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Energy-Aware Autonomy for Connected Electric Vehicles

Additional submitted attachment is included below.

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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:

Ross Greer, rossgreer@ucmerced.edu, 916-804-6791

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

University of California Merced. However, I am acting as an individual, not as an official representative of the university.

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?

The California Energy Commission should include an area in the EPIC 5 Investment Plan for Energy-Aware Autonomy for Connected & Electric Mobility. This would fund research, development, and demonstrations where connected and autonomous electric vehicles (CAVs), charging systems, and infrastructure actively optimize for grid conditions and battery health, not just safety. The purpose of such investment would be to:

- Develop planning and control stacks where battery-management system (BMS) signals—state of charge (SOC), C-rate (current as a multiple of capacity), and delta-resistance (ΔR) as an aging proxy, and support innovative approaches to CAV motion planning where grid/price signals are first-class inputs.
- Advance cooperative eco-driving (a.k.a. “green-wave” timing, vehicle-to-everything V2X coordination) that reduces stop-and-go energy waste.
- Validate vehicle-to-grid (V2G) and smart-charging strategies (including bidirectional where feasible) that soak mid-day renewable surplus and support the early-evening ramp.

EPIC support is essential to support this pre-commercial, cross-sector work (AI, power systems, transportation) that requires instrumented testbeds, bidirectional chargers, utility data/tariffs, and open datasets and studies for tech-transfer so California fleets and utilities can replicate results.

4. In accordance with Senate Bill 96, 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)?

- The barrier of battery-blind autonomy, where existing planners exceed safe C-rates and accelerate ΔR aging, which could target reduction of >1.5 C spikes and lower ΔR per battery cycle.
- The barrier of stop-and-go inefficiency, which wastes traction energy in cities; techniques to create "green waves" could aim to cut energy usage compared to non-connected driving.
- The barrier of mid-day renewable curtailment and evening ramp should be addressed, targeting reduction in energy curtailment and strategies for integration of bidirectional chargers to improve grid stability and validate PG&E V2X tariff structures.

  Further, such funding will address a research data gap combining perception and planning for CAVs with fine-grained battery data and feeder power, which can inform battery management system design, vehicle grid integration tariff models, and transportation research. For AI-facilitated innovations, solutions should also highlight explainability, where planners must produce human-readable rationales ("kept discharge under 1.5 C to meet battery-stress budget and signal timing"), enabling operator trust and audit.

  Beneficiaries and end users include distribution utilities planning EV load, municipal transit agencies, ride-hail operators, OEMs integrating battery-health constraints, and academic researchers.

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, reliability, affordability, environmental sustainability, and equity?

  At the program level, funded projects should credibly show:

  - Lower energy use per mile, dropping charging load and demand charges for ratepayers and public fleets.
  - Longer battery life, delaying expensive pack replacements and reducing raw-materials demand.

- Better grid alignment, shifting charging to surplus-renewables windows and smoothing evening ramps; where feasible, V2G export provides additional flexibility and resilience.
- Safety maintained or improved.
- Open artifacts (data, code, methods) that reduce duplication and accelerate adoption statewide.
- Equity & workforce gains, with demonstrations in or serving disadvantaged communities and funded training for local students and technicians.

If replicated across municipal and commercial light-duty fleets, even modest improvements translate into material statewide electricity savings, deferred distribution upgrades, and lower total cost of ownership—while cutting greenhouse-gas (GHG) emissions and fine particulate matter (PM 2.5) exposure in communities near busy corridors.

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

- Reduction in traction energy, as measured by vehicle controller area network telemetry and charger logs.
- Reduction in peak charger demand and feeder ramp, as measured by bidirectional charger metrology and available PG&E data.
- Reduction of frequency of C-rate excursions over 2 C, as measured by battery pack current sensors.
- Reduction in ΔR growth, as measured by battery pack telemetry.
- Reduction of safety-critical accidents or near-misses through CAV perception and planning stacks.
- Clear communication of AI rationale of vehicle planning decisions to human operators, as measured by operator survey.

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.

1. Molnar, Tamas G., and Gábor Orosz. "Destroying phantom jams with connectivity and automation: Nonlinear dynamics and control of mixed traffic." Transportation Science 58.6 (2024): 1319-1334.
2. Tianyi Ma et al. "Study on the evolution of internal resistance and entropy-thermal coefficients during the aging process of lithium-ion traction batteries." e-Prime - Advances in Electrical Engineering, Electronics and Energy (June 2025).
3. Lori Aniti; Solar and wind power curtailments are increasing in California (https://www.eia.gov/todayinenergy/detail.php?id=65364)

4. PG & E Vehicle-to-Everything (V2X) pilot program (https://www.pge.com/en/clean-energy/electric-vehicles/getting-started-with-electric-vehicles/vehicle-to-everything-v2x-pilot-programs.html)
5. PG&E/Edison/SSDG&E 2025 Vehicle-Grid-integration Forum Slides (https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/transportation-electrification/energization/2025-vgi-forum-slide-deck.pdf)
6. Paul Doherty, PG&E Helps Zum Deploy Nation's First 100% Electric School Bus Fleet in Oakland for New School Year (https://www.pge.com/en/newsroom/currents/future-of-energy/articles-4040-pge-helps-zum-deploy-nations-100-electric-school-bus-fleet-oakland-new-school-year.html)

8. The EPIC 5 Investment Plan must support at least one of five Strategic Goals:

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

This funding would support (a) Transportation Electrification: energy-conscious autonomous EVs reduce consumption & extend battery life, (b) Distributed Energy Resource Integration: bidirectional charger quantifies EVs as dispatchable distributed energy resources, and (d) Net-Zero Carbon, with smoother traffic and longer-lived packs cutting life-cycle emissions.