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Electric Program Investment Charge 2026â€“2030 (EPIC 5) Research Concept Proposal Form

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:**

   Andrew Star, PhD
   astar@rand.org
   (310) 730-8615

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

   RAND | Engineering & Applied Sciences
   https://www.rand.org

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?**

   Propelled by California's energy, decarbonization, and air quality legislation, EPIC 5 Investment Plan Strategic Goals will result in the uptake and therefore, eventual decommissioning and generation of vast electronic

wastes. Indeed, the docket for this research concept proposal form proposes deploying extensive batteries, battery chargers, heat pumps, inverters, transformers, smart meters and panels. At the same time, the US is poised to face shortages and supply chain disruptions in multiple critical minerals that are required for California to achieve its energy objectives.

RAND proposes an integrated analytical study for investment decision-making into circularizing California's electrification equipment to get ahead of the impending waste/scarcity problem. The study will combine technology screening, engineering pre-feasibility, lifecycle analysis, supply-chain modeling, policy impact analysis, and stakeholder engagement into a unified decision-support framework to evaluate circular and/or closed-loop material solutions for California. The study will help quantify how different EPIC-enabled incentives could affect project uptake, economic dynamism, waste burdens, environmental externalities, job creation, and would act as a filter, ensuring that EPIC funds are directed toward the most promising and impactful initiatives.

EPIC funds are essential to support this concept because the proposed analytical framework is a form of public interest research; it is a foundational study that would not be undertaken by private entities as the benefits are widespread and not tied to a single product or company. The analysis is complex and requires specialized cross-discipline expertise spanning engineering, science, economics, and policy which RAND specializes in. By funding this effort, the CEC is making a strategic investment in itself.

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)?**

By understanding the waste management/material scarcity implications of California's statutory energy goals, the RAND study will help EPIC get ahead of barriers to CA's policy objectives that could slow or even prevent their achievement. Our study would aim to tackle several critical hurdles such as:

- Forecasting equipment uptake and material flows based on equipment lifespans, failure rates to inform recycling capacity planning.
- Establishing quantitative targets for critical and/or valuable material recovery for scenarios adopting different technologies such as differing battery chemistry adoption, hydrogen technology adoption, and distributed versus centralized technology paradigms.
- Model and clarify incentive structures such as extended producer responsibility standards and low-interest financing programs.

CEC can utilize the results to prioritize future technology pilots and investments. By synthesizing technical, economic, and logistical considerations, the study will identify key processes needed and outstanding technology and data gaps to efficiently advance clean energy deployment, emissions reduction, and resource-efficiency goals under SB 96.

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]**

We anticipate that this research would provide the CEC with an analytical framework to optimize its EPIC investments. The outcomes would lead to more effective and impactful funding decisions, ultimately benefiting all of California's electricity ratepayers. This in turn is expected to lead to reduced technology and costs to ratepayers by identifying and modeling the most cost-effective circular and/or closed-loop systems. This research is anticipated to yield:

- Lower lifecycle costs: by identifying the most cost-effective circular pathways, recyclers and OEMs could potentially cut feedstock costs and

capital costs for new projects which ultimately translate to ratepayer savings.

- Improved performance & reliability: synthesizing data streams and benchmarking technologies, recycling and remanufacturing methods could result in improved refurbished components that extend equipment lifespans and reduce overall industrial throughput, all of which lower costs.
- Ratepayer & equity benefits: reduced procurement costs help keep utility rates affordable; safer, regulated e-waste streams enhance community health; and strategically located waste management facilities would create local green-job opportunities, potentially delivering economic benefit to disadvantaged communities and advancing equity goals.
- Sustainability: achieving material recovery and minimizing transport burdens would lower embedded emissions, indirectly bolstering California's greenhouse gas and air-quality goals.

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

To track the success and inform mid-course corrections of the circular-materials study, we would monitor:

Technical Metrics

- Material recovery rates: fraction of material and value reclaimed per unit of e-waste.
- Energy intensity: estimates of kWh consumed per kg of recycled material.
- Throughput: tons/day processing capacity of relevant materials.

Economic Metrics

- Unit processing cost: $/ton of feedstock, benchmarked against a relevant goal.
- Payback period: estimates of breakeven time for recyclers under modeled incentives (target < 5 years).
- Ratepayer savings: estimated reduction in overall CAPEX and OPEX costs, which are ultimately passed through to ratepayers and customers.
- Statewide net aggerate utility and welfare retained in $/year.

Environmental Metrics

- Waste diversion: tons of e-waste diverted from landfills per year.
- Greenhouse gas reduction: metric tons of CO_2-equivalent avoided via circular and/or closed-loop versus virgin-material manufacture in line with California SB 100 and AB 1279.
- Transport footprint: average haul distance and haul-miles per kilogram of material added or avoided.

Social & Equity Metrics

- Green jobs created: number of jobs (direct and indirect) in disadvantaged communities and non-disadvantaged communities.
- Stakeholder buy-in: preliminary acceptance by local agencies and municipalities of integrating study recommendations.

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.

California's statutory energy goals will result in substantial new waste streams. Californian's may reject landfilling in-state while other states and/or nations may similarly refuse to accept Californian wastes. Examples of both have already been observed:

California board voted to nix a controversial hazardous waste proposal - Los Angeles Times

Malaysia no longer takes U.S. plastic waste. What will California do? - Los Angeles Times

Many world-leading organizations are beginning to understand the potential benefits of circularization and closed-loop schema, but conceptions remain mostly notional, qualitative, and incompletely theorized. RAND will work with CEC to bring analytical clarity to these issues and identify the most critical metrics to be tracked and assessed toward achieving statewide goals.

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 research study will help CEC support all five goals in several ways:

- (Transport Electrification and 100% Net-Zero) Battery circularity: by modeling EV battery lifecycles, failure rates, and logistics costs, the framework may prioritize pathways that reclaim critical metals. This would lower sole-source raw-material dependency, reduce battery pack cost volatility, and accelerate EV deployment.
- (Building Decarbonization and 100% Net-Zero & coordinated role of gas) Infrastructure reuse: screening second-life device feasibility informs policy incentives that extend asset value and smooth utility-scale energy storage integration which can provision long-duration energy storage and save expensive gas-fired electricity generation for tactical moments of grid-stress and/or emergency events such as (n-1) events.
- (DER Integration and 100% Net-Zero): inverter and charger loops: analysis of power-electronics enables refurbished inverters and smart chargers to meet grid-interconnection standards, reducing upfront DER costs and improving resource dispatch flexibility.
- (DER integration) Local hubs for resilience: site-selection modeling ensures regional remanufacturing centers are within 200 miles of major DER clusters—minimizing downtime and enhancing microgrid reliability during outages.
- (Building Decarbonization) heat pump material flows: forecast equipment uptake under varying incentive scenarios, guiding EPIC to better understand pilot programs that may cut unit heat-pump costs.
- (Building Decarbonization and 100% Net-Zero) Policy levers: identify which subsidy and constraint structures yield favorable payback on circular retrofits, spurring wider adoption in residential and commercial buildings.

- (100 Net-Zero): embodied carbon reduction: by substituting virgin materials with recycled content, upstream emissions may vary; assessing this variation is vital for net-zero roadmap alignment.
- (100% Net-Zero and coordinated role of gas): Gas-grid transition planning: evaluate how circular-economy incentives impact hybrid systems (e.g., solar, storage, and possibly hydrogen), informing gas-decarbonization strategies that leverage recycled high-value materials.
- (Climate adaptation): resource security: mapping critical-metal recovery enhances supply-chain resilience against climate-driven disruptions (e.g., mining floods), ensuring stable clean-tech scale-up.
- (Climate adaptation) Equity in hardest-hit regions: targeted siting of recycling "living labs" in vulnerable communities creates green jobs and safeguards against hazardous informal e-waste handling, bolstering local climate resilience.

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