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Invinity's Input to EPIC 5 Proposal Form

Additional submitted attachment is included below.

Electric Program Investment Charge 2026–2030 (EPIC 5) Research Concept Proposal Form

The California Energy Commission (CEC) is currently soliciting research concept ideas and other input for the Electric Program Investment Charge 2026–2030 (EPIC 5) Investment Plan. For those who would like to submit an idea for consideration, please complete this form and submit it to the CEC by **August 8, 2025**. More information about EPIC 5 is available below.

To submit the form, please visit the e-commenting link: https://efiling.energy.ca.gov/EComment/ECommentSelectProceeding.aspx and select the Docket **25-EPIC-01**. Enter your contact information and then use the "choose file" button at the bottom of the page to upload and submit the completed form. Thank you in advance for your input.

1. Please provide the name, email, and phone number of the best person to contact should the CEC have additional questions regarding the research concept:

   John Hasar, Director of Business Development
   jhasar@invinity.com
   628 222 6648

2. Please provide the name of the contact person's organization or affiliation:

   Invinity Energy Systems (US) Corporation
   Director of Business Development

3. Please provide a brief description of the proposed concept that you would like the CEC to consider as part of the EPIC 5 Investment Plan. What is the purpose of the concept, and what would it seek to do? Why are EPIC funds needed to support the concept?

   Invinity is the leading global manufacturer of modular vanadium flow batteries (VFBs) for utility-scale energy storage deployments and is proud to have its U.S. headquarters in San Francisco.

   Invinity is now planning California manufacturing of its VFBs, taking on a significant part in the large-scale expansion of US-based advanced battery

manufacturing. Invinity's domestic manufacturing plan is based on its VFBs characteristics, including that they:
a) Are delivered from our factories fully functional and ready to "plug and play"
b) Do not require "gigafactory" scale to achieve market-leading cost and quality
c) Have their core intellectual property embodied in a small number of components
d) Use a single critical mineral – vanadium – with known sourcing and processing.

Invinity has well-established manufacturing capabilities at sites around the world that combine these characteristics to deliver lowest-possible-cost, high-quality products. Invinity believes it can best do this in the US by delivering one, then several "Flow Battery Superhubs". Each of these will include facilities for manufacturing, testing and customer delivery preparation of Invinity's products, and also for manufacturing of critical components including:
1) Processing of electrochemical materials,
2) Cell stack advanced manufacturing, and
3) Vanadium electrolyte blending and recycling.

As part of Invinity's Superhub plan, we will work with existing and emerging partners as subrecipients or contractors to ensure Superhubs improve upon product cost and performance.

One of the heaviest and most expensive components of Invinity's VFBs is the batteries' vanadium electrolyte and delivering a product embodying both low capital costs and optimum logistics costs will require rationalization of its supply. To this point, Invinity's Flow Battery Superhubs will include vanadium processing and electrolyte blending on site, potentially in partnership with proposed subrecipients.

4. In accordance with Senate Bill 96[i], please describe how the proposed concept will "lead to technological advancement and breakthroughs to overcome barriers that prevent the achievement of the state's statutory energy goals." For example, what technical and/or market barriers or customer pain points would the proposed concept address that would lead to increased adoption of clean energy technology or innovation? Where possible, please provide specific cost and performance targets that need to be met for increased industry and consumer acceptance. For scientific analysis and tools, provide more information on what data and information

gaps the proposed concept would help fill, and which specific parties or end users would benefit from the results, and for what purpose(s)?

Project Summary:
The project will develop a **high-energy-density vanadium electrolyte** enhanced with mixed metals to advance the performance and commercial viability of vanadium flow batteries (VFBs) for long-duration energy storage. The initiative will:

- **Develop and optimize** a next-generation electrolyte formulation with higher energy density than current industry standards.
- **Collaborate with a California-based sulfuric acid electrolyte supplier** to ensure a resilient, domestic supply chain.
- **Validate stability and performance** through laboratory and pilot-scale testing conducted by a **California-based research institution**.
- **Demonstrate scalability and commercial readiness**, paving the way for U.S. manufacturing of advanced electrolyte solutions.

This work directly supports California's **grid modernization and decarbonization goals** by enabling **cost-effective, long-duration storage** critical to integrating renewable energy and enhancing grid reliability.

Project Objectives:

- Increase electrolyte energy density to reduce VRFB system size and cost.
- Establish a domestic, scalable supply chain for high-performance vanadium electrolytes.
- Validate performance under real-world operating conditions to accelerate commercialization.

5. Please describe the anticipated outcomes if this research concept is successful, either fully or partially. For example, to what extent would the research reduce technology or ratepayer costs and/or increase performance to improve the overall value proposition of the technology? What is the potential of the innovation at scale? How will the innovation lead to ratepayer benefits in alignment with EPIC's guiding principles to improve safety,[ii] reliability,[iii] affordability,[iv] environmental sustainability,[v] and equity?[vi]

Need for High-Energy-Density Electrolytes:

- **Higher Energy per Volume:** Reduces tank size and system footprint.
- **Lower Levelized Cost of Storage (LCOS):** Improves lifecycle cost efficiency.

- **Supports 8–12+ Hour Storage:** Enables deep renewable energy integration and grid reliability.
- **U.S. Competitiveness:** Strengthens domestic leadership in long-duration storage technologies.

6. Describe what quantitative or qualitative metrics or indicators would be used to evaluate the impacts of the proposed research concept.

   Invinity's development of multiple Flow Battery Superhubs to manufacture key components of its VFBs in the US will enhance Invinity's ability to deliver the energy storage needed to enable California's 100% carbon-pollution free electricity goals, while maximizing of US content in the Invinity projects selected for funding by the DOE under FOA 2867 and LCL001. Specifically, the proposed project will:
   1) Advance MRL and TRL of Invinity's next-generation VFB product Endurium
   2) Deliver Invinity VFBs with US domestic content initially of >50% and ultimately >80%
   3) Achieve annual capacity of >300 MWh (2026-27) then >1,000 MWh (2028)
   4) Accelerate progress towards the DOE 2030 LCOS goal of $50/MWh.

   Innovation and Impacts: Innovation under this project will advance the MRL of the processing, manufacturing, and recycling processes that would be executed at each Flow Battery Superhub for Endurium. Those MRL advancements would include:
   a) Vanadium electrolyte blending: MRL 7 to MRL 9
   b) Vanadium electrolyte recycling: MRL 2 to MRL 7
   c) Advanced cell stack manufacturing: MRL 4 to MRL 9
   d) Final assembly and test: MRL 6 to MRL 9.

   Impact on Productivity and Workforce: In developing Endurium alongside partner Siemens Gamesa Renewable Energy, Invinity has already made significant strides towards validating it can meet the 2030 DOE LCOS target for LDES of <$50/MWh. Advancements through this project are expected to further improve productivity and accelerate towards that goal. Achieving project goals will see Invinity and its subrecipients create durable, well-paying jobs in the skilled trades and labor categories. Invinity expects each Flow Battery Superhub, when operating at its expected throughput of 1000 MWh per year, would have a staff of 220, with approximately 2000 additional full-time positions within Invinity's domestic supply chain.

7. Please provide references to any information provided in the form that supports the research concept's merits. This can include references to cost targets, technical potential, market barriers, equity benefits, etc.

   Commercial Market Viability:
   Total addressable market (TAM): Invinity's view of the TAM for VFB is informed by the DOE OTT paper, "Pathways to Liftoff: Long Duration Energy Storage". That report proposes a taxonomy for different types of storage including short duration (<10 hours), Inter-day LDES (10 to 36 hours), Multi-day LDES (36 to 160 hours) and Seasonal storage (>160 hours). The paper projects that the relative share of installed GWs by 2040 will be 12% (Short-duration), 60% (Inter-day LDES) and 28% (Weekly LDES).

   However, Invinity believes this proportion underplays the value that will be delivered by the LDES technologies. Incorporating the paper's reported average discharge duration and considering annual frequency of discharge for the various categories, Inter-day LDES would deliver 65% of the TWh of energy required by the grid, compared with 7% for Short Duration and 28% for Weekly LDES. In short, the Inter-day LDES capabilities described by the DOE "Liftoff" paper and that are Invinity's focus are expected to deliver the majority of stored energy to the future grid.

   Invinity Projected Market Share and Revenues: Invinity projects a market share in 2026 of 5.4% of the 11% flow battery TAM, rising to 16.7% in 2030. Even those modest market shares percentages represent annual revenues for Invinity of $550M (2026-27) and almost $3.8B (2030).

   Invinity Differentiators: Invinity's differentiators are (a) its intellectual property including patents, trade secrets, and know-how, (b) its extensive expertise in VFB, including the largest number of flow battery stacks (>2800) and largest number of independent flow batteries (>1200) known to have been delivered by any organization, and (c) its deep team experience.

   Assessment of price-competitiveness: In 2024, Invinity completed development of its next-generation product Endurium. Advancements in unit cell design, electrolyte technology, and system architecture deliver lower costs and, ultimately, a product that is cost competitive on a first-cost basis, and dramatically superior to lithium-ion solutions on an LCOS basis, with LCOS is expected to be $65/MWh (2026-27) trending to $40/MWh (2028).

Segmentation analysis: Energy assets are valued by energy delivered to customers who pay in kilowatt-hours, by national and global regulators who track energy flows by terawatt-hours. Through this lens, inter-day LDES as described above will deliver the majority of value, and therefore presents the largest commercial opportunity for storage to operators of our future net zero infrastructure. This area of greatest value is exactly where Invinity is focused, and precisely where our VFBs have the greatest comparative advantages over other solutions.

8. The EPIC 5 Investment Plan must support at least one of five Strategic Goals:[vii]
    a. Transportation Electrification
    b. Distributed Energy Resource Integration
    c. Building Decarbonization
    d. Achieving 100 Percent Net-Zero Carbon Emissions and the Coordinated Role of Gas
    e. Climate Adaptation

    Please describe in as much detail as possible how your proposed concept would support these goals.

Benefits to California:

- **Supports EPIC Goals:** Advances innovation in long-duration storage to enable a 100% clean energy grid.
- **Job Creation and Economic Growth:** Drives skilled employment in R&D, pilot-scale production, and future manufacturing.
- **Leverages California Research Expertise:** Engages local researchers to test, validate, and accelerate technology commercialization.
- **Promotes Energy Security:** Establishes a U.S.-based electrolyte supply chain, reducing reliance on foreign imports.
- **Strengthens California's Leadership in Energy Innovation:** Positions the state at the forefront of next-generation storage solutions.

The proposed concept directly supports the three of the EPIC 5 Strategic Goals:

● **Distributed Energy Resource Integration:** The proposed final battery product is a utility-scale DER that provides essential services for managing grid congestion, absorbing excess renewable generation, and providing capacity.

● **Achieving 100 Percent Net-Zero Carbon Emissions and the Coordinated Role of Gas:** Long-duration energy storage is a critical enabling technology for achieving 100% clean energy. By providing day(s) of power, this technology can help bridge long periods of low renewable

generation (e.g., multiple cloudy days), reducing the need for fossil-fuel peaker plants and backup generators. This enhances grid reliability without compromising California's decarbonization commitments.

- **Climate Adaptation:** The primary driver for this concept is to build a grid that is more resilient to the impacts of climate change, particularly the increasing frequency and intensity of wildfires. By providing reliable backup power at the community level during PSPS events, this solution is a direct and highly effective climate adaptation strategy that protects communities and critical infrastructure from climate-driven threats.

About EPIC

The CEC is one of four EPIC administrators, funding research, development, and demonstrations of clean energy technologies and approaches that will benefit electricity ratepayers of California's three largest investor-owned electric utilities.

EPIC is funded by California utility customers under the auspices of the California Public Utilities Commission.

To learn more about EPIC, visit: https://www.energy.ca.gov/programs-and-topics/programs/electric-program-investment-charge-epic-program

EPIC 5 documents and event notices will be posted to: https://www.energy.ca.gov/proceeding/electric-program-investment-charge-2026-2030-investment-plan-epic-5

Subscribe to the EPIC mailing list to stay informed about future opportunities to inform the development of EPIC 5: https://public.govdelivery.com/accounts/CNRA/signup/31897

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i See section (a) (1) of Public Resources Code 25711.5 at: https://leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?lawCode=PRC&sectionNum=25711.5.

ii EPIC innovations should improve the safety of operation of California's electric system in the face of climate change, wildfire, and emerging challenges.

iii EPIC innovations should increase the reliability of California's electric system while continuing to decarbonize California's electric power supply.

iv EPIC innovations should fund electric sector technologies and approaches that lower California electric rates and ratepayer costs and help enable the equitable adoption of clean energy technologies.

v EPIC innovations should continue to reduce greenhouse house gas emissions, criteria pollutant emissions, and the overall environmental impacts of California's electric system, including land and water use.

vi EPIC innovations should increasingly support, benefit, and engage disadvantaged vulnerable California communities (DVC). (D.20-08-046, Ordering Paragraph 1.) DVCs consist of communities in the 25 percent highest scoring census tracts according to the most recent version of the California Communities Environmental Health Screening Tool (CalEnviroScreen), as well as all California tribal lands, census tracts with median household incomes less than 60 percent of state median income, and census tracts that score in the highest 5 percent of Pollution Burden within CalEnviroScreen, but do not receive an overall CalEnviroScreen score due to unreliable public health and socioeconomic data.

vii In 2024 the CPUC adopted five Strategic Goals to guide development of the EPIC 5 Investment Plan. A description of the goals can be seen in Appendix A of CPUC Decision 24-03-007 available at: https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M527/K228/527228647.PDF