DOCKETED	
Docket Number:	25-EPIC-01
Project Title:	Electric Program Investment Charge 2026–2030 Investment Plan (EPIC 5)
TN #:	265493
Document Title:	ReMo Homes Comments - Low Voltage DC for Lighting & Air Circulation
Description:	N/A
Filer:	System
Organization:	ReMo Homes
Submitter Role:	Applicant
Submission Date:	8/8/2025 4:54:22 PM
Docketed Date:	8/8/2025

Comment Received From: ReMo Homes
Submitted On: 8/8/2025
Docket Number: 25-EPIC-01

Low Voltage DC for Lighting & Air Circulation

Additional submitted attachment is included below.

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:

   Vamsi Kumar Kotla, CEO, vkk@remo.homes, (323) 708-4094

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

   ReMo Homes

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?

Background

Many residential building systems convert AC to DC power internally. Common examples are LED lighting, heat pumps, air circulation, EV charging, induction stoves, and air filtration systems. (This is in addition to DC power consumed by many plugload devices such as phones, computers, and other electronics.)

With the right in-home infrastructure, residential DC equipment could integrate seamlessly with renewable on-site generation and battery storage, lowering costs and boosting reliability. As power is increasingly produced and stored behind-the-meter in a residential environment—typically in DC form—shifting in-home infrastructure to allow appropriate fixtures and equipment to use DC power directly and skip two or more cycles of inversion and conversion can avoid 20–30% or more in cumulative energy losses and inefficiencies in these systems, in addition to reducing the need for transformers and complex wiring.

In particular, low-voltage DC (LVDC) power is better than traditional line-voltage AC for many applications. Beyond aligning with today's technological needs and providing the efficiencies noted above, it also enhances safety and can improve construction productivity. LVDC poses far less risk of electric shock than line-voltage AC and can be easily run with lightweight cables, in many cases without an electrician, reducing this potential scope bottlenecks. LVDC can provide a cleaner, safer, and more future-ready solution for modern power distribution in the home.

However, due to the usually intermittent nature of on-site renewable energy and the cost and materials inefficiency of greatly oversized battery storage, grid power backup needs to be integrated into the home electrical system to ensure that the DC systems are still powered during longer periods of reduced on-site generation and other interruptions to behind-the-meter power.

Concept Summary

This concept would explore and seek to increase the viability of DC (and especially LVDC) infrastructure for directly powering common applicable loads in homes, optimizing use of on-site generation and storage. A priority would be increasing efficiency and decreasing both hard and soft costs.

In this context, it would focus in part on studying effective grid power backup schemes to on-site generation and storage—which exist common in commercial environments, such as data centers and large commercial buildings, and even other regions of the world, such as western Europe—and adapt these learnings for residential environments in the U.S.

Additionally, current Title 24 energy code requires that renewable energy power critical loads, so our concept would also study designing circuits that can simultaneously power both critical loads (AC and DC powered) and non-critical DC-powered loads during regular operation, without needless AC/DC conversions, and switch to powering only critical loads during power outages or system disruptions.

Overview of Benefits

- **Seamless Integration with Renewables and Electrification**

    - Most solar panels, batteries, and fuel cells produce DC power.
    - EV chargers, data centers, LED lighting, IoT devices, and some electrified thermal end uses (induction cooking, heat pumps) run natively on DC. Using LVDC reduces the need for AC–DC conversions, cutting energy waste, and provides a direct supply, improving reliability (and reducing materials/parts).
- **Drives Energy Efficiency Goals**
    - Conventional AC systems have some 10–15% inefficiency in conversion losses with each conversion, which can easily add up to 20–30% in cumulative losses.
    - LVDC reduces these losses, helping meet state energy and carbon.
- **Enables Safer, More Flexible Power**
    - Operating at Class 2 (<60V) DC is considered "safe to touch" under many electrical codes.
    - This reduces shock hazards, lowers installation costs, and makes it easier to deploy in dense urban or residential settings.
- **Reduces Infrastructure and Material Costs**
    - Requires smaller conductors and simpler cabling compared to AC for many loads.
    - Cuts up-front and replacement/maintenance costs for wiring, conduits, etc.; elimination of AC–DC conversion in each DC fixture and piece of equipment reduces points of failure, waste heat (with potential consequent space conditioning savings), and heat-driven wear/failure (especially common in LED lighting).
    - When using grid-supplied AC power, can convert to DC at a centralized point in the home (consolidating conversion equipment) then distribute as DC.
- **Future-Proof and Modular**
    - A central DC distribution hub allows easy expansion for new loads (like EV charging or additional renewables).
    - Fits well with smart grids and microgrids, supporting building and community energy resilience.

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

[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.

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 proposed exploration of LVDC power systems integration directly supports the state's statutory energy goals by driving technological advancements that reduce energy waste, enable renewable integration, and lower barriers to widespread clean energy adoption.

Barriers Addressed

- High up-front cost of housing, especially high-performance homes with on-site generation and storage; limited access to high-performance, energy-resilient housing in disadvantaged communities
- Technical difficulties, cost, and capacity constraints in incorporating clean energy technologies into homes
- High energy burden for residents
- Concerns around safety and reliability of electrified equipment

Performance and Cost Targets

- 20–30% electrical building system efficiency improvement from reduced conversion losses and more optimal use of on-site energy generation and storage
- 20–30% lower electrical equipment and installation costs
- Measurable reduction in maintenance costs (targeting ~15%)
- Substantial areas of new homes are "safe to touch," with no line-voltage AC (only LVDC)
- Better power reliability compared to conventional baseline
- Broad availability of high-performance, energy-resilient housing

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]

At full scale, LVDC has the potential to **transform California's building and energy infrastructure**, delivering measurable savings, higher reliability, and increased renewable integration. Even in partial deployment, the innovation meaningfully advances the state's carbon neutrality goals and EPIC's guiding principles. As outlined above (see Questions 3 and 4), this concept would pursue benefits that support safety, reliability, affordability, environmental sustainability, and equity.

Support California's 2045 Carbon Neutrality Goal

Operational Energy Savings Outcome: Illustrative Case

A typical all-electric home consumes 10 kWh/SF annually. For a typical 2,000-SF home this translates to 20,000 kWh annual consumption. If one assumes that 50% of this consumption happens ultimately through DC power, by avoiding the 30% conversion and inversion losses, one can reduce total electricity consumption by 15%, which comes to about 3,000 kWh annually. Assuming a reasonable 15-year lifespan for the grid-power-backup equipment (inverter and balance of system), one can estimate 45,000 kWh of lifetime savings; with California's average electricity cost per kWh of 32 cents, this comes to $14,400. However, the anticipated average cost per kWh is expected to climb due to climate adaptation, electrification, and demand from data centers and others. It is fair to assume that the present value of this long-term average cost would be closer to 40 cents and subsequently the cost savings would be closer to $18,000

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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.

per ratepayer. The power electronics can last longer, say 25 years, and the cost savings only increase to $30,000.

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

The following benefits would be evaluated:

- Potential up-front cost reduction (through materials and labor savings)
- Embodied carbon savings (less copper wire, smaller conductors, and simpler balance-of-system equipment)
- Operational energy savings from more efficient use of on-site generation and storage
- Reliability of in-home power, including during grid outages and periods of low on-site generation
- Optimization of reasonable battery storage size balanced with minimized use of grid power (and maximized use of carbon-free electricity)
- Increased safety (reduced risk of shock or causing a house fire)
- Potential savings to home insurance costs by reducing line voltage installation in homes

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.

Lawrence Berkeley National Laboratory (LBNL) analysis of DC power distribution funding that DC systems can be cost-effective when combined with on-site solar and storage (https://buildings.lbl.gov/publications/techno-economic-analysis-dc-power).

LBNL technology and market assessment of DC power distribution in buildings, with a general finding that DC power offers energy savings, potential for lower capital cost, and power quality and reliability improvements (https://energyanalysis.lbl.gov/publications/review-dc-power-distribution).

8. The EPIC 5 Investment Plan must support at least one of five Strategic Goals:[7]

[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

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.

Transportation Electrification

The proposed LVDC concept directly advances transportation electrification (and the state's EV-related mandates) by providing a more efficient and cost-effective platform for EV charging infrastructure.

- **Higher Efficiency**: LVDC-integrated chargers reduce AC/DC conversion steps, improving charging efficiency.
- **Grid-Friendly Charging**: By linking directly with renewable generation and battery storage, this charging approach prioritizes using proximate energy sources and reduces strain on the grid during peak charging periods.
- **Lower Costs**: Simplified wiring and reduced conversion equipment lower installation and operating costs for public and private EV charging networks.
- **Scalable Deployment**: LVDC hubs can support modular EV charging ports, making it easier to scale charging capacity in multifamily housing, workplaces, and public facilities.

Distributed Energy Resource (DER) Integration

LVDC enables seamless integration of distributed renewable and storage technologies.

- **Native Compatibility**: Solar PV panels and batteries operate on DC; LVDC avoids inverter losses, increasing round-trip efficiency.
- **Microgrid Applications**: LVDC supports resilient microgrids for critical home and community loads, ensuring uninterrupted clean power during outages.

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available at: https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M527/K228/527228647.PDF

- **Bidirectional Energy Flow**: Facilitates smoother power exchange among DERs, storage, and the grid.
- **Data-Driven Optimization**: Provides real-time monitoring and load balancing, reducing grid congestion and improving DER utilization.

Building Decarbonization

Low-voltage DC supports building decarbonization by improving efficiency and reducing reliance on fossil-fuel-based energy.

- **Efficiency Gains**: Eliminates multiple conversions, cumulatively saving some 20–30% of building electricity use.
- **Reduced Embodied Carbon**: LVDC systems require up to 30% less copper wiring, lowering the carbon footprint of building infrastructure.
- **Support for All-Electric Buildings**: Enables efficient operation of electrified HVAC, lighting, appliances, and EV charging.
- **Affordable Pathway**: Lower installation and operating costs make decarbonization more accessible for both new and retrofit projects.

Achieving 100 Percent Net-Zero Carbon Emissions and the Coordinated Role of Gas

LVDC helps California advance toward a carbon-neutral future by reducing emissions and supporting the electrification of end uses traditionally reliant on gas.

- **Direct Renewable Utilization**: Increases the usable fraction of renewable generation, accelerating the displacement of fossil-based electricity.
- **Reduced Grid Losses**: Higher efficiency reduces total demand, enabling more clean energy to serve end loads.
- **Facilitates Electrification of Gas Loads**: By lowering costs and improving efficiency, LVDC makes it easier to replace gas-fired heating, cooking, and water systems with electric alternatives.
- **Grid Synergy**: LVDC microgrids reduce the need for dirty, gas-fired peaker plants by cutting peak demand and supporting distributed storage.

Climate Adaptation

LVDC strengthens community resilience and adapts infrastructure for climate challenges.

- **Resilient Microgrids**: Supports islandable microgrids for critical facilities (e.g., hospitals, emergency shelters, schools), ensuring power during climate-related outages.

- **Heat and Fire Risk Reduction**: Operating at safe-to-touch voltages (<60 VDC) lowers electrical fire risks, reducing hazards during extreme heat and wildfire events.
- **Reduced Infrastructure Vulnerability**: Smaller wiring requirements reduce strain on material supply chains during climate-related disruptions.
- **Equity in Resilience**: Lower costs make resilient LVDC systems more accessible for disadvantaged and high-risk communities disproportionately affected by climate change.

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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