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Next-Gen Battery and Charging Solutions for Zero-Emission Medium- and Heavy-Duty Vehicles

Additional submitted attachment is included below.

CALIFORNIA ENERGY COMMISSION

CALIFORNIA NATURAL RESOURCES AGENCY

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:

   Dominik Haering, dhaering@uci.edu, 331-803-8670

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

   UC Irvine

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?

We propose a research initiative focused on accelerating the deployment of medium- and heavy-duty battery-electric trucks—including **drayage and off-highway vehicles**—by addressing key technical challenges in battery technology and charging infrastructure. The project has two core objectives:

1. **Battery Innovation**: Investigate emerging battery chemistries—particularly **sodium-ion (Na-ion)**—as a lower-cost, sustainable alternative to lithium-ion for medium-duty electric trucks. The research will assess performance, safety, degradation, and total cost of ownership to determine commercial viability for fleet use.
2. **Intelligent, Bi-Directional Multiplexer Fast Charging System**: Develop and evaluate a **V2G-enabled**, **bi-directional DC fast charging system (>50 kW)** that allows **multiple electric trucks** to connect to a single charging node. The system will include **intelligent control algorithms** to dynamically manage power flow—ensuring that charging and discharging are **proportional to each vehicle's state of health, battery age, and capability**. This allows optimized energy throughput while preserving battery life and maintaining system reliability.

   The project will also include **modeling of various operational scenarios**, evaluating configurations with **multiple vehicles**, **single or multiple DCFC units**, and optional **stationary energy storage**. These models will inform control strategies, system sizing, and cost-effectiveness across real-world use cases.

   This research directly supports California's goals of **transportation electrification**, **distributed energy resource integration**, and **net-zero carbon emissions** by improving system performance, lowering costs, and enabling more flexible, grid-supportive infrastructure. **EPIC funding** is essential to de-risk these early-stage innovations, validate them under real-world conditions, and generate publicly accessible data to guide policy and future deployments—ensuring cleaner and more equitable transportation solutions for all Californians.

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)?

This concept addresses major technical and market barriers to the widespread adoption of zero-emission medium- and heavy-duty trucks—particularly **high vehicle and infrastructure costs**, **battery supply chain constraints**, and **limited charging flexibility**.

By evaluating **sodium-ion batteries** as a lower-cost, sustainable alternative to lithium-ion, the project targets the cost-performance gap that hinders electrification of Class 3–7 vehicles. The research will provide critical data on durability, safety, and energy density benchmarks to assess commercial viability.

On the infrastructure side, the proposed **V2G-enabled, intelligent multiplexer charging system** addresses the high capital and operational costs of depot charging by enabling multiple trucks to share high-power DC fast chargers (>50 kW). It will include smart power allocation based on battery health, reducing grid strain while maximizing asset utilization. This also fills a key data gap around **battery aging impacts under shared charging/discharging strategies**.

Key end users—including fleet operators, utilities, and OEMs—will benefit from modeling results, validated hardware performance, and public datasets that support **optimized fleet planning, grid integration**, and **investment decisions**. This will accelerate clean energy adoption and help California meet its statutory climate, air quality, and equity goals.

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]

If successful, this research will advance battery-electric truck adoption by demonstrating cost-effective, scalable technologies tailored to medium- and heavy-duty applications. Sodium-ion batteries could lower vehicle costs and reduce reliance on constrained lithium supply chains, while the intelligent, V2G-enabled multiplexer charging system would maximize charger utilization, reduce depot infrastructure costs, and support grid flexibility.

At scale, the combined innovation could significantly reduce the total cost of ownership for fleets, enabling faster and more equitable deployment of clean trucks—especially in drayage and off-highway sectors where diesel impacts are severe.

Ratepayers will benefit through:

- **Improved reliability** via grid-supportive charging infrastructure.
- **Affordability** from shared fast charging and lower-cost battery options.
- **Environmental sustainability** through emissions reductions and cleaner freight corridors.
- **Equity** by prioritizing deployment in disadvantaged communities heavily affected by truck pollution.
- **Safety** via quieter, low-maintenance electric drivetrains.

Even partial success—such as identifying optimal use cases or confirming charging strategies—would yield valuable data to inform infrastructure planning and regulatory pathways.

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

The proposed research will be evaluated using the following metrics:

Quantitative Indicators:

- Battery performance: cycle life, energy density, cost per kWh, and safety benchmarks for sodium-ion cells.

- Charging system efficiency: kW delivered per charger, number of trucks charged per station, and charging throughput per day.
- V2G functionality: bidirectional power transfer rates, grid load balancing contribution, and response time.
- Battery aging impact from multiplexed and intermittent charging/discharging.
- Cost impacts: Estimated cost savings per vehicle and per charging site compared to baseline technologies.
- GHG reduction potential: Emissions avoided per truck per year.

Qualitative Indicators:

- Fleet operator and utility feedback on usability, integration complexity, and value proposition.
- Equity outcomes based on pilot deployment locations and community impact.
- Technical feasibility and scalability assessments based on real-world simulations or pilots.
- Scalability and market readiness: Insights into commercial potential and deployment challenges.

These metrics will help assess the concept's technical viability, cost-effectiveness, and alignment with EPIC goals.

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.

References:

  - Sodium-Ion Battery Potential & Cost TargetsU.S. Department of Energy (DOE), *Battery Critical Materials Supply Chain R&D Plan*, 2023.
  - https://www.energy.gov/eere/vehicles/articles/battery-critical-materials-supply-chain-rd-plan

Highlights sodium-ion as a cost-effective, abundant alternative to lithium-ion, with potential to reduce reliance on critical minerals.

- BloombergNEF, *Battery Price Survey 2023*. https://about.bnef.com/blog/battery-pack-prices-rise-for-first-time-to-an-average-of-151-kwh/

Provides benchmarks for battery cost competitiveness and market adoption thresholds.

2. Charging Infrastructure & Grid Integration
   - National Renewable Energy Laboratory (NREL), *Electric Vehicle Charging Infrastructure Trends from the Alternative Fueling Station Locator*, 2022. https://www.nrel.gov/docs/fy22osti/82306.pdf

   Highlights infrastructure limitations and the need for flexible, multi-vehicle charging solutions.

   - CALSTART, *Zeroing in on ZETs 2023 Report*. https://globaldrivetozero.org/publication/zeroing-in-on-zet-2023/

   Identifies deployment barriers for medium-duty electric trucks and infrastructure needs.

3. Equity & Environmental Justice
   - California Office of Environmental Health Hazard Assessment (OEHHA), *CalEnviroScreen 4.0*, 2021. https://oehha.ca.gov/calenviroscreen

   Used to identify disadvantaged communities disproportionately affected by diesel emissions from commercial vehicles.

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.

The proposed concept supports several EPIC 5 Strategic Goals:

a. Transportation Electrification
It accelerates adoption of battery-electric Class 3–7 trucks, including drayage and off-highway vehicles, by advancing sodium-ion batteries and intelligent, V2G-enabled multiplexer fast charging.

b. Distributed Energy Resource Integration
The bidirectional charging system enables electric trucks to function as mobile energy storage, supporting grid flexibility, load balancing, and DER integration.

d. Net-Zero Carbon Emissions
By displacing diesel trucks and reducing dependence on gas-fired peaker plants, the project helps decarbonize transport and electricity sectors.

e. Climate Adaptation
V2G-enabled trucks can serve as mobile backup power during grid outages, boosting resilience in vulnerable communities.

This concept supports EPIC’s goals through scalable, clean, and intelligent energy and transportation solutions.

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