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Integrated MEP Pod

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

The footprint of mechanical, electrical, and plumbing (MEP) equipment in any structure has a strong correlation with the cost and time of installation, ongoing maintenance, and resource use. Compacting the MEP footprint in homes by combining high-efficiency MEP functions in a consolidated "pod" can therefore have a significant effect on reducing the cost of labor and materials while also maximizing the livable area inside a home and providing other user and system benefits. As part of this, the pod format lends itself to repeatable prefabrication in a rational "industrialized construction" process that allows for more effective use of labor and an advantageous manufacturing learning curve. This can help address the challenge of stagnant or declining construction industry productivity (see for example: https://www.autodesk.com/campaigns/industrialized-construction-whitepaper) and support a lower cost of efficiency in new and existing buildings.

Basic Concept

The proposed concept focuses on developing **Integrated Mechanical, MEP Pods** as modular, prefabricated assemblies that combine advanced building systems into factory-built units that can meet the needs of homes placed in any orientation across California's climate zones. Each pod integrates:

- HVAC components (including energy recovery and demand-controlled ventilation)
- Electrical distribution, incorporating smart load management, which could enable virtual power plant (VPP) capabilities, and potentially low-voltage DC (LVDC) power)
- Major plumbing elements (including water heating)
- Building automation controls

Applications and Overview of Benefits

While MEP Pods are ideally suited for factory-built housing, they can be used as building components in all traditional construction, similar to how bathroom and kitchen pods are used. Additionally, variations of this approach can be used for retrofitting existing homes, solving for constraints around cost, time, and space, and occupant disruption (see for example: https://www.energy.ca.gov/sites/default/files/2025-06/CEC-500-2025-029.pdf and https://rmi.org/multifunction-mechanical-systems/).

Whatever the application, by leveraging uniform designs and factory-controlled processes, these pods benefit from high quality and consistency, supporting better system reliability and energy efficiency, as well as more work being performed in a higher-productivity environment. Their packaged configuration and standardized interface layouts reduce installation complexity and time in any environment—for example, with plug-and-play connections that minimize labor, coordination challenges, and construction waste—as well as simplifying future maintenance and upgrades. All of this amounts to lower-cost, more attainable high-efficiency building systems.

Additionally, integration of equipment can allow for salvaging waste heat to generate domestic hot water (DHW) more efficiently and for reduced material needs (e.g., copper for wires and plumbing) supporting a lower embodied carbon footprint. The potential integration of LVDC within the pods could also reduce energy losses (by eliminating multiple AC/DC conversions), save material costs, and lower embodied carbon via optimized material use, as well as supporting renewable and flexible energy sources and the possibility of safer and simpler power distribution to various lighting, appliance, and small electronics loads. In multifamily buildings, Integrated MEP Pods can be “unitized” for individual apartments in a multifamily building, helping reduce energy losses and extensive connections, distribution, and circulation.

Importantly, the replicability inherent in this consistent, “productized” concept means its benefits are more likely to be realized at scale, since its deployment can essentially be commoditized.

Funding Need

EPIC funding will support timely R&D to refine baseline pod designs, evaluate possible enhancements (e.g., LVDC integration), conduct pilot projects across building types (commercial, multifamily, and community facilities), and generate critical data on performance, lifecycle costs, and scalability. The project will also develop standards and best practices to drive market adoption and inform regulatory frameworks, strengthening the potential contribution of modular MEP pods to California’s energy efficiency, decarbonization, and electrification goals—and to lower energy burdens and housing costs for Californians.

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)?

Summary

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[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.

The Integrated MEP Pods concept dramatically streamlines building system installation by combining HVAC, electrical, major plumbing elements (including water heating), and controls into standardized, easy-to-connect factory-built modules. This replicable, modular approach tackles major barriers like high labor costs, designer inexperience, owner/developer decision inertia, fragmented trades and on-site construction, long installation times, energy inefficiencies (from lower-performance components, multiple power conversions, and unrecovered heat), and inconsistent quality.

Key Technical and Market Barriers Addressed

- Installation and retrofitting of MEP equipment is generally time consuming and expensive. More broadly, the conventional construction industry as a whole has experienced flat or declining productivity for
- High-efficiency and all-electric HVAC/DHW especially suffers from slow and costly installations, exacerbated by lack of familiarity and availability. Disadvantaged and Tribal communities may be particularly subject to this due to having less choice in equipment and installation providers.
- HVAC/DHW equipment installed in new and existing homes is often not as efficient as it could be, and selection of gas equipment is still widespread, partly due to legacy habits on the part of designers and contractors and decision inertia on the part of owners/developers. This results in needless energy waste (with corresponding higher utility spend) and emissions.
- Conventional HVAC systems commonly suffer from deficient performance due to inconsistencies in installation and commissioning.
- Lack of coordination of mechanical, electrical, and plumbing components, and fragmentation of the trades that install, service, and upgrade these, result in inefficient use of space by these systems, affecting usable area in homes, and commonly precludes beneficial heat recovery between systems.
- Unsystematic conventional approaches may also result in sub-optimal protection of property and safety because the physical relationship among different systems and spaces are not always proactively considered. (With alternative integrated approaches, however, there are important safety considerations around colocation of electrical and wet systems, which must be taken into account and designed for).

Key Innovation Strategies

- Modular, plug-and-play design enabling rapid, cost-effective deployment of highly efficient systems. Simplicity and replicability support scaling. Concentrating a greater proportion of work “upstream” at the factory can

mitigate the bottleneck of insufficient local contractor capacity, particularly in lesser-served communities, increasing equitable access.
- Potential for heat recovery between system components (especially of waste heat from air conditioning for DHW).
- Integration of low-voltage DC power reduces energy losses and supports renewable energy.
- Embedded sensors and controls allow real-time monitoring,optimization, and grid interaction (including potential virtual power plant [VPP] capabilities).
- Methodical, optimized, and tested designs for colocation of electrical, potentially combustible, and wet system elements, with passive and active protections (e.g., fire-blocking layers, dry chemical fire suppression).
- Complementary design of related elements, such as floor-cassette-integrated ductwork and close proximity of laundry and/or other fixtures, further improve productivity, material use, and space efficiency.

Cost and Performance Targets

- Reduce installation costs by **20–30%**.
- Achieve **8–12% energy savings** at the building level.
- Deliver payback periods under **5 years**.
- Cut embodied carbon by **up to 30%** through material optimization.

Data and Information Gaps Filled Through Further Research

- Real-world lifecycle performance and cost data of modular MEP systems.
- Reliability and quality comparisons to traditional methods.
- User acceptance and operational insights.
- Impact on renewable integration and grid interaction.

Beneficiaries

- Building owners and developers (lower cost, faster build).
- Contractors (simplified installation).
- Utilities and regulators (better efficiency and grid integration, policy support).
- Disadvantaged and Tribal communities (easier and more affordable access to clean energy tech).

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 Integrated MEP Pods research will deliver meaningful cost savings, performance improvements, and increased adoption of clean energy solutions in single-family and multifamily residences, aligning with EPIC principles and helping meet the state climate and energy goals, including California's goal of climate neutrality by 2045.

1. Cost Reductions

- **Installation Savings:** Modular MEP pods can reduce installation costs by 20–30%. For a typical 2,000 sq. ft. home, this may translate to **$8,000 to $12,000 saved** compared to conventional on-site construction.
- **Energy Savings:** Integrated systems and low-voltage DC power can reduce home energy use by some 30%. For an average household with annual electricity costs around $1,500, this means savings of **$120 to $180 per year**.
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2. Performance Enhancements

[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.

- **Reliability:** Factory-controlled quality reduces installation errors and potential callbacks, improving home system reliability and lowering maintenance costs.
- **Consistent Efficiency:** Standardized, validated designs employing high-efficiency components “bake in” higher performance, removing project-by-project guesswork and decision-making pitfalls.
- **Renewable Integration:** Enhanced efficiency through LVDC integration can increase effective use of rooftop solar and home battery systems by 10–15%, reducing grid reliance and carbon footprint.

3. Potential at Scale

- Scaled deployment in California’s residential sector could save **tens of gigawatt-hours annually**, equivalent to powering thousands of homes entirely.
- Widespread use of integrated systems with grid interactive controls could represent a **substantial VPP resource**, contributing to grid flexibility and resilience.
- Material savings, especially reduced copper wiring, could lower embodied carbon in housing stock by up to 30%, contributing significantly to state climate goals.

4. Alignment with EPIC Principles

- **Safety:** Standardized, validated designs holistically incorporate considerations around fire risk, leaks, proximity of electrical and wet elements, etc. The potential use of LVDC systems would reduce electrical shock risks and fire hazards, improving occupant safety.
- **Reliability:** Fewer field installation errors and embedded monitoring improve system uptime and homeowner satisfaction.
- **Affordability:** Lower installation and energy costs increase access to advanced energy technologies for middle- and lower-income households.
- **Environmental Sustainability:** Reduced energy use and materials lower greenhouse gas emissions (operational and embodied) and other environmental impacts.
- **Equity:** Faster, cost-effective deployment benefits disadvantaged communities (including lower-income and Tribal communities) by improving access to clean energy and resilient home systems.

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

Metrics & Indicators for Integrated MEP Pods			
Indicator	Metric	Target	Data Source / Method
Cost Savings	Reduction in installation costs vs. conventional MEP	20–30% reduction	Project cost analysis; contractor reports
	Annual homeowner energy cost savings	8–12% reduction	Utility bills; modeled energy performance
Energy Performance	Reduction in total household energy consumption (kWh/year)	≥10% reduction	Metered energy data; energy modeling
	Efficiency of HVAC, plumbing, and electrical systems	Higher than baseline by 8–12%	Commissioning reports; third-party verification
Reliability	Reduction in call-backs or failures	≥25% fewer incidents	Contractor service logs; warranty claims
	Average downtime for critical systems	≥15% improvement	Homeowner surveys; maintenance logs
Safety	On-site safety incidents during installation	≥30% reduction	Contractor safety records
	Post-installation safety or equipment failures	Near zero incidents	Homeowner feedback; inspector reports
Environmental Impact	Reduction in embodied carbon from optimized materials	Up to 30% reduction	LCA (Life Cycle Assessment) studies
	Annual greenhouse gas emissions avoided (CO_2e)	Based on ≥10% energy savings	Energy modeling; emissions factors

Equity & Accessibility	Percentage of deployments in affordable/disadvantaged housing and Tribal areas	≥25% of pilot projects	Deployment tracking; demographic data
	Cost savings as % of median household income	≥5% reduction in energy burden	Household energy burden analysis
Productivity	Installation Time Reduction	>=50% reduction in installation time	Contractor reports and Homeowner surveys
Grid Services	Ability to load shift	>=80% responsiveness to load shifting/demand reduction signals	Building controls data

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.

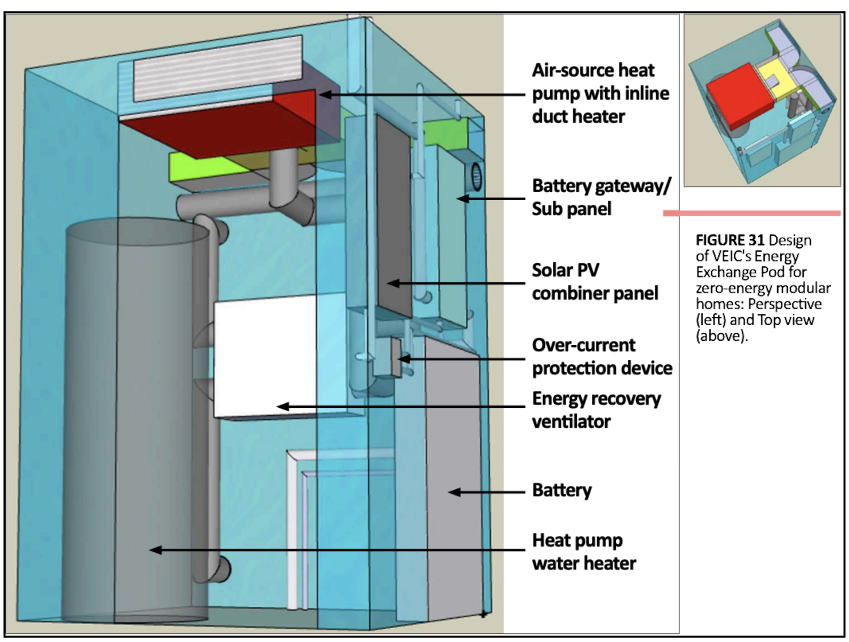
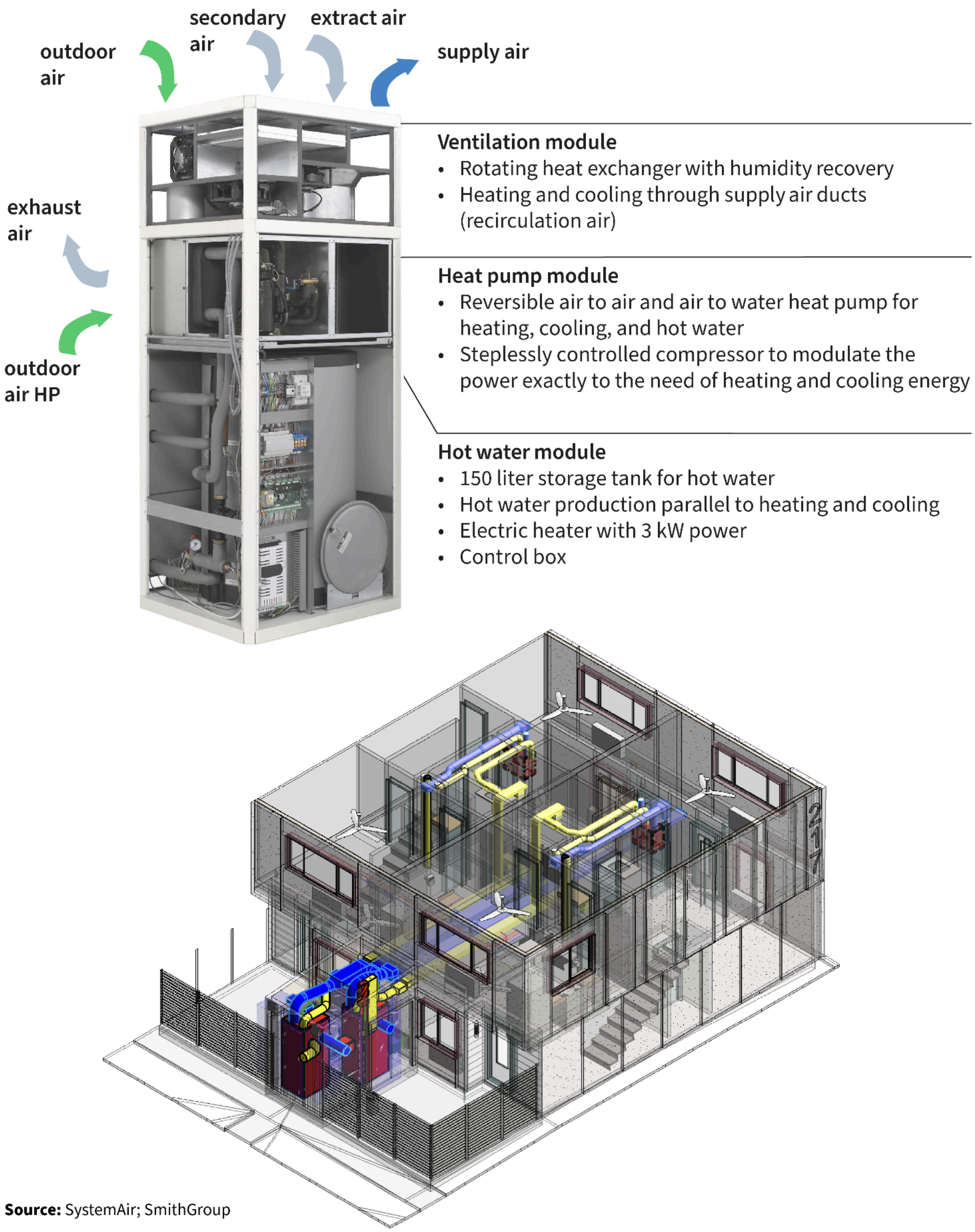


FIGURE 31 Design of VEIC's Energy Exchange Pod for zero-energy modular homes: Perspective (left) and Top view (above).

Some of the seminal work on integrated MEP Pods was done by the **National Renewable Energy Laboratory (NREL)**. However, market barriers and engineering roadblocks caused this work to stall before substantial commercial deployment in US housing.



Source: SystemAir; SmithGroup

RD&D on mechanical pods for retrofit applications has been carried out previously with CEC funding, for example the “Low-GWP Mechanical Modules for

Rapid Deployment” project conducted by **Association for Energy Affordability (AEA), Lawrence Berkeley National Laboratory (LBNL), the Smith Group, RMI, and Emanant Systems** (https://www.energy.ca.gov/sites/default/files/2025-06/CEC-500-2025-029.pdf), which found that combined mechanical systems show promise as one solution to help meet California’s energy and climate goals.

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
    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.

Integrated MEP Pods: Alignment with EPIC 5 Strategic Goals		
EPIC 5 Strategic Goal	**How Integrated MEP Pods Support**	**Quantified / Qualitative Impacts**
Transportation Electrification	Pre-wired EV-ready infrastructure built into pods for garages and multifamily parking. Integrated load management for charging.	20–30% lower EV charger installation cost.
		EV-ready homes at move-in, accelerating adoption.
		Reduced peak load impacts through smart charging.
Distributed Energy Resource	Pods designed for plug-and-play interconnection with	25–40% lower cost of DER integration.

[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

(DER) Integration	rooftop solar, batteries, and smart panels.	Faster interconnection approvals.
		Increased adoption in single-family and multifamily homes.
Building Decarbonization	All-electric HVAC, water heating, and appliances pre-integrated in pods. Optimized ducting, plumbing, and electrical systems.	8–12% annual household energy savings.
		Up to 30% reduction in embodied carbon.
		Accelerated electrification in new builds and retrofits.
Achieving 100% Net-Zero Carbon Emissions & Coordinated Role of Gas	Pods eliminate the need for new gas infrastructure, enabling fully electrified housing stock.	Supports California's 2045 clean energy mandate.
		Reduces reliance on gas pipelines.
		Scalable retrofit solution for older housing.
Climate Adaptation	Factory-built pods designed for rapid deployment in climate-impacted communities. Safer systems reduce fire and heat risks.	Rapid recovery after wildfires, floods, and heatwaves.
		30% fewer installation-related safety incidents.
		Affordable resilience solutions for disadvantaged communities.

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

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