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

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

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

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

<table>
<thead>
<tr>
<th>Time</th>
<th>Topic</th>
<th>Participants</th>
</tr>
</thead>
</table>
| 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 |
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**
- Digester
- Distribution Center

**Communities**
- City Hall, Police HQ, and Community Centers
- Airports

**Military**
- Camp Parks Reserve Forces Training Area

**Industrial**
- Digester
## Growing Need for Energy Storage in California
(CPUC Integrated Resource Plan)

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

<table>
<thead>
<tr>
<th>Resource Type</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
<th>2024</th>
<th>2026</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind</td>
<td>-</td>
<td>34</td>
<td>1,950</td>
<td>1,950</td>
<td>2,737</td>
<td>2,737</td>
<td>2,837</td>
</tr>
<tr>
<td>Wind on New Out-of-State Transmission</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>606</td>
</tr>
<tr>
<td>Utility-Scale Solar</td>
<td>2,000</td>
<td>4,000</td>
<td>6,000</td>
<td>8,000</td>
<td>8,000</td>
<td>8,000</td>
<td>11,017</td>
</tr>
<tr>
<td>Battery Storage</td>
<td>152</td>
<td>2,453</td>
<td>2,453</td>
<td>2,453</td>
<td>3,299</td>
<td>6,127</td>
<td>8,873</td>
</tr>
<tr>
<td>Pumped (long-duration) Storage</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>973</td>
</tr>
<tr>
<td>Shed Demand Response</td>
<td>222</td>
<td>222</td>
<td>222</td>
<td>222</td>
<td>222</td>
<td>222</td>
<td>222</td>
</tr>
<tr>
<td>Natural Gas Capacity Not Retained</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>(30)</td>
</tr>
</tbody>
</table>
Planning for California’s SB-100 Goals Latest
Modeling Results: System Resource Adequacy

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

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.
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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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

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

**Jonathan Weisgall**
Berkshire Hathaway Energy, representing the Lithium Valley Commission and the lithium extraction industry
Panel 2: Lithium-Ion Technology Batteries – Current Status and Future Outlook to Support California's Storage Needs

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

Operating Regions
- Imperial County

Greenfield Development

Key Mineral Quantities

<table>
<thead>
<tr>
<th>Mineral Leases</th>
<th>BHE Renewables / CalEnergy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resource Areas</td>
<td></td>
</tr>
<tr>
<td>Salton Sea Known Geothermal</td>
<td></td>
</tr>
<tr>
<td>Salton Sea Shallow Thermal</td>
<td></td>
</tr>
<tr>
<td>Anomaly</td>
<td></td>
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</table>

**CalEnergy Resources**

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<tr>
<th>Power MW</th>
<th>Potential Annual Mineral Production</th>
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<tr>
<td></td>
<td>Li$_2$CO$_3$</td>
</tr>
<tr>
<td>Operating</td>
<td>350</td>
</tr>
<tr>
<td>Greenfield</td>
<td>700</td>
</tr>
</tbody>
</table>

**Legend**
- Salton Sea Known Geothermal Resource Area
- Salton Sea Shallow Thermal Anomaly
- Controlled Thermal Resources
- Energy Source
- BHE Renewables / CalEnergy

**Imperial County Map**

Operating Regions:
- Imperial County

Greenfield Development:
- Hudson Ranch 1
- River Ranch Unit
- Elmore Unit
- Region 2 Unit
- Region 1 Unit
- Approximate Limit of Field

Imperial County Map

Legend:
- Salton Sea Known Geothermal Resource Area
- Salton Sea Shallow Thermal Anomaly
- Controlled Thermal Resources
- Energy Source
- BHE Renewables / CalEnergy
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: Matjaž Krivic
Lithium Brine Pools in Atacama Desert, Chile

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

Moderator: **Haresh Kamath**
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Berkshire Hathaway Energy, representing the Lithium Valley Commission and the lithium extraction industry
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 storage 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
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 supply agreement with Elemental Excelerator, based in Honolulu, HI

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

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

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

2017: Two-year cooperation agreement with Enel

2017: First commercial supply agreements with multiple global customers

2018: Hawaii Electric and China Solar + Flywheel projects operational

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

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Power</strong></td>
<td>8 kW</td>
</tr>
<tr>
<td><strong>Energy</strong></td>
<td>32 kWh</td>
</tr>
<tr>
<td><strong>Duration</strong></td>
<td>4.0 hours</td>
</tr>
<tr>
<td><strong>Cooling</strong></td>
<td>Passive</td>
</tr>
<tr>
<td><strong>Round-trip Efficiency (DC)</strong> (includes coasting loss)</td>
<td>&gt;86%</td>
</tr>
<tr>
<td><strong>Cycle Life</strong></td>
<td>11,000 (no daily limitation)</td>
</tr>
<tr>
<td><strong>Design Life</strong></td>
<td>30 years</td>
</tr>
<tr>
<td><strong>Environmental</strong></td>
<td>-20 to 50 C; 100% humidity</td>
</tr>
<tr>
<td><strong>DC Bus Voltage</strong></td>
<td>550-750 Vdc</td>
</tr>
<tr>
<td><strong>Full Power Response Time</strong></td>
<td>&lt; 1 sec</td>
</tr>
<tr>
<td><strong>Average Coasting Loss</strong></td>
<td>&lt; 65 watts</td>
</tr>
</tbody>
</table>
Grid Modernization

THE NEXT FRONTIER IN ENERGY STORAGE
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.
The Amber Advantage

- Stable & predictable supply chain
- Operational excellence in harsh environments
- No degradation in capacity
- High roundtrip efficiency
- 100% depth of discharge
- No daily cycling limitations

100% depth of discharge
Thank you!
Built for Harsh Environments

Highly Ruggedized Technology

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.
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.
Utility of the Future

**CASE STUDY**

**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.
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.
Achieving Operational Excellence

INDUSTRY-LEADING

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

TIER 1 VENDORS
 Amber Kinetics has built a rigorous supplier qualification guide to ensure only the highest performance of our product.

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.
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

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

**THE RESULT:**
Energy storage superior to and complementary with lithium systems

### 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
Invinity VS3-022

<table>
<thead>
<tr>
<th><strong>Safe. Dependable. Economical.</strong></th>
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<tbody>
<tr>
<td><strong>RATED POWER: CONTINUOUS</strong></td>
</tr>
<tr>
<td><strong>78kW</strong></td>
</tr>
<tr>
<td><strong>ENERGY STORAGE: NOMINAL</strong></td>
</tr>
<tr>
<td><strong>220kW</strong></td>
</tr>
<tr>
<td><strong>ENERGY STORAGE: DURATION</strong></td>
</tr>
<tr>
<td><strong>2-12 HOURS</strong></td>
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<tr>
<td><strong>LIFETIME</strong></td>
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<td><strong>25 YEARS</strong></td>
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<tr>
<td><strong>RECOMMENDED DEPTH OF DISCHARGE:</strong></td>
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<tr>
<td><strong>100%</strong></td>
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<tr>
<td><strong>CYCLE LIFE:</strong></td>
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<tr>
<td><strong>UNLIMITED</strong></td>
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</tbody>
</table>
VFB Use Cases

- Energy Superhub Oxford: Operating Reserves
- European Marine Energy CTR.: Tidal Dispatch
- Yadlamalka Energy: Solar Dispatch
- Sooba Fire Station: Resilience

Diagram:
- Wind and Tidal Dispatch
- Operating Reserves
- Solar Dispatch
- Overnight Renewables
- Peaker Replacement
- Resilience
Roadmap

2015
SMALL SCALE C&I

2018
SMALL SCALE C&I
SOLAR + STORAGE

2020
DISTRIBUTED GRID ASSETS

2023
CENTRALIZED
GRID ASSETS / 50MW+
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
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
Grid reliability in 2050 will be very different than 2021.
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
Not just a series of paper studies...

LONG DURATION STORAGE
Joint Procurement with Eight Community Choice Aggregators

In fall 2020, eight California Community Choice Aggregators (Joint CCAs) issued a Request for Offers for 500 MW of long-duration storage (LDS). The Joint CCAs collectively serve 2,324,250 customer accounts across 15 counties, with a peak load of 5,395 MW and an annual energy use of 24,748 GWh. This is the largest known single procurement effort for this amount of LDS. 51 developers submitted offers with over 300 unique pricing options and 18 different LDS technologies.

500 MW of long-duration

1000 MW of firm, zero-emitting
1000 MW of long-duration
Antora Energy’s solid state thermal battery

10 MWh_e blocks at 100 kW - 1 MW

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

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

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?
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/
To stay involved in EPIC 4:

Submitting Written Comments and EPIC 4 Plan Concepts:
Please use CEC’s e-commenting system:

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