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DG Matrix Solid-State Transformer (SST) Power Router for Grid-Edge Integration of Distributed Energy Resources (DERs)

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:

Thomas Schuldt
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+1 (415) 996-8371

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

DG Matrix

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?

Proposed Concept: DG Matrix Solid-State Transformer (SST) Power Router for Grid-Edge Integration of Distributed Energy Resources (DERs)

We propose that the CEC consider investing in the demonstration and commercialization of the DG Matrix multi-port solid-state transformer (SST) Power Router to address key gaps in distributed energy resource (DER)

integration, electric vehicle (EV) infrastructure, and energy resilience. The concept leverages a multi-port SST system—currently proven in behind-the-meter applications—to expand its use to front-of-meter deployments at the distribution level.

The DG Matrix Power Router enables the seamless integration and real-time management of multiple AC and DC energy sources and loads—including the grid, solar, wind, batteries, fuel cells, generators, EV chargers, and building loads—within a single compact unit. **In addition to bi-drectional DER integration for *any* power source, the Power Router can serve as a grid-forming device, virtual power plant, and/or EV charger.**

The Power Router offers up to 50% CAPEX savings, 3X lower OPEX, high efficiency, rapid deployment (*in days to weeks instead of months to years*), and a footprint up to 15X smaller than legacy systems.

Key technical features include:

- Six bi-directional, software-defined ports that are remotely programmable and configurable to adapt to evolving energy sources, loads, or operating conditions should demand change;
- Support for both AC and DC inputs / outputs;
- Native support for black start, islanding, UPS, grid-forming operation, Volt-VAR control, and vehicle-to-grid (V2G) integration;
- AI-driven energy management system that enables real-time balancing of inputs and outputs, dynamic load shaping to reduce peak demand, and use of on-site renewables or storage when grid capacity is constrained;

These features make the Power Router ideal for supporting critical facilities, community resilience hubs, and front-of-meter grid services.

The purpose of this concept is to accelerate the deployment of equitable, scalable, and flexible grid-edge solutions that reduce interconnection timelines, improve reliability and resiliency, and enable higher penetration of renewables and electrified transportation—particularly in disadvantaged communities and locations facing utility upgrade delays.

While the Power Router has already been demonstrated in behind-the-meter microgrids and EV infrastructure pilots, EPIC support is needed to evaluate, demonstrate, and de-risk its application in front-of-the-meter and utility-integrated use cases. This would include integration into California distribution systems, support for virtual power plants (VPPs), and delivery of grid services through aggregated DERs. Such validation is critical for enabling broader market

adoption and ensuring equitable access to affordable, reliable, and sustainable energy.

4. In accordance with Senate Bill 96[1], 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 DG Matrix Power Router represents a breakthrough in power electronics that directly addresses multiple barriers impeding the scale-up of clean energy technologies, especially at the distribution grid edge. By consolidating typically 10-15 traditionally discrete components—such as inverters, transformers, converters, protection systems, and EMS—into a single, compact, programmable solid-state transformer (SST) unit, it eliminates complexity, reduces costs, accelerates deployments, and increases the flexibility and resilience of DER integration.

Technical and Market Barriers Addressed:

- **High grid upgrade costs and delays**: Power Routers reduce CAPEX by up to 50% and installation time from months/years to days/weeks, allowing clean energy and EV projects to proceed without major utility-side infrastructure upgrades.
- **Incompatibility between AC and DC systems**: The system natively supports both AC and DC inputs/outputs and allows simultaneous integration of batteries, PV, EV chargers, fuel cells, and generators—removing a key interoperability barrier to widespread DER adoption.
- **Lack of resilience infrastructure**: With native black start, UPS, and islanding capabilities, the Power Router supports autonomous operation during grid outages—an essential feature for wildfire-prone and underserved communities.

[1] 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.

- **Fragmented control and monitoring**: The Power Router's AI-driven energy management system dynamically balances supply and demand, reduces peak loads, and supports V2G and virtual power plant (VPP) participation.

Performance Targets for Market Adoption:

- **Efficiency**: 96–98% system efficiency (vs. 85–92% for conventional systems)
- **Footprint**: Up to 15X reduction in physical space
- **Deployment speed**: Interconnection and commissioning in 1–7 days (vs. 6–24 months)
- **Payback**: 2–5 years for commercial/industrial use cases
- **Repair and configuration**: Remote software updates and modular maintenance reduce mean time to repair (MTTR) and total lifecycle cost

Data Gaps Addressed:
EPIC funding would support data collection, validation, and modeling of front-of-meter SST systems under real-world grid conditions, filling gaps in:

- Interoperability standards for multi-port AC/DC DER platforms
- Dynamic DER dispatch modeling for VPP/grid services
- Cybersecurity and resilience metrics for programmable energy systems
- DER hosting capacity optimization using software-defined power electronics

The beneficiaries of this technological solution would be multi-fold:

- **Utilities**: As a grid-alleviation tool that reduces peak load and grid congestions, improves voltage support, enables energy diversity, and defers capital upgrades with much simpler and lower cost O&M
- **Developers**: Through faster interconnection and simpler DER integration at a lower CAPEX for multi-technology sites
- **Communities and critical facilities**: By enabling cost-effective, reliable, resilient power in disadvantaged, rural, and outage-prone areas
- **Policy and research institutions**: By generating field data to guide interconnection policy, resilience planning, and DER incentive design

This concept will enable California to leap past conventional infrastructure constraints, supporting rapid, equitable, and resilient deployment of clean energy across sectors—and accelerating progress toward the state's 2045 climate and energy 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,[2] reliability,[3] affordability,[4] environmental sustainability,[5] and equity?[6]

If successful, the DG Matrix Power Router would unlock a transformative pathway for rapid, affordable, and resilient deployment of distributed clean energy infrastructure across California. By consolidating multiple complex components into a single programmable, software-defined solid-state transformer (SST) platform, the Power Router has the potential to **cut DER and EV infrastructure deployment costs by up to 50%**, reduce commissioning timelines from **months to days**, and increase system efficiency to **96–98%**, improving overall lifecycle value for both utilities and customers.

At scale, this innovation could serve as a **universal grid-edge interface** for a broad range of use cases—from front-of-meter DER integration and EV fleet charging to resilient community energy hubs and virtual power plants (VPPs). This would allow California to **overcome interconnection bottlenecks**, defer expensive grid upgrades, and enable clean energy access in load-constrained or underserved areas.

Anticipated ratepayer benefits include:

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[2] EPIC innovations should improve the safety of operation of California's electric system in the face of climate change, wildfire, and emerging challenges.
[3] EPIC innovations should increase the reliability of California's electric system while continuing to decarbonize California's electric power supply.
[4] 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.
[5] 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.
[6] 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.

- **Improved Safety**: Supports wildfire resilience and disaster preparedness through built-in black start, UPS, and islanding features that enable autonomous power supply for critical facilities and disadvantaged communities during outages.

- **Increased Reliability**: Serves as a grid-forming resource with real-time balancing, Volt-VAR support, and V2G capability, improving grid stability even with high DER penetration.

- **Greater Affordability**: Reduces upfront CAPEX, streamlines interconnection, and lowers O&M costs through remote diagnostics and AI-driven energy management. By shifting and reducing peak demand through intelligent load shaping, the Power Router also lowers system-wide procurement costs—translating into lower rates for all customers.

- **Environmental Sustainability**: Accelerates renewable energy integration, optimizes load shifting to coincide with solar and wind availability, and reduces the need for diesel backup systems.

- **Equity and Community Impact**: Enables clean, resilient energy access in **disadvantaged and vulnerable communities** by reducing land, permitting, and infrastructure constraints—making clean energy viable in dense urban environments, tribal lands, and pollution-burdened rural areas.

Even partial success—such as proving front-of-meter use cases or validating DER-grid services—would deliver significant policy and market impacts, advancing California's goals for decarbonization, resilience, and equitable energy access while lowering ratepayer costs.

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

The proposed research concept would be evaluated using a combination of quantitative performance metrics and qualitative impact indicators aligned with EPIC's guiding principles and California's statutory energy goals.

<u>Quantitative Metrics may include the following:</u>

a. **Cost Reduction**:
    - Percentage reduction in installed CAPEX compared to conventional DER infrastructure (target: up to 50%)

    - Decrease in O&M costs (target: up to 3X lower)
b. **Deployment Speed**: Time from arrival of equipment on site to start of operations (target: <7 days for typical installations)
c. **System Efficiency**: Power conversion efficiency of 96–98%
d. **Peak Load Reduction**: Reduction in site-specific or circuit-level peak demand (kW) due to dynamic load shaping
e. **Grid Support Capabilities**:
    - Number of hours in islanded operation enabled during outages
    - Volt-VAR response times and frequency stability contributions
f. **GHG and Pollutant Reduction**: Metric tons of CO_2 and criteria pollutants avoided through diesel generator displacement, increased renewable utilization, and need of fewer equipment pieces
g. **DER and EV Integration**:
    - Number and types of sources and loads integrated per unit (e.g., solar, batteries, EV chargers, fuel cells, etc.)
    - Number of charging sessions or kWh delivered to EVs through the Power Router

<u>Qualitative Metrics may include the following:</u>

a. **Resilience Impact**: Ability to maintain critical services during grid outages, particularly for disadvantaged communities or public facilities
b. **Scalability and Replicability**: Flexibility of system design to accommodate varied site configurations, use cases, and future loads
c. **Customer and Community Improved Experience**:
    - Stakeholder feedback from utilities, developers, and community organizations
    - Level of engagement and benefit reported by disadvantaged and vulnerable communities
d. **Interconnection and Permitting Improvements**: Reduction in administrative burden or permitting timeframes as reported by developers or AHJs (Authorities Having Jurisdiction)
e. **Technology Validation**: Feedback from utility or grid operator pilots regarding front-of-meter integration

These metrics can be tracked across pilot and demonstration sites and analyzed to evaluate the Power Router's technical performance, scalability, customer value, and contribution to California's clean energy, equity, and resilience 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.

The following links provide more details to support the technical capabilities, and benefits of the Power Router:

- **DG Matrix Website**: https://www.dgmatrix.com/
- **Power Router Webpage**: https://www.dgmatrix.com/power-router-technology
- **DG Matrix Power Router Brochure Video:** https://www.youtube.com/watch?v=QOP33lJTJ94
- **Power Router Brochure for EV Charging**: https://pub-603db131244d4898a25e35ad020f3bf9.r2.dev/assets/documents/the-dg-matrix-power-router-for-vehicle-electrification-brochure.pdf
- **Power Router Brochure for Building Electrification**: https://pub-603db131244d4898a25e35ad020f3bf9.r2.dev/assets/documents/the-dg-matrix-power-router-for-building-electrification-brochure.pdf

Additionally, below are links to case studies and articles that add additional context for the potential of the Power Router to overcome market barriers and infrastructure challenges, and to help provide societal benefits:

- **DG Matrix Case Study: *Enhancing Charging Efficiency for School Bus Depots***: https://www.dgmatrix.com/CaseStudyElectrification/enhancing-charging-efciency-for-school-bus-depots/153
- **Article - "Unlocking the Invisible Grid: How VPPs and Edge Intelligence Can Deliver Hundreds of Gigawatts Without Building New Infrastructure"**: https://www.dgmatrix.com/Article/unlocking-the-invisible-grid-how-vpps-and-edge-intelligence-can-deliver-hundreds-of-gigawatts-without-building-new-infrastructure/159
- **Article - "Why Solid-State Transformers are Finally Ready for Scale":** https://www.dgmatrix.com/Article/why-solid-state-transformers-are-finally-ready-for-scale/154

8. The EPIC 5 Investment Plan must support at least one of five Strategic Goals:[7]
    a. Transportation Electrification
    b. Distributed Energy Resource Integration
    c. Building Decarbonization

[7] 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

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 DG Matrix Power Router directly supports multiple EPIC 5 Strategic Goals, with primary alignment to **(a) Transportation Electrification** and **(b) Distributed Energy Resource (DER) Integration**, and secondary support for **(c) Building Decarbonization** and **(e) Climate Adaptation**.

a. Transportation Electrification

The Power Router addresses critical infrastructure challenges that inhibit the scale-up of EV adoption in California. It provides a compact, modular, and programmable platform that enables **fast deployment of EV charging infrastructure**, reduces **interconnection costs and timelines**, and supports **simultaneous integration of multiple DERs** (e.g., solar, batteries, fuel cells) to deliver resilient EV charging solutions. Key contributions include:

- **50% CAPEX savings** and rapid deployment (1–7 days) for DER and EV charging infrastructure, with 3X OPEX cost savings and 15X smaller footprint
- **Black start and islanding** capabilities to maintain charging access during outages—essential for DVCs and emergency response
- **Support for fleet charging depots, public transit electrification, and school bus projects**, especially where grid upgrades are cost- or space-prohibitive
- **V2G and load shaping** to reduce peak grid impacts and align charging with renewable generation
- Modular and scalable AC or DC Fast Charging with 400 kW capacity (more with parallelling) and 5 programmable ports per unit
- Can be remotely programmed and adapted for any vehicle type
- Compliance with all current standard EV charger certifications and requirements

These features directly align with the strategic goal to “support the planning, integration, scaling, and commercialization of technologies” that accelerate the transition to 100% zero-emission vehicles.

b. Distributed Energy Resource Integration

The Power Router is a next-generation DER interface that simplifies and accelerates integration of **AC and DC sources**—including solar PV, batteries, wind, fuel cells, and generators—into both behind-the-meter and front-of-meter systems. It offers:

- **Grid-forming control**, Volt-VAR support, and seamless participation in **virtual power plants (VPPs)**
- **AI-driven energy management** for dynamic load balancing and DER coordination
- **Programmable ports** that enable over-the-air reconfiguration as load or resource needs evolve
- **Plug-and-play deployment** that significantly reduces permitting and interconnection complexity

By simplifying DER integration, improving cost-effectiveness, and enabling flexible deployment in space-constrained or underserved areas; the Power Router directly supports the state's goal of deploying 7,000 MW of flexible load by 2030 and achieving zero-carbon electricity by 2045.

c. Building Decarbonization (*secondary support*)

The Power Router enables electrification of commercial, municipal, and multifamily buildings by serving as the central hub for **integrated onsite renewables, battery storage, EV charging, and building loads**. Its software-defined energy management platform helps optimize building energy use, reduce emissions, and support demand-side load shaping, all of which are foundational to building decarbonization strategies. It also enables new DERs to be added over time without costly retrofits.

e. Climate Adaptation (secondary support)

The system enhances community and grid resilience in the face of increasing outages driven by wildfire, heat, and other climate-driven events. Its **UPS and islanding features** allow critical services (e.g., schools, cooling centers, emergency shelters) to continue operations during grid failures. It also enables **resilience hubs** and **microgrid deployments** in **disadvantaged and vulnerable communities**, supporting equitable adaptation to climate-related risks.

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

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