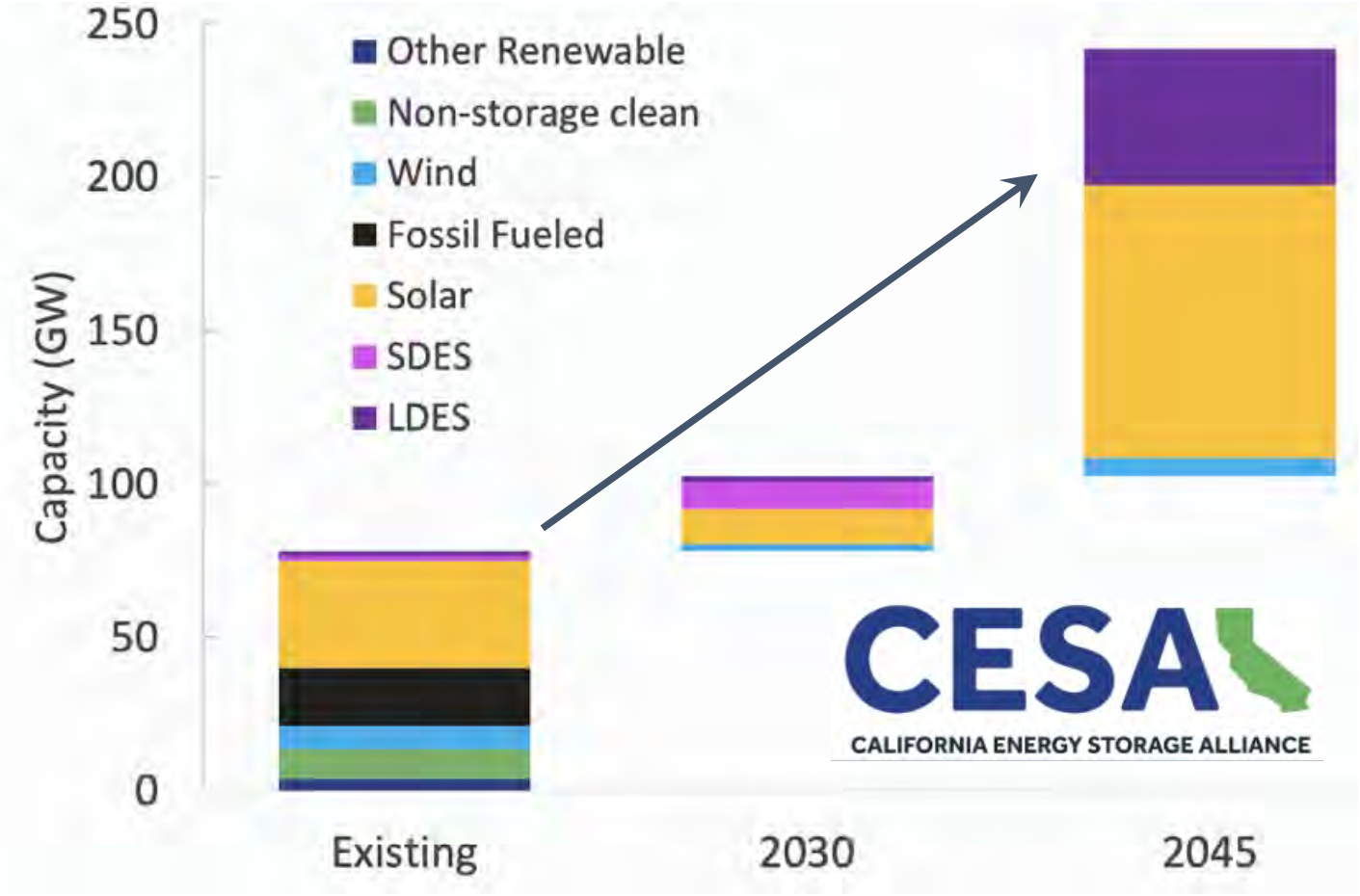
Grid reliability in 2050 will be very different than 2021



E3, *Long-run resource adequacy under Deep Decarbonization Pathways for California;* Photo by Jeff Schmaltz; NASA

Long duration storage is the lowest cost route to carbon-free

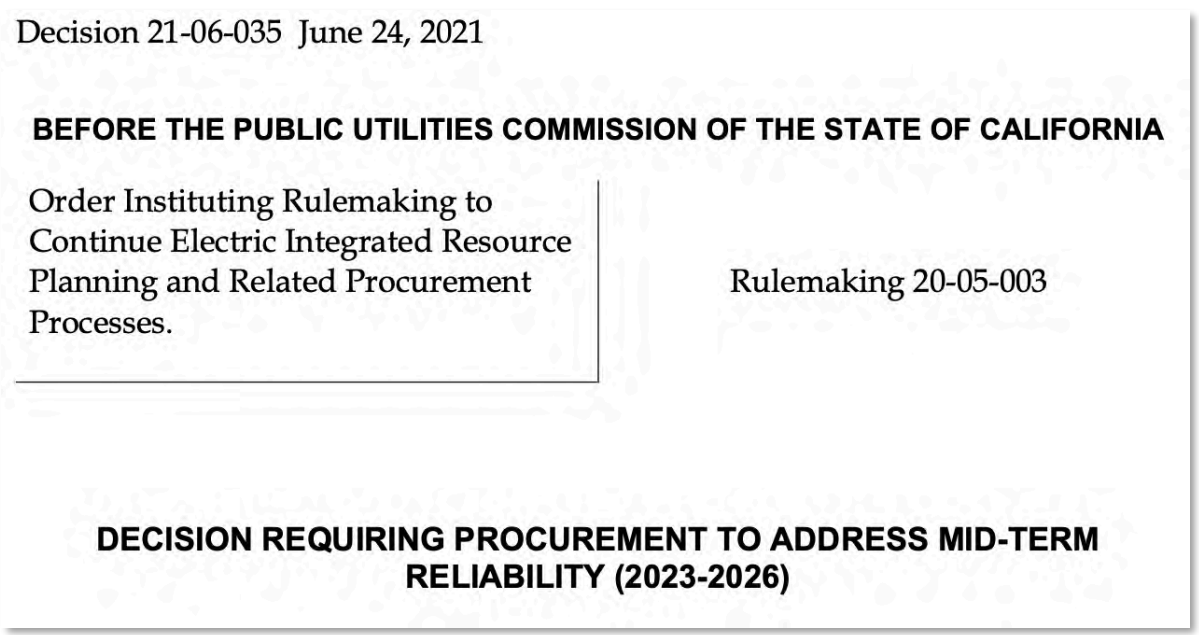
- **Enables *retirement of >20 GW*** of fossil plants in CA
- ***$1.5B/yr reduction*** in 2045 system cost
- ***Avoids 40 TWh/yr*** of curtailed renewable power



Strategen, *Long-duration Energy Storage for California's Clean, Reliable Grid*

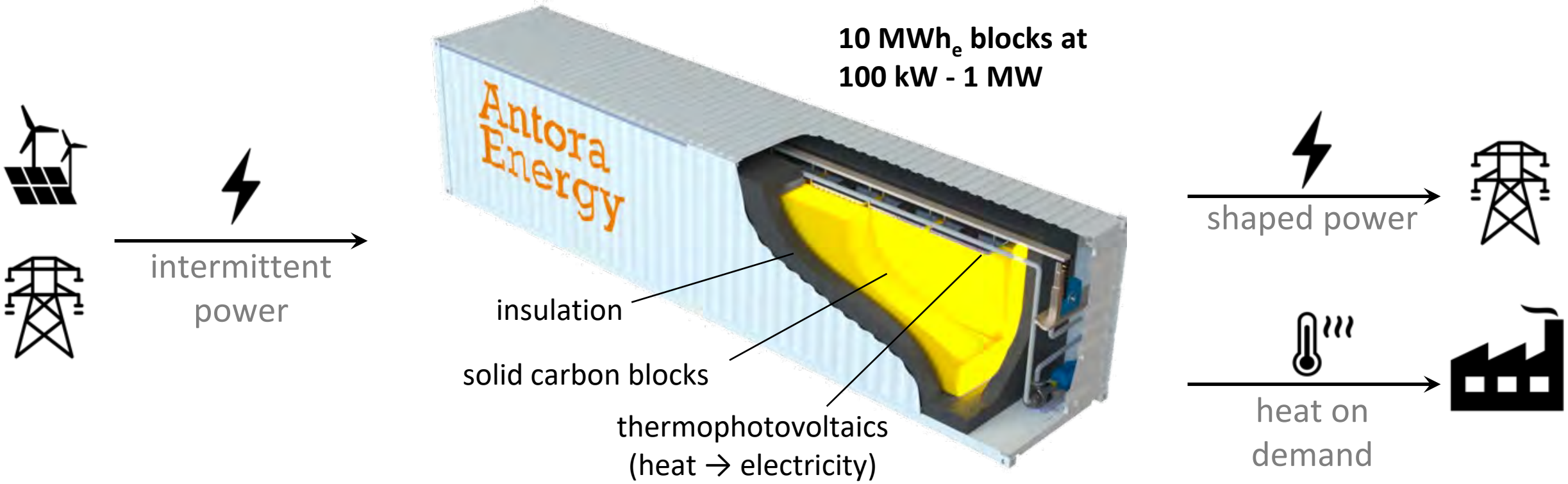
Not just a series of paper studies...

500 MW of long-duration



1000 MW of firm, zero-emitting
1000 MW of long-duration

Antora Energy's solid state thermal battery



Key Features

- **Long Duration:** 10-200+ hrs
- **Affordable:** <$10/kWh$_e$
- **Scalable:** mature supply chains
- **Safe:** no thermal runaway
- **Robust:** no cycling degradation
- **Site-able:** no geographic constraints


Thank you!
David Bierman
david@antora.energy

Panel 4: Addressing Long Duration Energy Storage Market—Opportunities and Gaps

Jason Houck

Manager, Policy and Regulatory Affairs, Form Energy, Inc.

Panel 4: Addressing Long Duration Energy Storage Market—Opportunities and Gaps

Moderator: **Jeff Sunquist**, CEC Energy Systems Research Office

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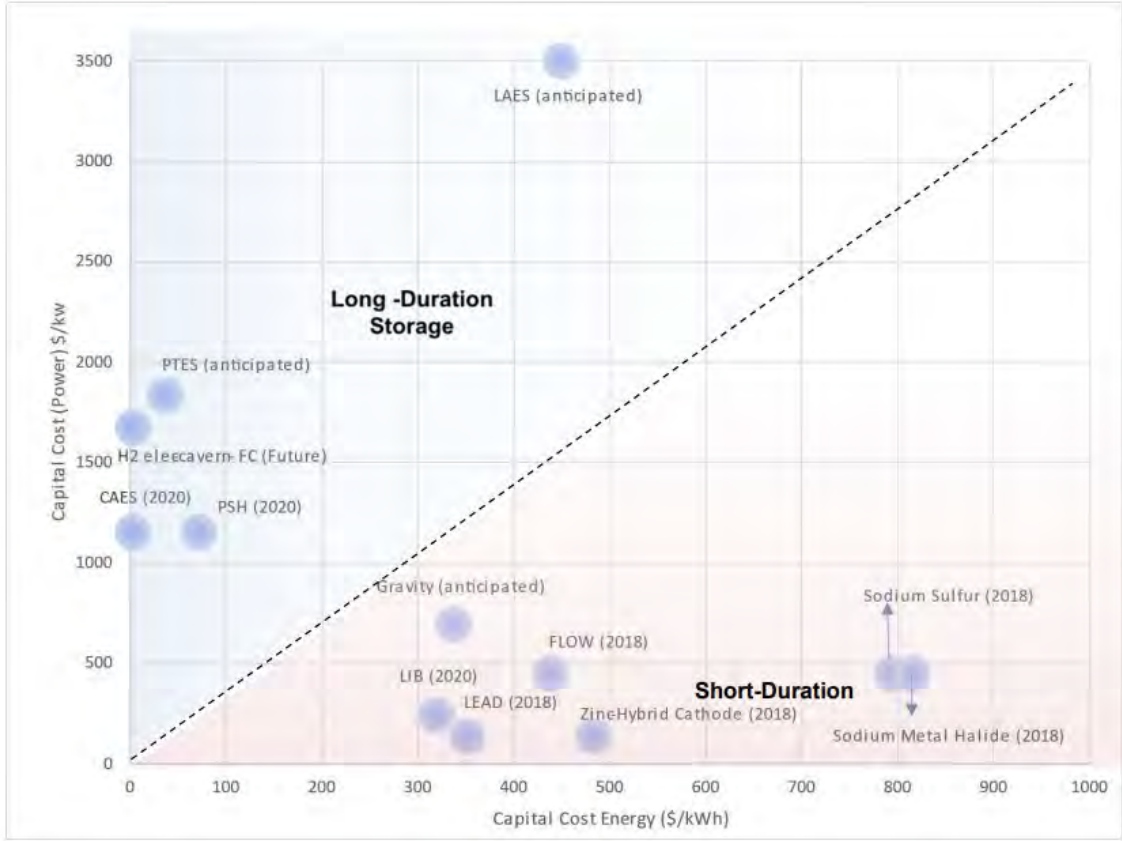
Panel 4: Addressing Long Duration Storage Market – Opportunities and Gaps

Long duration storage has a relatively low energy capacity cost component, which will enable it to fulfill certain energy needs at lower cost than other energy resources.

More data on the actual costs and performance of long duration storage technologies, as well as a deeper understanding of other sensitivities such as climate variation, are needed to accurately envision which needs long duration storage will fulfill.

Power capacity cost component ($/kW) versus energy capacity cost component ($/kwh)



Source: Augustine, Chad, and Nate Blair. Energy Storage Futures Study: Storage Technology Modeling Input Data Report. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5700-78694. https://www.nrel.gov/docs/fy21osti/78694.pdf

EPIC's Current Long Duration Storage Research

Pilot Demonstrations

- Vanadium Flow Batteries
- Zinc-Air Batteries
- Thermal Storage
- Green Electrolytic Hydrogen

Grid Modeling

- Updating modeling tools and data sets to include long duration storage.
- Developing scenarios to assess the possible roles of long duration storage in meeting California's future energy needs.

Panel 4: Long Duration Storage Questions

1. What role will long duration storage have in the following?
    a. Grid Reliability- Mitigating impacts of severe weather events to the grid (including exceptionally high demand and/or low generation)
    b. Lowering the energy and infrastructure costs of electric vehicle charging
    c. Improving resiliency and providing backup power for critical facilities

2. What are the most important technology barriers we need to overcome with EPIC research to bring these technologies to market at scale?

3.What efforts can bridge the gaps between researchers, utilities, and policy makers in understanding the performance and potential use cases for long duration storage?

4. What are the most promising near-term opportunities for long duration storage?

Lighting Round. What do you think is the one most important thing CEC should be doing to move this area forward?

PUBLIC INPUT SESSION

Stakeholder Comments on the Scope of the EPIC 4 Investment Plan

- 3 minutes per commenter, 1 commenter per organization
- Please clearly state your name and affiliation
- Use the raise hand function in Zoom and wait to be called upon to unmute
- Type questions/comments into the Q/A window

https://www.online-stopwatch.com/full-screen-stopwatch/

Next Steps

To stay involved in EPIC 4:

Visit **www.energy.ca.gov/epic4.**

Submitting Written Comments and EPIC 4 Plan Concepts:

Please use CEC's **e-commenting** system:
https://efiling.energy.ca.gov/Ecomment/Ecomment.aspx?docketnumber=20-EPIC-01

See **notice** for **e-mail and U.S. Mail** commenting instructions:
https://efiling.energy.ca.gov/getdocument.aspx?tn=238093

Workshop Comments are due July 30, 2021.

Thank You