DOCKETED	
Docket Number:	25-EPIC-01
Project Title:	Electric Program Investment Charge 2026–2030 Investment Plan (EPIC 5)
TN #:	270655
Document Title:	Sandia National Laboratories Comments - Sandia National Laboratories Comments - SNL EPIC 5 Research Concept Input
Description:	N/A
Filer:	System
Organization:	Sandia National Laboratories
Submitter Role:	Public
Submission Date:	6/16/2026 3:28:29 PM
Docketed Date:	6/16/2026

Comment Received From: Sandia National Laboratories
Submitted On: 6/16/2026
Docket Number: 25-EPIC-01

Sandia National Laboratories Comments - SNL EPIC 5 Research Concept Input

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:**

Todd Monson
tmonson@sandia.gov
505-845-2129

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

Sandia National Laboratories

Sandia National Laboratories is pleased to offer the following research concept for consideration in the EPIC 5 Investment Plan. We thank the California Energy Commission for its continued leadership in supporting critical energy research and development that support meeting its energy needs and affordability goals.

Sandia is a multidisciplinary national laboratory with deep research capabilities across energy sectors. Several Sandia research efforts have historically been strengthened through collaboration with California institutions and with programs funded by the CEC and the U.S. Department of Energy. EPIC 5 presents a timely opportunity to continue this collaboration.

The concept described below of ‘advanced soft magnetic materials for high-efficiency power conversion and electric machines’ is one area where Sandia's materials science and power electronics capabilities align closely with California's electrification needs and an identified national research gap. Sandia would also welcome the opportunity to contribute concepts in other areas of CEC interest, including energy storage safety and reliability, novel solar technologies, and grid resilience, should those be of value to staff as the EPIC 5 plan develops.

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?**

Concept: Advanced Soft Magnetic Materials for High-Efficiency Power Conversion and Electric Machines

Soft magnetic materials (SMMs) form the cores of the transformers, inductors, generators, and motors that convert and transform essentially every kilowatt-hour California generates, transmits, and consumes. Despite their critical role, SMMs are among the least-modernized components in the electricity system: no fundamentally new commercial soft magnetic material has been introduced since the development of nanocrystalline alloys in the late 1980s. Over the same period, the demands placed on these materials by data-center growth, vehicle electrification, and machine-driven industrial loads have changed substantially.

The U.S. Department of Energy's Advanced Materials and Manufacturing Technologies Office (AMMTO) has identified improved soft magnetic core materials as a leading opportunity for reducing losses in modern power electronics, noting that much of the design space for these materials remains unexplored. The U.S. DRIVE Electric Drive Technical Team Roadmap (2024) similarly identifies advanced soft magnetic materials as a priority research area for higher-efficiency, lower-rare-earth electric motors.

This concept proposes applied research, development, and independent demonstration of next-generation SMMs, and the power-conversion and electric-machine designs they enable, validated under conditions relevant to California's industrial, transportation, and grid loads.

The concept spans two related application areas:

- **Soft magnetics for high-frequency power electronics.**
  Wide-bandgap (WBG) semiconductors such as silicon carbide (SiC) and gallium nitride (GaN) enable power conversion at higher switching frequencies, but at those frequencies the magnetic core often becomes

the dominant source of loss and the dominant constraint on converter size, weight, and cost. Advancing SMM compositions, composites, and manufacturing methods for the 100 kHz to several-MHz regime would support more efficient AI data-center power supplies, solar inverters, EV onboard chargers, and EV Supply Equipment.

- **Critical-material-free soft magnetics for motors and drives.** Electric motors consume a large share of California's industrial electricity, and the highest-efficiency motors today rely on permanent magnets made from heavy rare-earth elements concentrated in foreign supply chains. Novel SMMs with high magnetization and low core loss could enable motor designs that reduce or eliminate rare-earth content while maintaining efficiency, improving both supply-chain resilience and motor-system energy performance.

EPIC support is appropriate because the benefits of advanced soft magnetic materials are realized only when they are validated and demonstrated in the specific applications and operating conditions California presents. EPIC's mandate to fund applied research and demonstration that delivers measurable ratepayer benefit is well-matched to this work, which carries a technology forward from promising materials science to independently validated, California-relevant performance.

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)?**

California's statutory goals of 100% clean retail electricity by 2045 (SB 100), zero-emission new passenger vehicles by 2035, accelerated industrial decarbonization, and reliable, affordable service for all ratepayers require moving additional energy through more conversion stages than ever before. Each conversion stage is a potential loss center, and the magnetic core within that stage is often where significant loss occurs. The proposed work would address three barriers:

- **High-frequency core loss limits the benefit of WBG semiconductors**
  Incumbent soft magnetic materials were developed for earlier switching-frequency regimes. Ferrites offer low loss but low magnetic saturation; amorphous and nanocrystalline alloys perform well at tens of kilohertz but become lossy at higher frequencies and are difficult to form into complex shapes. In response to the rapid adoption of WBG semiconductors, DOE has identified newer material families – including nitrides, high-entropy alloys, and nanocomposites – as promising but under-explored directions. Validated next-generation SMMs in these families could reduce core losses in the frequency range relevant to modern data-center power supplies, EV charging systems, and solid-state transformers (SSTs).
- **Motors depend on imported critical materials and waste energy as heat.**
  Permanent-magnet motors dominate EV traction and high-efficiency industrial drives but depend on heavy rare-earth elements subject to supply-chain and geopolitical risk. In addition, core losses remain a significant loss center across motor types. SMMs combining higher magnetization with lower core loss could enable rare-earth-free or rare-earth-reduced motor designs without sacrificing efficiency.
- **Validation gaps prevent California-relevant adoption**
  Even technically promising materials cannot be specified into products without independent demonstration under California-relevant conditions: high ambient temperatures, wildfire-mitigation operating envelopes, EV fast-charging duty cycles, and the thermal and reliability requirements of data centers concentrated in California utility service territories. EPIC-funded, independent validation directly de-risks adoption by California manufacturers and utilities.

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]**

Even partial success would produce ratepayer benefits aligned with EPIC's guiding principles:

- **Affordability:** Reducing energy losses at conversion stages between the generator and the load lowers the cost of energy for California ratepayers . With significant new data-center, EV-charging, and industrial-electrification

load anticipated over the EPIC 5 horizon, even modest per-stage efficiency improvements aggregate to substantial statewide savings.

- **Reliability:** Lower-loss magnetics operate cooler, potentially extending the service life of transformers and distribution equipment, reducing thermally driven failures, and lowering cooling load in data centers.
- **Safety:** Less waste heat reduces fire and thermal-runaway risk in densely populated and wildfire-prone areas, and lighter components improve handling safety.
- **Environmental sustainability:** Every kilowatt-hour saved through more efficient conversion is energy that need not be generated, transmitted, or stored. Rare-earth-free motor designs also reduce the environmental footprint associated with rare-earth mining and processing.
- **Equity:** Upstream materials improvements reach all ratepayers automatically, regardless of income, housing type, or ability to install rooftop solar or purchase a new EV.
- **Innovation at scale.** Soft magnetic materials are foundational: a successful new material could propagate across transformers, inductors, motors, and any device that converts electrical energy. The scale potential for a single materials investment is therefore unusually large, and California – with its concentration of advanced energy manufacturers, data-center investment, EV deployment, and SST innovators – is a natural place to validate and deploy these technologies.

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

Suggested metrics include:

- **Core-loss reduction** (W/kg) under standardized conditions versus incumbent materials, at frequencies and flux densities representative of target applications.
- **System-level efficiency improvement** (percentage points) demonstrated in representative platforms such as a server power supply, EV charger, or motor drive.
- **Power density** (kW/L) improvement in converter and motor designs enabled by new magnetic components.
- **Critical-material reduction** (kilograms of heavy rare-earth content per motor or per kW) relative to incumbent permanent-magnet designs.
- **Modeled cost trajectory** ($/kW or $/kg) at projected production volumes.

- **Reliability and lifetime** under California-relevant thermal-aging and duty-cycle conditions.
- **Technology and manufacturing readiness level** (TRL/MRL) progression, including pathways to California-sited pilot manufacturing where feasible.

Qualitative indicators include adoption interest from California manufacturers and utilities, contributions to relevant standards bodies, peer-reviewed publications, and workforce-development outcomes through university and community-college partners.

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.**

- U.S. Department of Energy, Advanced Materials and Manufacturing Technologies Office (AMMTO), "Wide Bandgap Power Electronics Strategic Framework" (2025): https://www.energy.gov/sites/default/files/2025-01/AMMTO%20Draft%20WBG%20PE%20Strategic%20Framework_FINAL.pdf
- U.S. DRIVE Partnership (US DOE, USCAR, energy company partnership), "Electric Drive Technical Team Roadmap" (2024): https://www.energy.gov/sites/default/files/2024-06/EDTT_Roadmap_2023_JOG_Consensus_compliant.pdf
- Silveyra, J. M., Ferrara, E., Huber, D. L., Monson, T. C., "Soft magnetic materials for a sustainable and electrified world," Science 362, eaao0195 (2018): https://www.science.org/doi/10.1126/science.aao0195
- Lawrence Berkeley National Laboratory, "2024 United States Data Center Energy Usage Report," December 2024 (LBNL-2001637): https://eta-publications.lbl.gov/sites/default/files/2024-12/lbnl-2024-united-states-data-center-energy-usage-report_1.pdf
- U.S. EIA / Pew Research, "U.S. data centers' energy use amid the artificial intelligence boom," October 2025: https://www.pewresearch.org/short-reads/2025/10/24/what-we-know-about-energy-use-at-us-data-centers-amid-the-ai-boom/

- U.S. Department of Energy, "Energy-efficiency policy opportunities for electric motor-driven systems" (IEA, 2011): https://www.oecd.org/content/dam/oecd/en/publications/reports/2011/05/energy-efficiency-policy-opportunities-for-electric-motor-driven-systems_g17a1f7e/5kgg52gb9gjd-en.pdf
- Monson, T. C. et al., U.S. Patent 9,963,344 (2018), "Method to Synthesize Bulk Iron Nitride.": https://patents.google.com/patent/US9963344B2/en
- R&D 100 Winner 2022: Iron Nitride Soft Magnetics: https://www.sandia.gov/ess/2023/02/15/rd-100-winner-2022-iron-nitride-soft-magnetics

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.

This concept supports several of the CPUC-adopted EPIC 5 Strategic Goals (D.24-03-007):

- **Distributed Energy Resource Integration – Accelerating Grid Connection of Clean Resources and Beneficial Loads**

  Advanced soft magnetics are fundamental components of the solid-state transformers (SSTs) identified by the CEC's draft initiatives as bridging solutions for fast grid interconnections. Reducing the core losses that limit SST size, cost, and efficiency at WBG-enabled frequencies is key to the development of next-generation SSTs that get the most out of the existing grid. More broadly, every distributed energy resource (rooftop solar, behind-the-meter storage, EV chargers) depends on a power converter, and every converter depends on soft magnetic components. Lower-loss, smaller, lower-cost magnetics improve DER economics, integration, and reliability in California's high-ambient-temperature and wildfire-prone environments.

- **Transportation Electrification – Harnessing the Value of Transportation Electrification for Ratepayers**
  Novel soft magnetics can improve efficiency across the EV charging chain (onboard chargers, EV Service Equipment, and supporting infrastructure), extending EV range and accelerating adoption. In addition, they can increase the efficiency of stator cores in electric motors, reducing or eliminating the need for rare-earth motor cores and lowering a significant cost driver in EVs, further supporting adoption.

- **Achieving 100 Percent Net-Zero Carbon Emissions – Enhancing Clean Energy Technology Safety, Supply Chains, and Life Cycle Benefits**
  Many legacy soft magnetics are made with nickel or cobalt, critical materials subject to supply chain risks and volatile prices. In addition, electric motor cores are highly dependent on permanent magnets made with rare-earth materials. Advancing the development of novel soft magnetics made from abundant, domestically available elements will strengthen domestic supply chains and lower system costs. Higher-efficiency soft magnetics can also enable motor designs with less or zero permanent magnets, further strengthening the supply chain and lowering costs.

- **Building Decarbonization and Climate Adaptation (indirect):** Heat-pump compressors, ventilation motors, and appliance power electronics all use soft magnetic materials; Higher-efficiency cores reduce the operating cost of electrified buildings and improve customer acceptance of electrification.

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

---

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