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CALIFORNIA NATURAL RESOURCES AGENCY

California Energy Commission

COMMISSION DRAFT REPORT

Electric Program Investment Charge

2024 Annual Report

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PREFACE

The California Energy Commission's (CEC) Energy Research and Development Division (ERDD) supports energy research and development programs to spur innovation in energy efficiency, load flexibility, renewable energy and advanced clean generation, transportation, grid transmission and distribution, and energy-related environmental protection.

In 2011, the California Public Utilities Commission (CPUC) established the Electric Program Investment Charge (EPIC) to fund public investments in research that create and advance new energy solutions, foster regional innovation, and bring ideas from the laboratory to the marketplace. The CPUC initially authorized the program through 2020 and selected the CEC and the state's three largest electric investor-owned utilities (IOUs) — Pacific Gas and Electric Company, San Diego Gas & Electric, and Southern California Edison — to administer EPIC funds. EPIC is funded by a ratepayer surcharge from customers of these IOUs, and its investments deliver benefits back to ratepayers.

In 2020, the CPUC renewed the EPIC Program for an additional ten years, through 2030, and approved the CEC to continue as an EPIC program administrator. In 2021, the CPUC extended the role of the IOUs as administrators of the EPIC Program until 2025. Moreover, CPUC Decision 21-11-028 established a mission statement that EPIC investments provide "equitable access to safe, affordable, reliable, and environmentally sustainable energy for electricity ratepayers." Decision 21-11-028 revised the guiding principles to ensure ratepayer benefits of improved safety, increased reliability, increased affordability, improved environmental sustainability, and improved equity. Additionally, the CPUC established several administrative requirements to increase transparency and better align future EPIC investments with its Environmental Social Justice and Distributed Energy Resources action plans, as well as the federal Justice40 Initiative.

ERDD is responsible for executing the EPIC Program at the CEC. For more information about ERDD's work on the EPIC Program, please visit the CEC's website at https://www.energy.ca.gov/programs-and-topics/programs/electric-program-investment-charge-epic-program.

ABSTRACT

The Electric Program Investment Charge (EPIC) Program is California's premier electricity sector research and development program. EPIC drives innovation and advances science and technology in energy efficiency, load flexibility, renewable energy and advanced clean generation, transportation, grid transmission and distribution, and energy-related environmental protection, among other areas important to California's electricity system. EPIC is funded by a ratepayer surcharge from the state's electric investor-owned utilities, and the investments of EPIC deliver benefits back to ratepayers.

EPIC is overseen by the California Public Utilities Commission (CPUC) and administered separately by the California Energy Commission (CEC) and electric investor-owned utilities. CEC-administered EPIC investments support applied research and development, clean energy demonstration and deployment projects, and market facilitation activities that benefit electricity ratepayers and lead to technological advancements that, in turn, can overcome key barriers to the state's statutory energy goals.

This report summarizes the progress and status of EPIC-funded CEC activities from January 1, 2024, through December 31, 2024. The report was prepared in accordance with applicable CPUC decisions and California Public Resources Code Section 25711.5.

Keywords: Advanced generation, affordability, agriculture, bioenergy, buildings, California Energy Commission, California Public Utilities Commission, clean energy economy, climate change, decarbonization, demand response, disadvantaged community, distributed energy resources, distributed generation, Electric Program Investment Charge, electric vehicles, electricity, electrification, energy efficiency, energy equity, energy policy, energy research, energy storage, entrepreneurial ecosystem, environmental, floating offshore wind, geothermal, greenhouse gas, heat pumps, industrial, jobs, low-income community, ratepayer benefits, renewable energy, resilience, safety, solar, public engagement, transmission, transportation, U.S. Department of Energy, water

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Program Overview

Through the Electric Program Investment Charge (EPIC) Program, the California Energy Commission (CEC) funds innovation to advance an affordable, clean, safe, and reliable electricity system that benefits California ratepayers. EPIC was established in 2011 and, as of December 31, 2024, has invested $1.4 billion across 543 public research and development projects. Collectively, private companies that have received EPIC funding have gone on to attract more than $18.9 billion in additional private funding — a greater than 13-fold amplification that demonstrates EPIC's success in launching innovative clean energy technologies.

Key Results

Notable program impacts through 2024 include:

- $1.4 billion invested across 543 public research and development projects since program inception in 2011.
- Private companies that have received EPIC funding collectively attracted more than $18.9 billion in additional private funding through 2024.
- Grant recipients completed 45 EPIC projects in 2024.
- 60 percent of CEC EPIC technology demonstration and deployment funding has been awarded to projects located in and benefiting disadvantaged and low-income communities through 2024.
- $30.4 million of CEC EPIC technology demonstration and deployment funds have been invested on California Native American tribal lands through 2024.

Additionally, grant recipients from more than 200 EPIC projects that were either active or completed during the 2024 calendar year reported the following impacts:

- A collective total of 2.1 gigawatt-hours of electricity consumption avoided by projects in 2024, as reported by 20 respondents.
- More than 1,000 full-time-equivalent jobs collectively enabled by EPIC funding during 2024, as reported by 156 respondents.
- More than 3,500 metric tons of carbon dioxide equivalent emissions collectively avoided in California by projects in 2024, as reported by 25 respondents.

Key Successes and Highlights at a Portfolio Level

The program portfolio is advancing a more affordable, clean, resilient, and nimble electricity system integrating critical new renewable energy resources and flexible loads, while also contending with more severe climate events. For instance, grid energy storage in the state has more than doubled from 6.6 gigawatts in 2023 to 13.4 gigawatts in 2024. In support of this

buildout, EPIC demonstration projects, sited in investor-owned utility service territories, have validated novel technologies and approaches, such as advanced microgrid controls and second-life battery repurposing, to support a modernized, cleaner, and more affordable electricity system.

The program also supports companies and innovations that optimize the electric vehicle charging infrastructure buildout, user experience, affordability, and potential value for more than 1 million fully electric vehicles on California's roads. Notably, several EPIC projects in the past year have started demonstrating cost-effective deployment of charging infrastructure for medium- and heavy-duty electric trucks and buses, including in California cities such as Bakersfield and Riverside that historically have supported transportation corridors with significant tailpipe emissions. Such EPIC investments are developing solutions to reduce the disproportionate burden of these transportation emissions on the communities surrounding the transportation corridors. Moreover, grid-supportive transportation projects, such as the WattEV electric truck depot project in Bakersfield, feature onsite solar and storage and can reduce the need for grid upgrades.

EPIC load flexibility research aims to maximize the benefits of energy storage that electric vehicle batteries, homes, and utility-scale power plants can offer. Energy storage has diverse use cases that can support community benefits like energy accessibility, resilience, and independence; energy affordability; and energy decarbonization. To enhance the deployment of energy storage, EPIC-funded research and demonstration projects test both whole-system and component solutions, such as communication and control technologies. Load flexibility projects also evaluate the benefits of aggregating energy storage applications to leverage economies of scale, efficiencies, cost savings, and use-case interactions in support of California's electricity grid and its ratepayers.

One key effort established in part by EPIC funds is the California Load Flexibility Research and Development Hub, or CalFlexHub, led by Lawrence Berkeley National Laboratory. This initiative supports the adoption of affordable and reliable load-flexible technologies. CalFlexHub has made progress in evaluating and promoting price-responsive, flexible load end-use technologies for utility customers and the grid. Demonstrated technologies include heat pump water heaters, smart thermostats, and electric vehicle charging stations, among others, with field tests at more than 100 sites, of which about half are in a disadvantaged or low-income community. Results generated from this work improve the affordability of clean energy technologies and distributed energy resources by increasing awareness of optimal times and ways to dispatch energy to the grid for cost savings, energy efficiency, and other benefits. Ongoing research may provide a solution for homes with limited electric panel capacity, enabling more affordable and widespread electrification retrofits to occur.

EPIC provides grant funding to accelerate electrification and improve energy efficiency in the industrial and buildings sectors. The CEC released two solicitations in 2024 and invested more than $50 million in 11 projects to demonstrate technologies addressing several key industrial sector challenges, including thermal energy storage, commercial cold storage and refrigeration, and advanced materials separation, such as using polymeric membranes for water purification. The potential for ratepayer benefits from significant cost, energy, and peak

load savings from these projects is promising. Artificial intelligence controls in industrial refrigeration systems, for example, could greatly reduce site peak energy use and energy costs. Field tests from these solicitations will familiarize industrial sector end users with emerging decarbonization technologies and their benefits, promoting future deployments.

To advance building decarbonization, EPIC continues to fund a wide array of efforts to make electrification more affordable and accessible and to inform policies, planning, codes, and standards. In support of the state's goal of installing 6 million heat pumps by 2030, the portfolio includes demonstration and deployment projects in disadvantaged and low-income communities where advanced electric appliances are installed onsite and assessed for performance and cost. Other demonstration projects are testing more efficient electric devices or retrofit strategies that directly reduce energy consumption, thereby improving comfort and affordability for occupants while decreasing strain on and emissions from the grid. Additional projects are introducing new tools into the field to make it easier to check the performance of buildings, find electrification solutions, and manage permits and purchases. These tools help customers electrify their homes and businesses more quickly and effectively.

In 2024, previously funded EPIC recipients built upon their momentum with private capital and federal funding. Previously funded companies and projects progressed to achieve technology validation, at-scale deployment, early-stage manufacturing, and product commercialization. Other grant recipients, with projects collectively spanning various stages of technology readiness, secured their first rounds of investment and production contracts. Innovative EPIC-funded companies received support at critical stages of product development and later raised scale-up funds to expand research and manufacturing. The significant amounts of follow-on and match funding that the program leverages amplify the impacts of EPIC clean energy research and deployment programs, greatly enhancing the state's ability to achieve climate and energy goals, deliver ratepayer benefits, and serve as a leader in advancing the clean energy transition across the United States.

EPIC enables and accelerates this transition by investing in technologies that can lower production costs, expand equitable access to clean energy resources and benefits, improve grid planning and operations, and significantly decrease greenhouse gas emissions with novel approaches.

EPIC funding enabled the program to make significant progress in 2024 toward achieving previous and current investment plans' strategic objectives and initiatives. The majority of active projects in the portfolio are funded from the EPIC 3, Interim, and EPIC 4 investment plans. *The EPIC 4 Investment Plan*, approved by the California Public Utilities Commission (CPUC) in April 2022, codifies program guidelines until 2025. Staff also engaged with the CPUC and its Policy + Innovation Coordination Group to help guide the development of strategic goals and initiatives for the next investment plan that will establish a program investment framework for 2026 to 2030.

This annual report highlights progress toward the most recent *EPIC 4 Investment Plan* strategic objectives and initiatives.

Challenges and Impediments at a Portfolio Level

Project teams and companies across EPIC's expansive research and deployment portfolio cited several common challenges. The rising cost of electricity relative to fossil gas has made fuel-switching projects more financially challenging, particularly in the building and industrial sectors, while also underscoring the importance of demonstrating emerging, cost-effective approaches to electrification and decarbonization. Furthermore, long interconnection queues and permitting challenges consistently delay project timelines, thereby increasing costs. Field projects also broadly continue to report supply chain issues, prolonging the construction and installation of devices such as electric vehicle chargers and electric heat pumps. Some EPIC-funded companies commercializing energy storage systems and bidirectional electric vehicle charging infrastructure have encountered difficulties obtaining Underwriters Laboratories certifications. These difficulties primarily stem from a lack of familiarity with emerging technologies by certification bodies, which can hinder obtaining fire permits needed for site installation. Similarly, some building decarbonization projects have struggled to obtain approval to utilize refrigerants that offer greenhouse gas emissions savings but are less commonly used. Other general challenges include inflation and rising costs, difficulty hiring staff and contractors versed in the new technology, and challenges in securing and retaining host sites for field testing and demonstrations. Multiple project teams demonstrating load flexibility and vehicle-to-building technologies, such as electric vehicles that supply power to a home during a power outage, cited submetering challenges, certification difficulties, and the lack of robust regulations and industrywide standards as routine causes for project delays.

Advancing Energy Equity

Energy equity, the fair distribution of the costs and benefits of energy use and climate change responses across all segments of society, is essential to a just and fair clean energy transition. It is a focus of the CEC's EPIC Program to expand opportunities for participation from disadvantaged and low-income communities, tribes, and rural communities in developing the state's clean energy economy. In addition to program development, project investment and benefits must reach California's priority populations. Through 2024, 60 percent of CEC EPIC technology demonstration and deployment funds were invested in projects with demonstration sites in low-income communities or disadvantaged communities, as defined by Assembly Bill 523 (Reyes, Chapter 551, Statutes of 2017). This total excludes projects involving combustion. Also through 2024, $30.4 million of technology development and demonstration funds were invested in projects on California Native American tribal lands.

Status of EPIC

In Decision 20-08-042, the CPUC renewed EPIC for 10 years, through 2030, and authorized the CEC to continue as an EPIC administrator with an annual budget of $147.26 million for the first five years of this period. The CPUC approved on July 21, 2021, the CEC's *Interim EPIC 4 Investment Plan* covering the first year of EPIC 4 funding. A year later, the CPUC approved the *EPIC 4 Investment Plan* covering 2022 to 2025.

In 2023, the CPUC began the initial scoping of the *EPIC 5 Investment Plan* by developing strategic goals that form the basis for the strategic objectives in CEC and IOU administrator EPIC 5 investment plans. In March 2024, the CPUC approved Decision 24-03-007, which adopted the following five strategic goals for EPIC 5:

1. Transportation Electrification
2. Distributed Energy Resources Integration
3. Building Decarbonization
4. Achieving 100 Percent Net-Zero Carbon and the Coordinated Role of Gas
5. Climate Adaptation

CPUC staff's proposed strategic objectives for EPIC 5 were released in March of 2025, and after considering comments from parties, the CPUC will adopt final strategic objectives.

CHAPTER 1:
Introduction and Overview

Background on EPIC

In 2011, the California Public Utilities Commission (CPUC) established the Electric Program Investment Charge (EPIC) Program and authorized the California Energy Commission (CEC) as one of four administrators alongside California's three largest investor-owned electric utilities (IOUs) — Pacific Gas & Electric Company (PG&E), San Diego Gas & Electric, and Southern California Edison (SCE). The EPIC Program is funded by California electric investor-owned utility customers under the auspices of the CPUC. The CEC administers 80 percent of the total program funds, investing in clean energy technologies and approaches to provide benefits from and "equitable access to safe, affordable, reliable, and environmentally sustainable energy for electricity ratepayers."[1] The CEC funds projects in all three investment areas of EPIC: applied research and development (AR&D), technology demonstration and deployment (TD&D), and market facilitation.

Using a competitive selection process, the CEC awards EPIC funding to advance technological breakthroughs and accelerate the achievement of the state's statutory energy goals in an affordable and equitable manner. These goals include reducing greenhouse gas (GHG) emissions, improving affordability, adapting to climate change, improving energy efficiency and load flexibility, advancing renewable energy, supporting low-emission transportation, and expanding economic development.

The CPUC oversees the administration of EPIC funds, including approval of the CEC's EPIC Investment Plans that outline proposed project concepts in a given investment period. Investment plans are shaped by CPUC decisions voted on by the five CPUC Commissioners. In 2021, the CPUC issued Decision 21-11-028, adopting the EPIC Mission Statement and streamlining EPIC's Mandatory Guiding Principles to provide greater focus to the program and improve transparency. The five streamlined principles for the EPIC are to improve safety, increase reliability, increase affordability, improve environmental sustainability, and improve equity.[2]

The state Legislature must grant the CEC spending authority to disburse EPIC funds for project awards and to use EPIC funds for administrative expenses. State law requires the CEC's EPIC projects not only to benefit electricity ratepayers and help achieve California's statutory clean energy goals, but also to reduce the costs of building electrification and strategically focus investments on overcoming significant technological challenges.[3]

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1 California Public Utilities Commission. 2021. Decision Approving the Utilities as Electric Program Investment Charge Administrators with Additional Administrative Requirements, Appendix A, https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M425/K515/425515575.PDF.

2 Ibid.

3 California Public Resources Code, Section 25711.5. https://leginfo.legislature.ca.gov/faces/codes_displayText.xhtml?lawCode=PRC&division=15.&title=&part=&chapter=8.1.&article=.

This *Electric Program Investment Charge 2024 Annual Report (2024 EPIC Annual Report)* is provided to the CPUC in accordance with CPUC decisions to date. To ensure consistent reporting among all four administrators, those decisions specify the outline and contents of this report, including project reporting requirements. The CEC also provides the *2024 EPIC Annual Report* to the Legislature, as required by California Public Resources Code Section 25711.5, and makes the report publicly available on the CEC website (https://www.energy.ca.gov).

EPIC Program Components

The CEC has awarded 543 EPIC projects to date, spanning 13 years and five EPIC investment plans. Detailed information on these projects (cumulative through December 31, 2024) and their status (active, completed, terminated ([with funds spent], or pending final approval) can be found in Appendix C. Chapters 2 and 3 provide details on CEC's EPIC coordination activities and budget, respectively. Chapter 4 describes how the CEC project portfolio is driving progress, achieving project and program goals, and addressing barriers across current EPIC strategic objectives and initiatives.

Tracking Benefits

The CEC continually collects information on quantifiable project outcomes to assess their real-world impact. Grant recipients are required to complete agreement-specific documentation of technical development throughout the project duration through progress and final reports. Additionally, the CEC deploys two main tools to regularly gather information for agreements funded under EPIC: annual surveys and benefits questionnaires.

Annual surveys: Each EPIC recipient completes an annual survey to capture information for inclusion in the EPIC annual report. The survey includes fields for the following items:

- Determination of whether projects advanced safety, reliability, affordability, environmental sustainability, or equity
- Technology deployments in California beyond those funded by EPIC, including those in disadvantaged and low-income communities, and on California Native American tribal lands.[4] Recipients also report on the funding source for these additional deployments.
- Attendance at community engagement events, as well as language services provided, and whether events were held in disadvantaged or low-income communities
- Recipient type and organization or company size
- Job creation and trade apprentice involvement
- Reduced electricity consumption
- Energy storage and load shifting capacity
- On-bill savings

4 Tribal lands refer to lands located in the State of California that are tribally owned lands, buildings, or facilities, lands a tribe exercises jurisdiction over, or lands that the Bureau of Indian Affairs holds in trust for tribes, individual allottees, or public domain allottees, or lands managed through conservation easements, lease agreements, or co-management agreements, for the benefit of tribes.

- Avoided GHG emissions.

EPIC annual surveys are continuously refined based on feedback and new guidance. Staff will continue to monitor the development of additional CPUC equity metrics. Further development will facilitate and improve CEC's ongoing incorporation of equity into all aspects of EPIC administration.

Benefits questionnaires: Recipients for every new EPIC agreement are required to complete an initial benefits questionnaire before beginning work to estimate a project's expected impact. Upon project conclusion, recipients complete a final benefits questionnaire to confirm whether the estimates were realized. The questionnaires capture metrics including the following:

- Jobs funded by the project (including those anticipated to persist beyond the duration of the agreement)
- Electricity consumption reduction
- Peak load reduction
- Fuel consumption reduction
- Energy generation

Tables 1 and 2 summarize quantifiable impacts and benefits that CEC EPIC-funded projects have achieved. Impacts are grouped into the following overarching categories: technology advancement and commercialization, technology diffusion, knowledge generation and dissemination, and diversity and equity.

Table 1: Quantifiable Benefits of California Energy Commission Electric Program Investment Charge Investments by Impact Category

Impact Category	Quantifiable Benefits
Technology Advancement and Commercialization	• Private companies that have received EPIC funding have collectively attracted more than $18.9 billion in private funding.[5]
Knowledge Generation and Dissemination	• Staff hosted the 10th annual EPIC Symposium in October 2024 to share research findings. Total in-person and online attendance exceeded 800.

5 This number comes from Pitchbook, which tracks the financial information from more than a million companies. However, not all EPIC award recipients are included in their database. Some larger research partners, like the national laboratories and the University of California, are tracked, but individual research centers within these institutions are often not separately identified. As a result, CEC staff only track private companies with Pitchbook, leading to a smaller total for private funding than would be possible if accurate tracking were possible for all EPIC recipients.

Impact Category	Quantifiable Benefits
	• The CEC's Empower Innovation platform[6] surpassed 4,700 members with more than 1,300 organizations and more than 570,000 page views.
Diversity and Equity	• 60 percent of CEC EPIC TD&D funding has been awarded to projects located in and benefiting disadvantaged and low-income communities.[7] • $30.4 million of the CEC's technology demonstration and deployment funds have been invested in projects on California Native American tribal lands.

Source: California Energy Commission staff

As part of EPIC administration, CEC staff surveyed recipients of EPIC-funded agreements either active or closed within the reporting period (2024 calendar year). Table 2 summarizes quantifiable impacts and benefits that CEC EPIC-funded projects have achieved based on survey responses from more than 200 EPIC agreement recipients. Impacts are grouped by Impact Category.

Table 2: Cumulative Quantifiable Benefits of CEC EPIC Investments by Impact Category from the *2024 EPIC Annual Report* Recipient Survey

Impact Category	Quantifiable Benefits
Technology Advancement and Commercialization	• More than $330 million in non-CEC public funding garnered, enabled by EPIC awards. • More than $600,000 in on-bill savings collectively enabled by EPIC projects, as reported by 15 respondents. • 348 commercial and industrial buildings underwent electrification projects, enabled by EPIC funding to 21 respondents.[8] • 2.1 gigawatt-hours of electricity consumption was collectively avoided by EPIC projects in 2024, as reported by 20 respondents. • More than 1,000 full-time-equivalent jobs collectively enabled by EPIC funding, as reported by 156 respondents.

6 Empower Innovation (https://www.empowerinnovation.net/) is an initiative of the CEC, in partnership with leading California technology accelerators, fellowship programs, nonprofits, and private partners. Empower Innovation strives to accelerate your cleantech journey with easy access to funding opportunities, curated resources, and connections to people and organizations working toward a clean economy for all.

7 Calculations of disadvantaged and low-income community funding percentages exclude combustion-related TD&D projects.

8 Respondents are EPIC awardees who responded to the 2024 EPIC Annual Report Survey.

Impact Category	Quantifiable Benefits
	• More than 3,500 metric tons of carbon dioxide equivalent emissions avoided in California by EPIC projects, reported collectively across 25 respondents, which is equivalent to removing approximately 750 light-duty cars from the road. • More than $65 million in revenue generated by EPIC-funded work, as reported by 20 respondents.
Technology Diffusion	• 42 projects advanced tools or technologies that streamline compliance with regulatory codes or standards. • 1,956 deployments of EPIC-funded clean energy technologies or innovations in projects beyond those funded by the CEC, including outside of California, as reported by 19 respondents.
Knowledge Generation and Dissemination	• 241 tools and resources developed or enhanced by EPIC-funded projects. • More than 1,000 community engagement events with more than 18,000 participants in 2024, reported collectively across 73 respondents.
Diversity and Equity	• 59 percent of recipient or subrecipient company respondents have a woman, underrepresented minority, or lesbian, gay, bisexual, transgender, or queer employee in high-ranking executive positions. • 44 percent of respondents were from small or microbusinesses (100 or fewer employees).

Source: California Energy Commission staff

Table 3 shows the match funds that CEC EPIC projects attracted to California.

Table 3: Total Match Funds (Millions)

Match Funding	EPIC Funding Awards	Match as Proportion of EPIC Awards
$727	$1,356	54 percent

Match funds are funds contributed by partners of grant recipients as part of the project award.

Source: California Energy Commission staff

Investing in Disadvantaged and Low-Income Communities

EPIC administrators are required to invest at least 25 percent of their TD&D funding to projects located in and benefiting disadvantaged communities, and an additional 10 percent to

projects located in and benefiting low-income communities.[9] The Legislature originally directed this requirement toward the CEC's EPIC funding in Assembly Bill 523 (Reyes, Chapter 551, Statutes of 2017), which expired in 2023. The CPUC extended those requirements permanently in April 2023 and expanded it to include the IOUs' TD&D investments.[10]

The CEC's EPIC TD&D investments exceed the minimum investment requirements for projects located in and benefiting disadvantaged and low-income communities. Solicitations require project teams to include a reputable community-based organization and allocate an appropriate portion of their budget for outreach and engagement activities relative to the proposed project scope. Through 2024, 35 percent of TD&D project funding was awarded to projects located in and benefiting disadvantaged communities, and an additional 25 percent was awarded to projects located in and benefiting low-income communities. Together, 60 percent[11] of CEC EPIC TD&D funding has been awarded to projects located in and benefiting disadvantaged and low-income communities. Moreover, $30.4 million of TD&D funding was awarded to projects on California Native American tribal lands, an increase of $9 million compared to last year's total.[12]

Figure 1 illustrates the cumulative number of CEC EPIC TD&D project sites through December 31, 2024, in disadvantaged communities, in low-income communities that are not also designated as disadvantaged, and on California Native American tribal lands. This mapping and community assignment approach avoids double-counting in the calculation of disadvantaged and low-income community funding percentages. Most of California's disadvantaged communities are also low-income communities, and those dual-community TD&D sites are counted only once and assigned to the disadvantaged community category only.

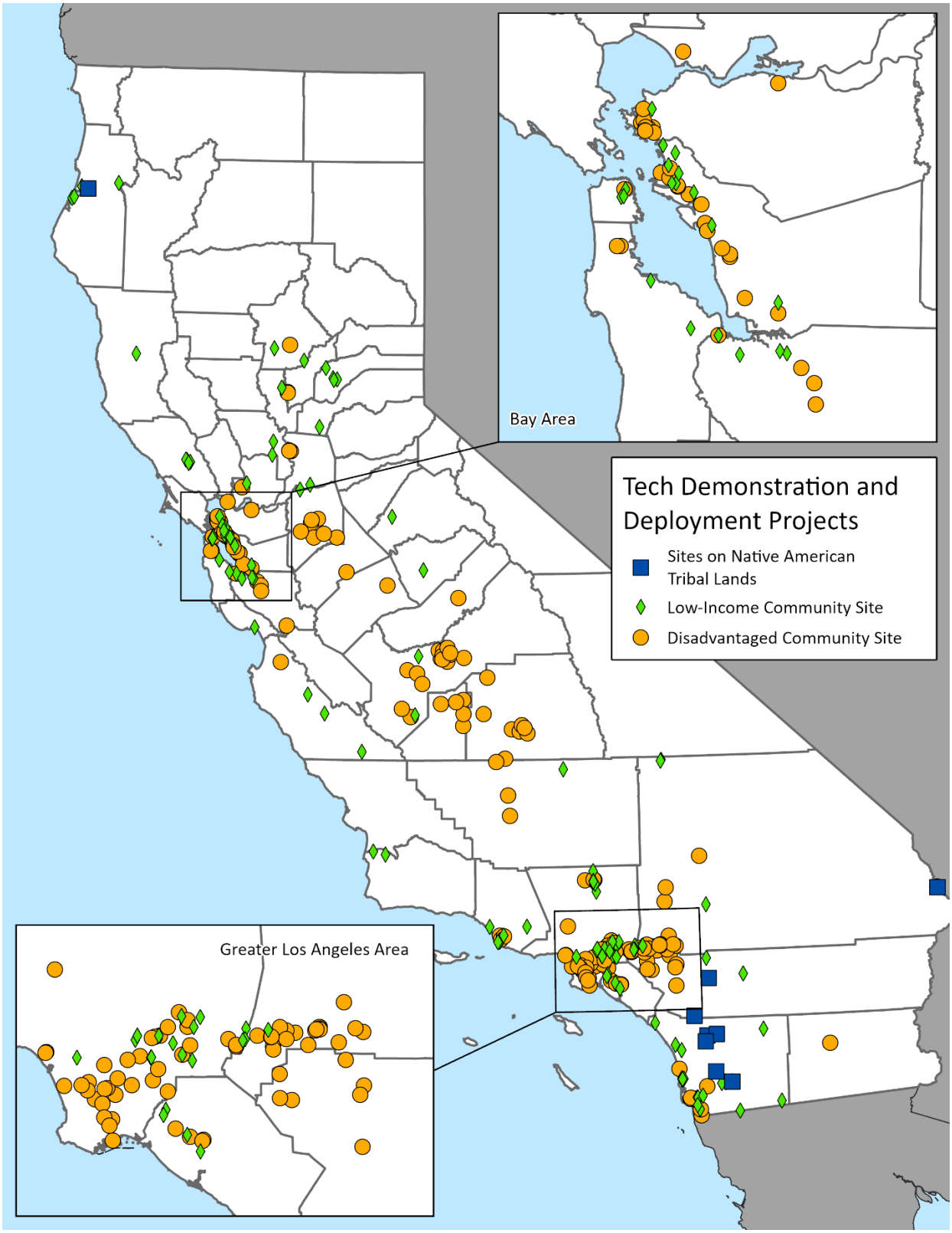
9 Disadvantaged communities are those designated under Health and Safety Code Section 39711 as representing the 25 percent highest-scoring census tracts in California Communities Environmental Health Screening (CalEnviroScreen) Tool 4.0, https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-40. Low-income communities are those within census tracts with median household incomes at or below 80 percent of the statewide median income or the applicable low-income threshold listed in the state income limits updated by the California Department of Housing and Community Development.

10 California Public Utilities Commission. 2023. Decision on Phase 2-C of Electric Program Investment Charge Rulemaking, https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M507/K499/507499284.PDF.

11 These data exclude combustion-related technology demonstration and demonstration projects.

12 "Tribal lands" are lands located in California that are tribally owned lands, buildings, or facilities, lands a tribe exercises jurisdiction over, or lands that the Bureau of Indian Affairs holds in trust for tribes, individual allottees, or public domain allottees, or lands managed through conservation easements or through lease agreement, or through co-management agreements, for the benefit of tribes.

Figure 1: EPIC TD&D Project Sites in Disadvantaged or Low-income Communities or on California Native American Tribal Lands through 2024



Source: California Energy Commission staff

Staff will monitor the development of equity metrics through the CPUC Policy + Innovation Coordination Group (PICG)[13] workshop process for EPIC 5 to continue to improve, in conjunction with other efforts, the CEC's ongoing integration of equity into all aspects of EPIC administration.

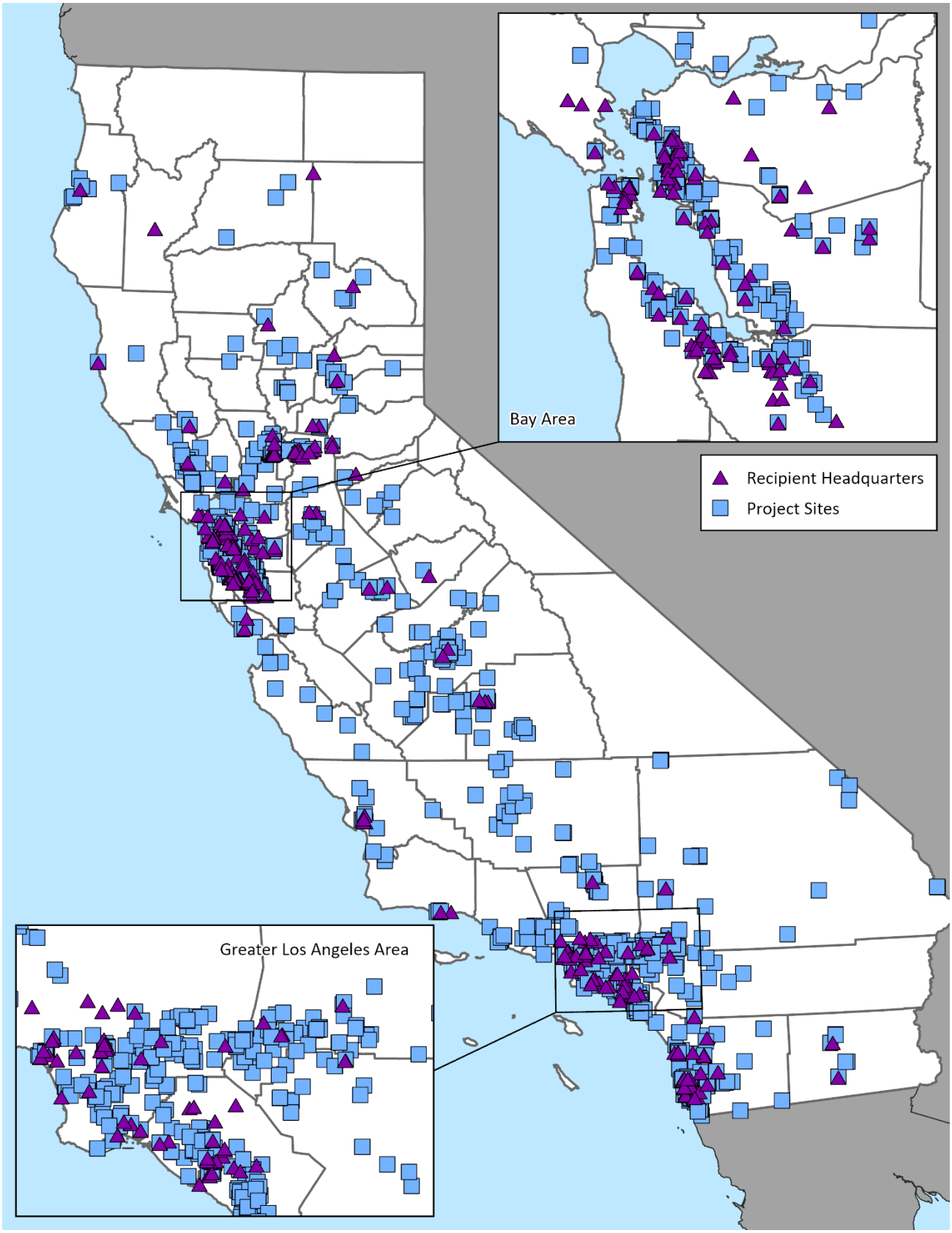
Geographic Diversity to Accelerate Technology Diffusion and Technological Learning

Successful emergence and diffusion of clean energy innovations from laboratory to market involves technological learning and iterative feedback from local installers, workers, early adopters, inspectors, regulators, and communities, among others. Technological learning within EPIC is cultivated primarily in the TD&D program area, in which new technologies, devices, and equipment are tested in the real world under careful observation, measurement, and performance verification. To ensure direct benefits to the ratepayers who fund EPIC, the siting of these projects is limited to California electric IOU service territories.

Figure 2 shows CEC EPIC awardee headquarters and project sites across California, illustrating the wide reach and range of EPIC projects across the state. This map includes a cumulative total of CEC EPIC awards through 2024 for AR&D, TD&D, and market facilitation projects.

13 CPUC Decision 18-10-052 established the EPIC Policy + Innovation Coordination Group (PICG). The PICG is comprised of a Project Coordinator, the four program administrators, and the CPUC. The PICG ensures meaningful collaboration between its members and that EPIC investments align with and are informed by CPUC and California energy innovation needs and goals.

Figure 2: EPIC Recipient Headquarters and Project Site Locations through 2024



Source: California Energy Commission staff

Increasing Diversity and Equity in EPIC

California's promise, successes, and innovations stem from the rich and diverse qualities and abilities of its people. The CEC is committed to conducting outreach to inform diverse business entities and under-resourced communities about opportunities to participate in EPIC solicitations and activities. Furthermore, the CEC continuously iterates on solicitations to help reduce the barriers that may prevent disadvantaged vulnerable communities (DVCs)[14] from accessing clean energy research opportunities. Appendix C of this annual report identifies EPIC award recipients who are California-based entities, small businesses, or businesses owned by women, minorities, or disabled veterans.

Transparent Public Process and Competitive Solicitations

The CEC has a robust outreach strategy to shape research priorities, investment planning, and grant solicitations. Public workshops, conducted virtually and in-person throughout all stages of a grant funding opportunity (GFO), are a core function through which the CEC shares information with and solicits input from interested parties. Other outreach efforts include:

- Broadening scoping and engagement efforts with local governments, community-based organizations and advocates, environmental justice organizations, academics, industry representatives, state and federal agencies, and market actors.
- Sharing knowledge, results, and lessons learned to inform policies, proceedings, codes, standards, and protocols.
- Promoting geographic diversity in CEC EPIC project funding to accelerate technology learning and diffusion.

Scoping Efforts

CEC staff solicits input on research roadmap[15] development, research scenario development, and draft competitive solicitations by holding scoping workshops and meetings or by issuing requests for information (RFI). Staff conducted six public scoping activities in 2024, including the following:

- May 16: Staff held a workshop to identify research gaps to improve predictability of behind-the-meter (BTM) resources[16] for grid operators. The California Independent System Operator[17] (California ISO) gave a presentation outlining current methods for forecasting BTM resources and ways that this information is integrated into real-time

14 The CPUC refers to the communities most vulnerable to climate change as disadvantaged vulnerable communities (DVCs). DVCs consist of census tracts with the 25 percent highest overall score according to the most recent version of 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 because of unreliable public health and socioeconomic data.

15 A research roadmap is a specific plan to achieve certain research outcomes.

16 Energy systems located on the customer's side of the utility meter, such as rooftop solar panels or electric vehicle chargers.

17 A nonprofit independent system operator that manages the flow of electricity across California's high-voltage transmission grid.

and day-ahead grid operations. California ISO representatives also identified opportunities to improve forecasting tools through targeted research.

- August 5: Staff issued an RFI to gather information for a potential future funding opportunity on offshore high-voltage direct current (HVDC) substations and associated electrical infrastructure, transmission, and grid integration of floating offshore wind (FOSW).
- September 20: Staff held a public scoping workshop to solicit input on a staff concept to establish a battery pilot manufacturing line in California that would help accelerate the development and adoption of new advanced battery technologies into electric transportation and other clean energy applications. The workshop highlighted research needs that could be funded by a future EPIC GFO.

Preapplication Workshops

- For all solicitations, CEC staff holds preapplication workshops with potential applicants to discuss the solicitation's purpose and scope in a public forum. These workshops provide an opportunity for attendees to ask in-depth questions and network. All questions and answers are posted online following preapplication workshops. In 2024, staff held 13 preapplication workshops, including the examples listed below:
    - January 18: "Grid-Supportive Transportation Electrification" (GFO-23-306), a solicitation focused on developing and demonstrating innovations to manage charging in response to local grid conditions; improve efficiency, affordability, and scalability of high-power charging; and enable more flexible siting of opportunity charging solutions.
    - March 29: "Non-Energy Impacts and Process Evaluation of Integrated Energy Retrofit Packages in California's Residential Buildings" (GFO-23-310), a solicitation focused on assessing the air quality and other non-energy related impacts of consolidated packages of electrification retrofit measures.
    - July 8: "Energy Storage Innovations to Support Grid Reliability" (GFO-23-317), a solicitation focused on research to help advance short- to long-duration stationary energy storage technologies. The solicitation will fund demonstrations to benefit historically under-resourced communities at risk of being left behind in the clean energy transition.
    - July 23: "Industrial, Agriculture, and Water Demand Flexibility Research and Deployment Hub (IAW FlexHub)" (GFO-23-316), a solicitation funding a research hub administrator that will establish a hub to convene leading researchers and dynamically manage projects that promote demand flexibility in these sectors.
    - August 28: "Environmental Sustainability of a Clean Energy Transition (Enviro-SET)" (GFO-24-301), a solicitation focused on funding AR&D to help guide California's transition to an equitable, affordable, zero-carbon energy system that is climate-resilient and meets environmental goals.

Sharing Knowledge and Lessons Learned

The CEC, as a public research program administrator, shares knowledge and lessons learned from EPIC projects with numerous parties. Examples include technology innovators, adopters, and investors, architectural and engineering firms, industry leaders, start-up and product incubator services, public funding providers, local communities and governments, state and federal agencies, environmental justice advocates, researchers, policy makers, and the public. This exchange is important for scientific and technological diffusion and accelerates the uptake of innovative achievements. Staff participation at external events and meetings is critical to enabling direct knowledge transfer of CEC EPIC-funded research, findings, and lessons learned for dissemination, replicability, and discussion, which — in turn — can help identify future investment needs. In 2024, the CEC participated in various knowledge-sharing efforts. Efforts to which the CEC contributed include, for example:

- January 18: Staff participated in the Offshore Wind Tribal Working Group to inform audiences about EPIC projects enabling oceanic wind energy resources.
- May 23 and September 26: CEC staff participated in SCE's Solid-State Transformer Technical Advisory Working Group meetings focused on improving the common understanding of solid-state transformer technologies. Staff provided updates on the Electric Truck Research and Utilization Center (eTRUC)'s Advanced Transportation Research Center, which can support testing of high-power charging technologies, such as solid-state transformers (EPC-21-010). This is just one example of staff's regular engagement with the three IOU EPIC administrators, which includes sharing project results and best practices in administering the program and discussing opportunities for collaboration on technology areas of shared interest.
- November 5: Staff hosted a webinar to provide an overview of seven FOSW R&D projects funded by EPIC. Grant recipients engaged in OSW R&D projects provided project summary presentations (EPC-23-001, EPC-23-002, EPC-23-003, EPC-23-005, EPC-23-006, EPC-23-007, EPC-23-008).
- Other examples of ongoing knowledge dissemination efforts include the following:
    - Updated EPIC project information and results are shared through the online Energize Innovation Project Showcase (https://www.energizeinnovation.fund/projects).
    - Project recipients are encouraged to share project results in academic and scientific journals, industry-recognized publications, and public conferences.

Overview of Strategic Objectives

The CPUC approves new strategic objectives and initiatives with each investment cycle. In 2024, active CEC EPIC projects spanned multiple investment plan cycles, and projects from different investment cycles correspond to the strategic objectives and initiatives of distinct plans. For simplicity, progress in this *2024 EPIC Annual Report* is reported in relation to the current *EPIC 4 Investment Plan* strategic objectives and initiatives. The summary below details

how 2024 CEC EPIC activities made progress in addressing EPIC 4 strategic objectives and initiatives.

Strategic Objective 1: Accelerate Advancements in Renewable Generation Technologies

Investments under this objective fund primarily R&D activities advancing key renewable energy technologies in support of Senate Bill (SB) 100 (De León, Chapter 312, Statutes of 2018) implementation. The four main topic areas for CEC investments are OSW, bioenergy, geothermal energy, and solar photovoltaic (PV) generation. Notable progress toward this objective in 2024 included the following:

- The CEC hosted a webinar with more than 170 external attendees to summarize progress on seven projects focused on developing and testing biological monitoring technologies and components for FOSW deployments.
- The CEC published final reports for two OSW-related projects, including for EPC-19-009, *A Numerical Modeling Framework to Evaluate Effects of Offshore Wind Farms on the California Upwelling Ecosystem*.[18] This study provided a framework for modeling the potential impacts of OSW development on upwelling, which refers to deep, cold water rising to the surface of the ocean. Outcomes from the report indicate predictions of upwelling metrics under a variety of environmental conditions, and OSW farm scenarios could enable the design of environmentally benign wind farm configurations and management actions. This study has also guided subsequent evaluations funded by the Bureau of Ocean Energy Management (BOEM) and the Ocean Protection Council. BOEM frequently cited two journal papers[19] resulting from this EPIC-funded project in its *2024 California Offshore Wind Draft Programmatic Environmental Impact Statement*,[20].
- The CEC published three final reports relating to geothermal energy and lithium recovery innovations, including one from EPC-19-017, *Pilot Scale Recovery of Lithium from Geothermal Brines*. This project demonstrated, on a pilot scale, a cost-effective integrated process for recovering lithium from geothermal brines using a new high-capacity selective sorbent and an innovative sorbent regeneration process.
- The CEC published three final reports relating to solar innovations, including for EPC-19-004, *High-Efficiency Perovskite Tandem Modules with Resilient Interfaces*. This

18 Raghukumar, K., et al. 2024. A Numerical Modeling Framework to Evaluate Effects of Offshore Wind Farms on the California Upwelling Ecosystem. California Energy Commission. Publication Number: CEC-500-2024-006. https://www.energy.ca.gov/sites/default/files/2024-02/CEC-500-2024-006.pdf.

19 Raghukumar K., C. Chartrand, G. Chang, L. Cheung, and J. Roberts. 2022. "Effect of Floating Offshore Wind Turbines on Atmospheric Circulation in California." Frontiers in Energy Research. https://www.frontiersin.org/journals/energy-research/articles/10.3389/fenrg.2022.863995/full.

Raghukumar, K., T. Nelson, M. Jacox, C. Chartrand, J. Fiechter, G. Change, L. Cheung, and J. Roberts. 2023. "Projected Cross-Shore Changes in Upwelling Induced by Offshore Wind Farm Development Along the California Coast." Communications Earth & Environment 4:116, https://www.nature.com/articles/s43247-023-00780-y.

20 BOEM. 2024. California Offshore Wind Draft Programmatic Environmental Impact Statement, https://www.boem.gov/sites/default/files/documents/renewable-energy/state-activities/2024_1021_CA_PEIS_Vol_I_508c_0.pdf.

agreement successfully developed perovskite-on-silicon tandem solar cells using silver-free conductive adhesives, moving toward a conversion efficiency of greater than 32 percent while reducing environmental impacts. The final report from EPC-19-002, *"Smart Greenhouse:" Integrated Photovoltaics/Photosynthesis for Energy and Food* [21] summarizes the successful project integration of PV into a greenhouse roof using semitransparent organic solar cells, demonstrating increased plant growth while generating clean electricity. EPC-19-003's final report, *Processing and Architecture Design to Develop and Demonstrate Stable and Efficient Perovskite+Silicon Tandem Modules*,[22] describes how the project demonstrated stable perovskite solar cells and panels, scaled up to high-throughput industrial processes and commercial quality performance.

Strategic Objective 2: Create a More Nimble Grid to Maintain Reliability as California Transitions to 100 Percent Clean Energy

As California works to meet its clean energy targets, the development of zero-carbon firm resources, defined as energy generation that can reliably supply electricity on demand for a sustained period; increased load flexibility; grid modernization; and cybersecurity risk mitigation will all be critical to maintaining a flexible and reliable grid. Notable progress toward this objective in 2024 included the following:

- The CEC released a $30 million solicitation in June 2024 to fund technology advancements in energy storage. The CEC received more than 90 abstracts during Phase 1 of the solicitation, demonstrating the interest and need for innovation and funding in this space. Of those, 37 abstracts are moving forward for consideration in Phase 2, and five awards are anticipated in the first quarter of 2025.
- The CEC awarded $8 million total in December 2024 to two projects that will use renewable gas coupled with onsite electricity generation to provide backup power.

Strategic Objective 3: Increase the Value Proposition of Distributed Energy Resources

EPIC funds a diverse range of technologies and demonstration and deployment projects that increase the value and benefits of distributed energy resources (DERs) for customers and the electric grid. DERs that interface with the electric grid include electric vehicle (EV) batteries and energy storage systems at homes or utility-scale sites. Improvements in how DERs operate, communicate, and are constructed can increase the affordability and reliability of electricity supply for California ratepayers. Notable progress toward this objective in 2024 included the following:

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21 Yang, Yang, Ying Zhang, Yepin Zhao, and Jinsung Kim. 2023. "Smart Greenhouse": Integrated Photovoltaics/ Photosynthesis for Energy and Food. California Energy Commission. Publication Number: CEC-500-2024-017, https://www.energy.ca.gov/publications/2024/smart-greenhouse-integrated-photovoltaics-photosynthesis-energy-and-food.

22 Colin Bailie. 2023.Processing and Architecture Design to Develop and Demonstrate Stable and Efficient Perovskite+Silicon Tandem Modules. California Energy Commission. Publication Number: CEC-500-2023-057, https://www.energy.ca.gov/sites/default/files/2023-10/CEC-500-2023-057.pdf.

- The California Load Flexibility Research and Development Hub (CalFlexHub) technology demonstration portfolio grew to 21 active or completed projects across homes, commercial buildings, campuses, and EV-charging sectors.
- As of December 2024, WattEV, a company based in the City of Long Beach advancing heavy-duty transportation electrification, fully installed its 21st Century Truck Stop in Bakersfield and began testing and commissioning. Full operation is expected by the end of March 2025 and will contribute to cleaner trucking that reduces negative air quality impacts, particularly on DVCs.
- In April 2024, the San Diego State University Research Foundation successfully commissioned a demonstration of its second-life battery energy storage system (BESS) at the UC San Diego Library Annex.
- In 2024, ReJoule, a company located in Signal Hill (Los Angeles County) and repurposing batteries through its innovative battery diagnostics tool, fully installed and began testing and commissioning its pilot second-life BESS at the Claremont Lewis Museum of Art in Claremont (Los Angeles County). Full operations began in January 2025.
- UC San Diego's Sustainable Materials & Energy Laboratory successfully demonstrated its advanced recycling of lithium-ion battery (LIB) materials in the laboratory and began a second EPIC-funded project to demonstrate its LIB technology at pilot scale in April 2024.

Strategic Objective 4: Improve the Customer Value Proposition of End-Use Efficiency and Electrification Technologies

EPIC funds have been critical in advancing the technology readiness level (TRL) of promising innovations in industrial and building decarbonization. For example, several EPIC-funded prototypes offer lower-emission solutions for industrial processes that are difficult to decarbonize due to thermal or chemical conditions. In the buildings sector, low and ultra-low global warming potential (GWP) refrigerants for heating, ventilation, and air-conditioning (HVAC) systems can enable further emissions reductions as consumers adopt more electric appliances. These refrigerants can accelerate cost reductions for electric appliances as their usage scales to meet demand and regulations. Notable progress toward this objective in 2024 included the following:

- The CEC awarded $52 million for 11 projects addressing decarbonization and electrification of industrial processes through various strategies including load flexibility, thermal energy storage, energy efficiency, advanced separations, and electrification of industrial processes. The awards generated nearly $30 million in match funding.
- C-Crete Technologies, a materials science company based in San Leandro, began developing a first-of-its-kind pilot demonstration to replace the mineral binders in carbon-intensive Portland cement, conventionally made from limestone, with "noncarbonate" rocks. C-Crete's technology uses zeolite rock, a limestone alternative found naturally in abundance, and a unique electrified process for creating cement

binders without the need for industrial kilns. At scale, the technology could reduce millions of tons of carbon dioxide (CO_2) emissions annually.

- Build It Green, a nonprofit organization in Oakland committed to building sustainable communities, was awarded an EPIC grant to develop a novel decision-making tool to electrify homes with limited electrical panel capacity. As upgrading the electrical panel can be one of the costliest barriers to home electrification, the tool will aim to support ratepayers in avoiding panel upgrades and reducing costs while electrifying. This project will produce an open-source calculation engine for onsite electrical building loads and an online customer interface. The $4.7 million grant will be paired with $2.5 million in match funding to build a tool that will assist homeowners with collecting household-specific information, performing electrical load calculations, and evaluating solutions for the most efficient and lowest-cost electrification plans.

Strategic Objective 5: Enable Successful Clean Energy Entrepreneurship Across California

The CEC's California Energy Innovation Ecosystem[23] (entrepreneurial ecosystem) supports new clean energy technology ventures by providing entrepreneurs with access to the networks, funding opportunities, mentoring, facilities, and expertise needed to take their inventions from idea to market. The California Sustainable Energy Entrepreneur Development Initiative (CalSEED), California Test Bed Initiative (CalTestBed), and four Regional Energy Innovation Clusters (REICs) (Southern California Energy Innovation Network [SCEIN], Los Angeles Cleantech Incubator, Activate Berkeley, and BlueTech Valley [BTV]) comprise the entrepreneurial ecosystem. By the close of 2024, these programs supported more than 380 companies. Notable progress toward this objective in 2024 included the following:

- Twelve, a Berkeley-based chemical company, is constructing a first-of-its-kind, demonstration-scale CO_2 transformation plant that will use an EPIC-funded CO_2 electrolyzer to produce low-emission sustainable aviation fuel (e-SAF), which aims to reduce aviation fuel life-cycle emissions by 90 percent.
- Skyven Technologies, based in Fresno, specializes in decarbonizing industrial process heat with steam-generating heat pump technology. In 2024, it completed a $1.1 million project to develop an artificial intelligence (AI)-driven platform known as Galileo to analyze decarbonization measures and recommend efficiency measures.
- Sonocharge Energy, Inc., a battery innovation company in San Diego, is improving LIB construction and performance through its Surface Acoustic Wave, which transmits acoustic waves inside LIB cells, ultimately resulting in faster charging times, longer lifespan, higher energy density, increased safety, and lower cost.

23 The specific components of the entrepreneurial ecosystem that are abbreviated here are described in detail under Chapter 4, Strategic Objective 5.

Strategic Objective 6: Inform California's Transition to an Equitable, Zero-Carbon Energy System that Is Climate-Resilient and Meets Environmental Goals

Climate resilience and environmental sustainability are chief priorities for the state. The CEC is leveraging $33 million in EPIC funding to ensure health, equity, and climate considerations are taken into account during California's clean energy transition. Notable progress toward this objective in 2024 included the following:

- The Cal-Adapt Analytics Engine, developed by Eagle Rock Analytics, is a consortium of climate researchers convened as a product of EPIC funding. In 2024, the Engine generated data and products that informed demand forecasting activities by the CEC, Integrated Resource Planning efforts by the CPUC, and Climate Adaptation and Vulnerability Assessments by the IOUs.
- The United States Geological Survey (USGS) published its final EPIC project report: *Investigating the Influence of "Lake Effect" from Utility-Scale Photovoltaic Solar Facilities on Avian Behavior in California*.[24] The findings provided evidence to support the Lake Effect Hypothesis, which suggests that utility-scale solar panels can attract birds by mimicking the visual cues used to locate water bodies, leading to avian collisions and fatalities. These findings can support future efforts to reduce those negative effects.

24 Diehl, Robert, Bruce Robertson, Karl Kosciuch. 2024. Investigating the Influence of "Lake Effect" from Utility-Scale Photovoltaic Solar Facilities on Avian Behavior in California. California Energy Commission. Publication Number: CEC-500-2024-055. https://www.energy.ca.gov/sites/default/files/2024-06/CEC-500-2024-055.pdf.

CHAPTER 2:
Coordination Activities in EPIC

The CEC continues to build partnerships and engage with diverse groups, networks, and interested partners as it develops and implements EPIC. Collaborators include EPIC administrators, federal and state agencies, the Disadvantaged Communities Advisory Group (DACAG),[25] environmental and social justice (ESJ) communities and advocates, and other clean energy market actors. The CEC also regularly engages with technology developers, academia, and industry associations as part of its statutory activities, including the development of grant solicitations, the annual IEPR or IEPR Update, and public knowledge-sharing events.

The "Transparent Public Process and Competitive Solicitations" section of this report provides detailed information and data demonstrating how the CEC as an EPIC administrator leverages public processes, workshops, CPUC proceedings, policies, legislation, and other direction to refine coordination and engagement processes continually. Table 4 summarizes the various engagement activities staff conducted in 2024.

Table 44: Summary of EPIC Staff Engagement Activities in 2024

Type of Engagement	Number of Efforts
Interagency Coordination with Local, State, and Federal Agencies	16
EPIC Administrator/CPUC/PICG Coordination	7
ESJ Community Engagement	9
DACAG Engagement	2
Total	**34**

Note: This does not represent event totals, as several efforts include monthly, quarterly, or semiregular meetings.

Source: California Energy Commission staff

Market and Other Actors

This section details EPIC coordination efforts with various actors in 2024.

U.S. Department of Energy, National Organizations, and Other States

- Ongoing coordination between the CEC and the United States Department of Energy (U.S. DOE) Advanced Research Projects Agency — Energy (ARPA-E) built upon existing federal funding activities to move transformational energy technologies out of the laboratory and into the market. Common areas of research included energy efficiency,

25 The Disadvantaged Communities Advisory Group is an 11-member advisory group created by SB 350 (de León, Chapter 547, Statues of 2015) that advises the CEC and CPUC on how to design and implement policies and programs to be more effective on behalf of disadvantaged communities and in the achievement of California's clean energy and pollution reduction goals.

energy storage, transportation, DERs, and power electronics. Activities in 2024 included:

  - Coordination meetings in which the agencies shared perspectives and analyses on emerging technology advancements, identified market opportunities for technologies within their respective portfolios, discussed best practices and lessons learned regarding program design and administration, and coordinated participation as advisory members on related projects.

- Ongoing coordination with several U.S. DOE offices served to guide and align California and federal research efforts for transportation electrification and building decarbonization topics. Activities included:

  - Quarterly calls with national laboratories on heat pump research, participation in Argonne National Laboratory's Megawatt+ MultiPort Electric Vehicle Charging Industry Work Group, and meetings with Oak Ridge National Laboratory related to building equipment, low-GWP refrigerants, and building envelope research.

  - Bimonthly Long Duration Energy Storage Consortium meetings convened by Sandia National Laboratory. Meetings focused on identifying barriers and potential synergies and collaboratively developing and implementing strategies to achieve technology commercialization.

  - Participation in the U.S. DOE Building Technologies Office's Emerging Technologies Collaborative for Buildings to share the CEC's perspective and coordinate research planning. The collaborative drives market transformation by helping address the nation's priority energy technology RD&D needs for the building sector.

  - Coordination with the National Association of State Energy Officials' (NASEO) Clean Transportation Program on a case study highlighting how partnerships between state energy offices and the private sector can support clean energy microgrids and EV charging. The study features WattEV, an EPIC grant recipient, opening California's first electric truck charging depot that integrates solar and battery storage microgrid technologies. The report will be published in early 2025.

  - In May 2024, presentation at the U.S. DOE's Western Connected Communities Summit to share findings on affordable multifamily building decarbonization and design from the CEC's Next EPIC Challenge. Attendees participated in discussions on grid-interactive and efficient building strategies and technologies deployed in the DOE Connected Communities funding program.

  - In August 2024, attendance at the U.S. DOE's Building Technologies Office Stor4Build program annual meeting to present on CEC's research efforts for advancing equitable and affordable thermal energy storage solutions for buildings. Attendees toured Oak Ridge National Laboratory and received briefings on the latest U.S. DOE research developments.

- In October 2024, presentation at the 2024 Building Technologies Office's peer review meeting on the latest CEC research efforts on low-GWP refrigerants and technical reviews for several U.S. DOE-sponsored projects.

- Ongoing coordination with several federal and out-of-state agencies and national organizations on R&D for OSW planning. This coordination included:
  - Regular meetings with U.S. DOE to discuss and gather feedback on FOSW solicitation ideas and innovation needs.
  - Participation in the National Offshore Wind Research and Development Consortium (NOWRDC), funded by a block grant agreement, EPC-22-009, focused on collaboration with industry to fund prioritized R&D activities that accelerate the deployment of OSW facilities. The CEC is a consortium member, and staff participate in monthly R&D Committee meetings. Staff members attended the NOWRDC OSW Symposium held in December 2024.
  - Regular discussions with the New York State Energy Research and Development Authority, U.S. DOE, Massachusetts Clean Energy Center, BOEM, and other agencies to discuss research priorities, examine new research funding opportunities, and review existing R&D projects to guide NOWRDC activities.
  - Quarterly meetings with BOEM to discuss and gather feedback on FOSW solicitation ideas and innovation needs.
  - Meetings with the National Renewable Energy Laboratory (NREL), LBNL, National Association of State Energy Officials, and the State of Maine to gather feedback on FOSW solicitation ideas. Topics included entanglement of marine life, mooring integrity monitoring technology, seismic concerns, cost reductions in station-keeping systems, and development of offshore transmission systems.

U.S. Department of Defense

The CEC continued its partnership with different branches of the U.S. military to coordinate R&D of innovative clean energy technologies that are of joint priority interest, such as base energy resiliency and reliability. Efforts included participating in monthly calls with the Navy to share updates and implement actions aligned with a memorandum of understanding signed between the CEC and Navy in December 2021. Other notable activities for 2024 include:

- Development and execution of a CEC and Air Force memorandum of understanding in June.
- Participation in a two-day summit with Navy civilian and military leadership to discuss collaboration opportunities between the CEC and Navy. Topics discussed included Lithium Valley,[26] microgrid deployments, long-duration storage, EV charging, and

26 Lithium Valley refers to the area adjacent to the Salton Sea in Southern California that contains significant quantities of extractable lithium loosened from geothermal activity beneath the sea.

building decarbonization. The CEC shared information about EPIC-funded technologies that could meet Navy needs, as well as upcoming EPIC funding opportunities.

- Ongoing efforts to electrify the nontactical vehicle fleet at the Los Angeles Air Force Base (EPC-16-059), including assessment of different methods to allow base personnel to use government chargers for their personal vehicles and reimburse the government for these costs. This research project is evaluating different rate-charging options that will meet the needs of the government and individuals. Successful research can expand charging options and use across facilities operated by the U.S. Department of Defense (DOD).
- Site visits by CEC Commissioners and staff to Fort Irwin, Camp Pendleton, and the Naval Post Graduate School to discuss building decarbonization and the use of newer heat pump technology on DOD base infrastructures. Follow-up meetings are planned for 2025.
- Continued progress on the microgrid projects located at the Miramar Marine Corps Air Station (EPC-17-032), Army Camp Parks and Naval Base Ventura County (EPC-17-038), and Port Hueneme Navy Data Center (EPC-18-001). These projects improve military base energy resiliency using microgrids to support critical military operations and data processing facilities.

Other California State Agencies

In 2024, staff coordinated with several California state agencies to help advance research, demonstration, and deployment activities for emerging clean energy technologies. Representative activities in 2024 include:

- In January 2024, meeting with the California Air Resources Board (CARB) to learn about its onboard diagnostics regulatory authority under the Advanced Clean Cars II regulations and vehicle-to-grid integration (VGI) connections. The meeting informed staff about the regulations and ways that CARB can aid in adopting submetering via vehicle telematics.[27]
- In May 2024, meeting with CARB and the Southern California Air Quality Management District to provide feedback on CARB's research concepts for characterizing battery charging trends, energy use, and activity patterns, and alternative charging solutions for zero-emission off-road equipment and heavy-duty vehicles. CEC staff shared a list of interested parties that have engaged with CEC on electric off-road equipment and provided technical input on the utility of collecting activity and charging data for assessment of VGI opportunities.
- Regular OSW coordination meetings with the California Natural Resources Agency (CNRA) departments, CPUC, California Department of Transportation, Governor's Office of Business and Economic Development (GO-Biz), the Office of Land Use and Climate

27 The integrated use of telecommunications and informatics in vehicles.

Innovation (formerly the Office of Planning and Research), and BOEM (a federal agency).

- Bimonthly OSW Environmental Topics Coordination meetings with CNRA, California Department of Fish and Wildlife, California State Lands Commission, California Coastal Commission, California State Water Resources Control Board, and CEC's Siting, Transmission, and Environmental Protection Division to coordinate on environmental studies and impacts of California OSW. Participants discussed monitoring and environmental research needs, and CEC staff provided updates and overviews of relevant EPIC research projects.
- Monthly Interagency Transportation Electrification Coordination Meetings with the CPUC, CARB, GO-Biz, California Department of Transportation, California ISO, and California Department of Food and Agriculture's Division of Measurement Standards to provide updates on activities related to transportation electrification. Topics included the High DER Proceeding, California Vehicle Survey, Advanced Clean Cars II, and the California Flexible Unified Signal for Energy, among others.
    - Staff presented a summary of proposed awards for GFO-23-306, "Grid-Supportive Transportation Electrification," participated in the Energy Transition Coordinating Council (ETCC)[28] leadership group and helped plan the 2024 Energy Transition Summit to convene entrepreneurs, technologists, policy makers, utilities, and others to accelerate the clean energy transition.
- Quarterly multiagency meetings convened by the Ocean Protection Council to discuss coastal resilience issues, including emerging science, policy, and projects. Agency members provided input on California's *Sea Level Rise Guidance Report and the Sea Level Rise Action Plan for California,*[29] and CEC staff provided updates and overviews of relevant EPIC research projects.
- Monthly meetings with California's Governor's Office of Land Use and Climate Innovation, CNRA, and the California Strategic Growth Council on the implementation of *California's Fifth Climate Change Assessment*.[30]
- Quarterly meetings with the California Department of Public Health and the California Health & Human Services Agency to plan effective short- and long-term indoor air quality activities and to advance strategic indoor air quality priorities in the state. Staff provided updates and overviews of relevant EPIC research projects and discussions to help guide future EPIC-funded research.

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28 The ETCC is a collaborative among the CEC, the three electric IOUs, Southern California Gas Company, Los Angeles Department of Water and Power, and Sacramento Municipal Utility District. It focuses on expanding knowledge of emerging technologies and has shared project results, methodologies, and coordination opportunities for advanced lighting, water heating, space heating, and air-conditioning systems. The ETCC is the only organization in California dedicated to identifying and assessing technologies for utility customer programs.

29 California Ocean Protection Council and California Ocean Science Trust. 2024. Sea Level Rise Guidance Report and the Sea Level Rise Action Plan for California, https://opc.ca.gov/wp-content/uploads/2024/05/California-Sea-Level-Rise-Guidance-2024-508.pdf

30 See https://lci.ca.gov/climate/icarp/climate-assessment/ for information.

EPIC Administrator and CPUC Coordination

Coordination among administrators maximizes EPIC's effectiveness by ensuring implementation across the program is complementary. Sharing lessons learned from the most significant technological innovations can enhance future grant offerings. The CEC is committed to ongoing coordination and collaboration with the CPUC, the three IOU administrators of EPIC funds, and the PICG.

IOU Administrators

CEC staff regularly engages with the three IOU EPIC administrators by sharing project results and best practices in administering the program and by discussing opportunities for collaboration on technology areas of shared interest. These activities align resources across the program and amplify meaningful outcomes from the most promising innovations. The administrators hold biweekly meetings, coordinate notifications and outreach for upcoming events, and participate in joint public workshops. Other notable activities from 2024 include:

- May 23 and September 26: Staff participated in SCE's Solid-State Transformer Technical Advisory Working Group meetings focused on improving the common understanding of solid-state transformer technologies. Staff provided updates on eTRUC)'s Advanced Transportation Research Center, which can support testing of high-power charging technologies, such as solid-state transformers (EPC-21-010).
- June 3: Staff participated in SCE's Vehicle-to-Grid (V2G) project Technical Advisory Board meeting. Board activities focused on technical implementation of utility interconnection methods aligned with industry standards, including advanced utility grid management systems focused on capabilities for real VGI use cases. The meeting included a general project update and a report from working groups on harmonization, cybersecurity, and V2G alternative charging standards.
- August 5: Staff participated in the Joint IOU Annual EPIC Workshop, presenting updates and lessons learned on affordability, outreach and engagement with ESJ communities, and VGI.
- Monthly calls with PG&E to discuss VGI topics, including dynamic rates, pilots, flexible connections, bidirectional charging, and submetering. The calls promoted knowledge sharing of EPIC-funded VGI projects and technology status across administrators.
- Monthly coordination calls with the ETCC.

PICG and EPIC 5 Development

Following Decision 24-03-007[31] and adoption of the five strategic goals for EPIC 5, the CPUC initiated the second half of the planning process to develop strategic objectives for program

31 California Public Utilities Commission. 2024. Decision Adopting Strategic Goals for the Electric Program Investment Charge Program. https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M527/K228/527228647.PDF.

administrators to strive toward in their upcoming investment plans. The CEC participated in each of the following workshops as part of this process:

- March 19: Strategic Objectives Kick-Off Workshop
- April 2: EPIC Impact Analysis Framework and Metrics Workshop
- April 10: Transportation Electrification In-Person Working Group #1
- April 11: Building Decarbonization In-Person Working Group #1
- April 12: Achieving 100% Net-Zero Carbon Emissions and the Coordinated Role of Gas In-Person Working Group #1
- April 30: Distributed Energy Resource Integration In-Person Working Group #1
- May 1: Climate Adaptation In-Person Working Group #1
- May 13: Transportation Electrification Working Group #2
- May 14: Building Decarbonization Working Group #2
- May 15: Achieving 100% Net-Zero Carbon Emissions and the Coordinated Role of Gas Working Group #2
- May 29: Distributed Energy Resource Integration Working Group #2
- May 29: Climate Adaptation Working Group #2
- July 9: Strategic Objectives Final Workshop

At the Strategic Objectives Kick-off Workshop, CPUC staff presented an overview of the process for drafting strategic objectives and existing knowledge gaps under each adopted strategic goal as enumerated in Decision 24-03-007. The Impact Analysis Framework and Metrics Workshop focused on developing a Uniform Impact Analysis Framework to be used by all administrators to measure the impacts of future EPIC investments. The first working group for each strategic goal was dedicated to drafting strategic objectives for the group's corresponding goal. Follow-up working groups were held to refine the 13 proposed draft strategic objectives, which were presented at the July 9 workshop:

1. Reducing medium-/heavy-duty vehicle charging infrastructure costs.
2. Overcoming barriers to EV benefits in DVCs.
3. Smart systemwide planning tools for new load.
4. Reducing cost of whole-home electrification.[32]
5. Innovative approaches for difficult-to-decarbonize sectors.
6. Community-scale decarbonization.
7. Impacts research for new generation and storage.
8. Increasing predictability of weather, intermittent resources, and load.
9. Leveraging DERs for grid and community resiliency.
10. Expediting and streamlining interconnection and permitting.
11. Providing data input into a value of DER framework.
12. Reducing feeder/circuit peaks.
13. Cost-effective grid hardening for long-term climate impacts.

32 "Home electrification" refers to switching all home energy uses, such as heating, cooking, and powering appliances, to electricity instead of gas.

The CPUC will consider feedback received in previous workshops and release a staff proposal of draft objectives that will be considered for formal adoption in 2025. The CPUC requires EPIC administrators to submit their EPIC 5 Investment Plans by October 1, 2025.

CPUC

In addition to the efforts with PICG mentioned above, the CEC and its recipients coordinated with the CPUC on numerous EPIC-related activities in 2024, including the following:

- Between March and August 2024, staff attended several CPUC Smarter Inverter Working Group meetings to learn about updates on the V2G Alternating Current Interconnections Standards Update, the Common Smart Inverter Profile, the Underwriters Laboratories (UL) 3141 and Hitachi's Digital Energy Solution Research Program, industry actions for alternative charging V2G, and the role of relays for limited generation profiles.
- CEC staff coordinated a meeting with the CPUC and EPIC recipient Gridtractor (EPC-22-004) in September. Gridtractor representatives shared their experience with barriers to EV submetering, including ineligibility for net-energy-metering customers and challenging requirements for meter data management agents that hinder enrollment.
- In fall 2024, staff attended two CPUC Data Working Group meetings to learn more about the California ISO's short-term forecasting, data utilization, prioritization of DER-related forecasting challenges, and DER adoption in ESJ communities. The meetings identified barriers to DER adoption and data use cases to support DER customer program outreach and adoption in ESJ communities.
- CEC staff held joint monthly transportation electrification and VGI coordination calls to discuss grid planning for charging infrastructure, energization, EV submetering, dynamic rates, utility pilots, and funding programs. The discussions generally related to CPUC Rulemaking 23-12-008 and Rulemaking 24-10-018, as well as the CEC's EPIC GFO "Responsive, Easy Charging Products with Dynamic Signals."

ESJ Communities

The CEC is committed to ensuring all Californians benefit from clean energy research. Consistent with legislative and CPUC direction and CEC commitments, the CEC has prioritized energy equity in its research programs to ensure that the most vulnerable communities benefit from emerging clean energy technologies.[33]

33 In 2015, the CEC adopted a diversity policy resolution outlining its commitment to ensure all Californians have an opportunity to participate in and benefit from CEC programs, https://www.energy.ca.gov/sites/default/files/2020-07/diversity_policy_resolution_ada.pdf. In 2016, the CEC's Low-Income Barriers Study recommended the CEC's EPIC Program target a minimum of 25 percent of technology demonstration and deployment funding for sites located in disadvantaged communities, https://www.energy.ca.gov/publications/2016/low-income-barriers-study-part-overcoming-barriers-energy-efficiency-and.

Alignment With ESJ Action Plan and Justice40 Initiative

In 2022, the CPUC adopted a revised ESJ Action Plan, *ESJ Action Plan 2.0,* containing nine goals and objectives and 91 action items.[34] The action plan informs programmatic considerations when incorporating equity into investment planning. Decision 23-04-042[35] in April 2023 directed EPIC administrators to address the CPUC's ESJ Action Plan goals and objectives in future investment plans. The decision also required administrators to engage ESJ communities and California Native American tribes early in the scoping process and consult with them on workforce development opportunities.[36] In addition, the decision requires EPIC administrators to implement the program in alignment with the federal Justice40 Initiative[37] goals and criteria that at least 40 percent of benefits are allocated to DVCs.

The CPUC provided additional guidance on what projects may count toward alignment with the Justice40 Initiative goal. EPIC-funded, front-of-the-meter projects upstream of disadvantaged and low-income communities that have clear and verifiable benefits to disadvantaged communities meet the criteria for the Justice40 goal. However, projects "with state- or region-wide impacts (such as wildfire reduction) are excluded because that may circumvent the legislative requirement for disadvantaged/low-income-specific-benefits." The CPUC distinguishes that its *ESJ Action Plan 2.0* uses a metric based on the project's location, while Justice40 measures the accrual of benefits from the investment.[38]

The following activities in 2024 illustrate how CEC aligned EPIC investments and activities with select *ESJ Action Plan 2.0* goals that are most relevant to the CEC's work in administering the EPIC Program. The goals listed below reflect modified language to provide context for CEC activities.

34 California Public Utilities Commission. 2022. Environmental & Social Justice Action Plan Version 2.0, https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/news-and-outreach/documents/news-office/key-issues/esj/esj-action-plan-v2jw.pdf.

35 California Public Utilities Commission. 2023. Decision on Phase 2-C of Electric Program Investment Charge Rulemaking, https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M507/K499/507499284.PDF.

36 ESJ communities are predominantly communities of color or low-income communities that are underrepresented in the policy setting or decision-making process, subject to a disproportionate impact from one or more environmental hazards, and likely to experience disparate implementation of environmental regulations and socioeconomic investments in their communities. It targets "Disadvantaged Communities" designated by the California Environmental Health Screening (CalEnviroScreen) Tool, all California tribal lands as defined in 18 U.S.C. 1151 subsection (a), low-income households with incomes below 80 percent of the area median income, and low-income census tracts with aggregated household incomes that are less than 80 percent of area or state median income.

37 On January 27, 2021, President Joseph R. Biden Jr. issued EO 14008, Tackling the Climate Crisis at Home and Abroad. Section 223 of EO 14008 establishes the Justice40 Initiative, which directs 40 percent of the overall benefits of federal investments to flow to disadvantaged communities, including in areas such as clean energy and energy efficiency, clean transit, affordable and sustainable housing, training and workforce development, remediation and reduction of legacy pollution, and development of clean water infrastructure.

38 California Public Utilities Commission. 2023. Decision on Phase 2-C of Electric Program Investment Charge Rulemaking.

- Goal 1: Consistently integrate equity and access considerations throughout CEC's EPIC activities.
    - The CEC applied specific equity scoring criteria to several TD&D solicitations issued. These solicitations designated funding to ensure ESJ communities would benefit from clean energy resources. The criteria included considerations for:
        - Anticipated benefits, including increased access to clean energy or sustainability technologies, improved economic impacts, and increased community capacity
        - Community engagement efforts conducted before project development and during project implementation
        - Localized health impacts, including improved health benefits or reduced exposure to pollutants
        - Budget allocation for community engagement activities
        - Support from the community on where the project will be located, and the proposed community partner
    - The CEC ERDD Equity Team conducted monthly internal meetings to discuss equity-related topics and funding opportunity considerations and disseminate knowledge from both the CEC's Office of the Public Advisor, Energy Equity, and Tribal Affairs and the DACAG Equity Framework.[39] The team is developing resources for staff, including best practices for community engagement, for use in projects and outreach activities.
    - The CEC prioritized discussions on equity, affordability, accessibility, and energy resiliency at the 2024 EPIC Symposium, CEC's premier EPIC event.

- Goal 2: Increase investment in clean energy resources to benefit ESJ communities, especially to improve local air quality and public health.
    - The CEC awarded nearly $3 million from GFO-23-310, "Non-Energy Impacts and Process Evaluation of Integrated Energy Retrofit Packages in California's Residential Buildings," to the County of Ventura to research non-energy benefits of home electrification, such as affordability, comfort, and health, and to evaluate experiences of residents, contractors, and others with the retrofitting process.
    - The CEC developed a GFO, "Modeling and Monitoring Air Quality and Co-Benefits of Energy Interventions to Inform Clean and Equitable Energy Transition," that is anticipated to be released in mid-2025. It proposes to fund research to improve

39 Joint California Energy Commission and California Public Utilities Commission Disadvantaged Communities Advisory Group. 2024. CA Disadvantaged Communities Advisory Group (DACAG) Equity Framework 2024 Update, https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/infrastructure/disadvantaged-communities/2024-dacag-equity-framework.pdf.

existing ambient air quality modeling and measurement approaches, and to conduct analysis quantifying the air quality implications and related human health impacts of clean energy interventions across energy use sectors.

- Goal 4: Increase climate resiliency in ESJ communities.
    - The CEC issued the following awards to projects aimed at providing climate resiliency in ESJ communities.
        - One project for $9 million (EPC-23-025), from the Next EPIC Challenge (GFO-20-305), a design-build competition developing all-electric, multiuse building designs throughout the state, will build permanent, new affordable housing for seniors and community resources in Stockton. The design includes grid-interactive technologies unified by a building management system controller to offer climate resiliency and up to 85-percent utility bill savings.
        - Three projects totaling nearly $27 million (EPC-23-037, EPC-23-027, and EPC-23-036), from GFO-22-307, "Optimizing Long-Duration Energy Storage (LDES) to Improve Resilience and Reliability in Disadvantaged and Low-Income Communities and Native American Tribes," will fund TD&D to accelerate the commercialization and technical validation of LDES technologies, which can improve grid reliability and resilience in California ESJ communities.
        - Three projects totaling more than $5.7 million (EPC-24-016, EPC-24-017, and EPC-24-018), from GFO-23-302, "Power Electronics for Zero-Emission Residential Resilience," will demonstrate DER technologies within disadvantaged, low-income, or tribal communities, providing clean, affordable backup power solutions.
- Goal 5: Enhance outreach and public participation opportunities for ESJ communities to meaningfully participate in the CEC's decision-making process and benefit from the CEC's EPIC Program.
    - Staff participated in monthly DACAG meetings and engaged with ESJ advocates to stay informed about ESJ priority concerns and respond to public comments on EPIC. For example, ERDD DACAG liaisons met with an interested applicant who shared concerns over the EPIC solicitation match requirements, which may be challenging for ESJ communities. After deliberation, ERDD lowered the match requirements for solicitations aimed at providing support to ESJ communities.
    - Staff began planning ESJ roundtable discussions to engage with ESJ communities, tribes, and advocates on the CEC's administration of EPIC and the upcoming *EPIC 5 Investment Plan*. Outreach is planned in collaboration with the CEC's Office of the Public Advisor, Energy Equity, and Tribal Affairs for 2025 after CPUC approval of EPIC 5 strategic objectives. Input will be used to inform the CEC's EPIC 5 research and identify possible areas needing improvement to enable greater ESJ community participation in EPIC.

- Goal 8: Improve training and staff development related to ESJ issues within EPIC's electricity service territories.
    - The ERDD Equity Team facilitated monthly internal meetings to discuss equity-related challenges and solicitation considerations, and to disseminate updates on terminology usage, ESJ concerns, and community engagement best practices.
    - The ERDD Equity Team and DACAG Liaisons attended CNRA trainings on cultural awareness and best practices for tribal engagement.

Outreach and Engagement with ESJ Communities and Tribes

CEC staff participated in several programmatic and project-related outreach and engagement activities throughout 2024 with disadvantaged and low-income communities, environmental justice groups, and tribes, including DACAG monthly meetings. Other notable efforts in 2024 include the following:

- CEC and BOEM convened an Offshore Wind Tribal Working Group in January to share updates related to FOSW development in California with tribal leaders and representatives. Staff presented a summary of R&D technology investments related to OSW environmental concerns. Staff answered questions on how EPIC identifies strategic investment priorities for future OSW solicitations to include greater participation and benefits to California Native American tribes.
- February 16: Staff held a call with the California Environmental Justice Alliance, a statewide coalition of grassroots environmental justice organizations, to strengthen relationships and discuss equity priorities that could be addressed in EPIC. The California Environmental Justice Alliance's input included concerns with previous investments in combustion technologies located in ESJ communities and encouragement of opportunities for ESJ communities to better engage and help codevelop projects.
- August 6: The CEC EPIC recipient, ZNE Alliance, co-hosted a public event with clean energy provider MCE in Richmond, California to showcase one of the project's all-electric homes (EPC-19-005). The ZNE Alliance team is working with the City of Richmond and the Richmond Community Foundation to refurbish abandoned and blighted homes and make them available to income-qualified, first-time home buyers. The goal is to integrate the homes into MCE's pilot virtual power plant (VPP) — a system integrating clean energy technologies like solar panels, battery storage, and EV chargers into a unified, remotely controlled network — to provide equitable, affordable, community-driven solutions that address climate challenges while promoting economic resilience.
- In collaboration with the ERDD staff, two University of California (UC) Berkeley graduate students participating on a fellowship at the CEC conducted case studies in the fall of 2024 investigating strategies for engaging communities in grid resilience planning and preparedness. They shared their findings on best practices for effective, meaningful, and equitable community engagement and workforce development with

staff. ERDD staff will consider the recommendations when developing best practices that can feed into future ERDD solicitations and project requirements.

- In collaboration with CEC's Tribal Advisor and ERDD's Tribal Liaison, a UC Berkeley graduate student participating in a fellowship at the CEC surveyed non-energy benefits resulting from three EPIC-funded tribal microgrid projects (EPC-14-054, EPC-17-002, EPC-19-045) in the fall of 2024. Findings on surveyed benefits and recommendations for capturing non-energy tribal microgrid project benefits were shared with the CEC in early 2025. The ERDD Equity Team will consider this information when developing guidance for project benefit tracking and reporting in early 2025.
- As part of the eTRUC project (EPC-21-010), the CARB Advanced Transportation Initiative and the Electric Power Research Institute (EPRI) established a Community-First Technical Advisory Committee and Workforce Development Advisory Committee designed to provide input on project tasks. Both committees held four meetings in 2024, in which the project team presented project updates and solicited feedback from committee members (see the eTRUC website [etruc.org] for lists of committee members, committee objectives, and meeting materials). For example, both committees have been engaged in the development of mapping tools to determine medium- and heavy-duty charging infrastructure needs, including an equity map layer to assess benefits to disadvantaged communities and a workforce map layer to identify local workforce needs.
- CEC staff regularly interacts with tribes in planning and executing projects, such as GFO-23-317, "Energy Storage Innovations to Support Grid Reliability," ensuring tribes' needs are carefully considered in EPIC solicitations. Staff also connect tribes to promising energy technology innovators that are potentially fundable by forthcoming EPIC solicitations.
- In November, CEC facilitated a collaborative partnership between a California Native American tribe seeking to install a solar + storage microgrid and an energy storage developer. The developer had secured federal funding through the U.S. DOE's Long Duration Energy Storage Program and sought EPIC cost share for the project. CEC staff traveled to the rancheria, joined by a lead representative of the energy storage developer, and listened to the tribe's resiliency needs and recent accomplishments.

Coordination on CPUC's *DER Action Plan 2.0*

California has been at the forefront of DER integration into the electric grid for more than ten years. Under California's Assembly Bill 327 (Perea, Chapter 661, Statutes of 2013) and Public Utilities Code Section 769(a), DERs include:

- Distributed renewable generation resources (for example, solar PV panels).
- Energy efficiency in buildings.
- Energy storage.
- EVs.
- Demand response technologies.

In 2016, the CPUC published the *Distributed Energy Resources Action Plan: Aligning Vision and Action*,[40] known as *DER Action Plan 1.0*, to align the organization's visions and actions. The plan guided the development of the Distribution Resources Plans Proceeding and Integrated Distributed Energy Resources Proceeding — two proceedings established to guide state efforts on utility DERs.

In April 2021, the CPUC approved the current *DER Action Plan 2.0*. Two months later, the CPUC issued an Order Instituting Rulemaking to Modernize the Electric Grid for a High Distributed Energy Resources Future, known as the High DER Proceeding. This proceeding sought to implement the overall vision and action elements of the DER Action Plan. One factor prompting these actions was the CEC's *2020 Integrated Energy Policy Report*[41] (IEPR) forecast of large increases in BTM solar generation, BTM energy storage capacity, and EV demand from 2019 to 2030. In that report, the CEC cited advancements in technology and cost declines, which public investment programs like EPIC can help expedite, as the primary factors driving DER growth.

Since its inception in 2011, the CEC's EPIC Program has closely coordinated with the CPUC and considered its proceedings and action plans to develop DER-related advancements in technology and cost declines that help the state achieve its clean energy goals. In April 2023, the CPUC directed EPIC administrators to "demonstrate that they have taken the *DER Action Plan 2.0* (covering 2022–2026) into account in developing their Strategic Initiatives," starting with the *EPIC 4 Investment Plan*. Although the CEC's *EPIC 4 Investment Plan*[42] was approved in June 2022, projects funded across EPIC's investment plans and strategic objectives have helped meet the goals of the *DER Action Plan 2.0*.

CEC staff closely monitors developments in the High DER Proceeding and coordinates on biweekly calls with CPUC Energy Division and IOU staff to ensure that future CEC solicitation development is closely aligned with *DER Action Plan 2.0*. In 2024, CEC staff met with multiple groups of interested parties concerning DERs, including:

- Energy storage technology developers
- Electric vehicle supply equipment (EVSE) technology developers
- The Ports Collaborative, an interagency working group with California ports
- State agencies, including CARB, California Department of Transportation, and GO-Biz
- California ISO
- Think tanks, national laboratories, and academic institutions
- U.S. DOE

40 See https://www.cpuc.ca.gov/about-cpuc/divisions/energy-division/der-action-plan for more information and links to DER Action Plans.

41 Senate Bill 1389 (Bowen, Chapter 568, Statutes of 2002) requires the CEC to prepare an Integrated Energy Policy Report (IEPR) every two years, with updates in alternate years. The report contains an integrated assessment of major energy trends and issues facing California's electricity, natural gas, and transportation fuel sectors. It provides policy recommendations to conserve resources, protect the environment, ensure reliable, secure, and diverse energy supplies, enhance the state's economy, and protect public health and safety.

42 Virginia Lew, Anthony Ng, Mike Petouhoff, Jonah Steinbuck, Erik Stokes, Misa Werner. 2023. The Electric Program Investment Charge 2021–2025 Investment Plan: EPIC 4 Investment Plan. California Energy Commission. https://www.energy.ca.gov/publications/2021/electric-program-investment-charge-2021-2025-investment-plan-epic-4-investment

- NASEO and the National Association of Regulatory Utility Commissioners
- DER aggregators

The CEC hosted, participated in, and supported EPIC recipient participation in several events in 2024 to support EPIC coordination with the CPUC *DER Action Plan 2.0*. Some notable events include the following:

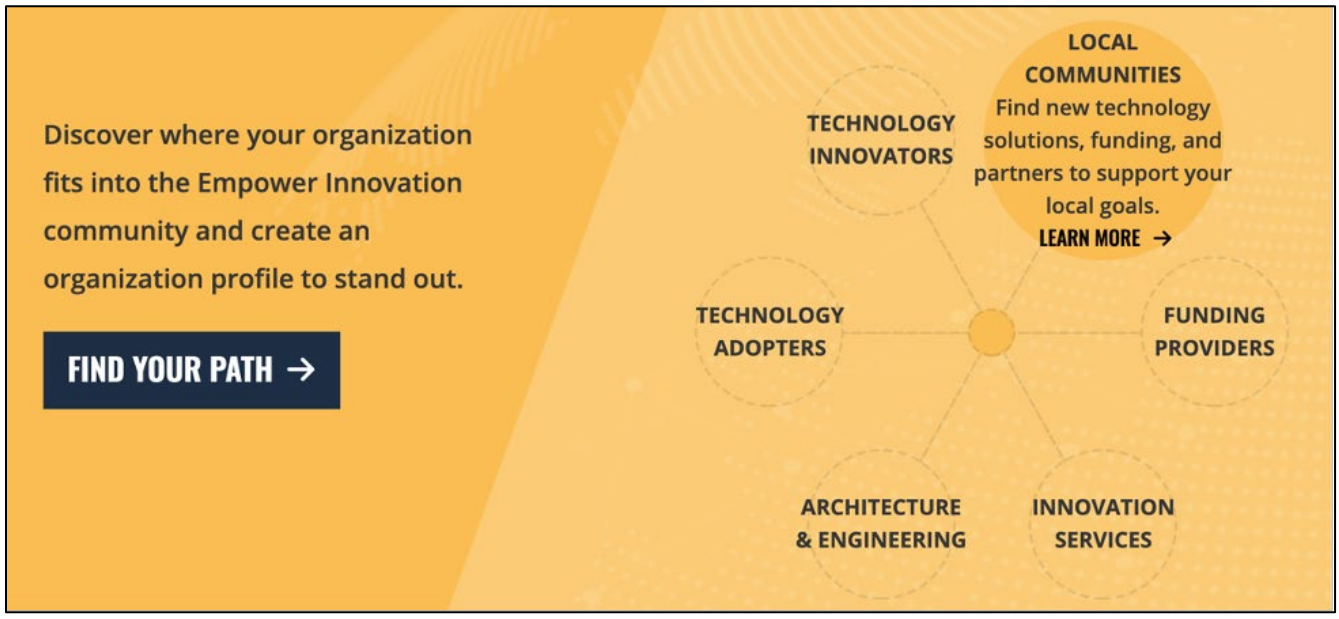
- CalFlexHub Symposium.
- American Council for an Energy-Efficient Economy (ACEEE) Summer Study on Energy Efficiency in Buildings.
- ETCC Summit.
- U.S. DOE Stor4Build Conference.
- Institute of Electrical and Electronics Engineers Power and Energy Society General Meeting.
- Institute of Electrical and Electronics Engineers Green Energy and Smart Systems Conference.

Promoting Partnerships for EPIC Projects

Participation from a broad range of interested parties helps ensure that local insights and concerns inform the products and impacts resulting from demonstration and market facilitation projects. Contributions from interested parties can help accelerate access, affordability, and adoption of clean energy innovation across California. The partnerships developed in EPIC are the result of intentional actions, consistent dialogue, and deliberate structuring of solicitation documents for the program.

Launched in 2019, Empower Innovation Network (https://www.empowerinnovation.net/) was the first clean energy networking platform designed for professionals seeking to advance and improve the accessibility of the clean energy economy. Participation in the platform has grown quickly. As of December 31, 2024, the Empower Innovation Network platform had more than 4,700 members and nearly 1,300 organizations. Notably, since its inception, the platform has received more than 570,000 page views and hosted more than $27 billion in funding opportunity announcements. Figure 3 shows the different types of partner groups represented in the Empower Innovation Network.

Figure 3: California Energy Commission Empower Innovation Network Platform



Source: Empower Innovation, an initiative funded by the CEC, https://www.empowerinnovation.net/

CHAPTER 3:
EPIC Budget

This chapter summarizes the CPUC-authorized budget for the CEC's EPIC Program, as well as funding commitments and encumbrances, dollars spent on program administration, and other budget-related topics.

Authorized Budget

The CPUC approved the following overall budget totals for each of the following investment plans:

- *EPIC 3 Investment Plan* (2018–2020): $444,000,000
- *EPIC 4 Interim Investment Plan* (2021): $148,000,000
- *EPIC 4 Investment Plan* (2022–2025): $592,000,000

These totals include the amount allocated for CEC EPIC administration activities. Summaries of these investment plan budgets, divided by program area or funding initiative, can be found in Appendix A (Tables A-3 through A-5b). While the focus of this annual report is to align project reporting with the *EPIC 4 Investment Plan*, many projects in 2024 were funded from the *EPIC 3 Investment Plan* under differently titled but comparable objectives and initiatives.

Funding Commitments and Encumbrances

To clarify the difference between commitments and encumbrances for EPIC, the CPUC adopted the following definitions in Decision 13-11-025:

> "'Committed funds' are funds identified during the planning of a solicitation for a specific project that will be needed to fund a contract or grant for that project at the conclusion of a planned or released solicitation . . . 'Encumbered funds' are funds that are specified within contracts and grants signed during a previous triennial investment plan cycle and associated with specific activities under the contract or grant. All activities carried out under a contract or grant during a specific triennial investment plan cycle need not be completed, and funds need not be spent during that program cycle if the activities undertaken pursuant to the contract or grant are expected to be completed. Only funds that are committed or encumbered during the prior program cycle are eligible for being rolled into the following program cycle."[43]

43 California Public Utilities Commission. 2013. Ordering Paragraphs 44 and 45. Decision Addressing Applications of The California Energy Commission, Pacific Gas and Electric Company, San Diego Gas & Electric Company And Southern California Edison Company For Approval Of Their Triennial Investment Plans For The Electric Program Investment Charge Program For The Years 2012 Through 2014. https://docs.cpuc.ca.gov/publisheddocs/published/g000/m081/k773/81773445.pdf.

As of December 31, 2024, the CEC has committed 100 percent of the approved project funding for the EPIC 4 Interim and 2021–2025 Investment Plans and encumbered about 45 percent of those funds. Table A-7 in Appendix A provides a summary of encumbered funding for all EPIC cycles to date.

Approved Awards in 2024

In 2024, the CEC approved 43 new projects at CEC Business Meetings, totaling more than $149 million in investments.

Direct Awards Made Through an Interagency Agreement or Sole Source Method

As of December 31, 2024, CEC approved four direct project awards through either an interagency agreement or a sole source. Table A-9 in Appendix A summarizes these projects as well as the action of the Joint Legislative Budget Committee.

Follow-On Project Awards

Public Resources Code Section 25711.5(f)(8) requires the CEC's EPIC Annual Report to provide "[a] brief description of each project for which follow-on funding was awarded in the immediately prior calendar year, including the amount of follow-on funding awarded for the project and the method and criteria used to select that project." Requirements for noncompetitive follow-on funding awards are set forth in Section 25711.5(h)(4)(A).

As of December 31, 2024, the CEC had approved 13 follow-on projects since 2011, totaling more than $76 million. These projects were initially awarded EPIC project funds through competitive solicitation. CEC staff identified grant recipients who could best leverage and benefit from follow-on funding based on prior project performance, policy impact, and statutory requirements. The CEC then invited those grantees to submit a proposal for follow-on funding. A CEC technical evaluation committee then evaluated the proposals and recommended whether the project merited a follow-on award. The proposed follow-on agreement was subsequently considered for approval at a CEC Business Meeting. Details for the 13 follow-on projects and the statutory criteria that authorize CEC to award EPIC project funds to follow-on projects can be found in Tables A-10 and A-11 in Appendix A.

Funding Shifts

In prior EPIC investment plans, EPIC administrators were required to obtain CPUC approval if seeking to shift more than five percent of budgeted funds from one funding category or program area to another existing or new category or program area within an approved EPIC triennial investment plan.[44] However, Decision 21-11-028, Ordering Paragraph 9, updated that requirement. Beginning with the 2021-2025 *EPIC 4 Investment Plan*, the CEC is "authorized to

44 California Public Utilities Commission. 2013. Decision Addressing Applications of The California Energy Commission, Pacific Gas And Electric Company, San Diego Gas & Electric Company And Southern California Edison Company For Approval Of Their Triennial Investment Plans For The Electric Program Investment Charge Program For The Years 2012 Through 2014.

reallocate up to 15 percent of funds among each of their approved initiatives without additional [CPUC] approval."

In 2024, the CEC did not shift or apply to shift more than 15 percent of funds between funding categories or program areas or to new categories or program areas. Appendix A Tables A-13 through A-15 summarize the shift of funds for each open EPIC investment plan (2018–2020 EPIC 3 Investment Plan, 2021–2025 Interim EPIC 4 Investment Plan, and 2021–2025 EPIC 4 Investment Plan, respectively) as of December 31, 2024.

Uncommitted and Unencumbered Funds

Uncommitted funds are those not committed during the planning of a solicitation. Unencumbered funds meet one of the following conditions:

- The funds are committed but have not been encumbered.
- After funds were encumbered, the funds were disencumbered for projects in which the encumbrance period had expired. This includes projects canceled or terminated with no CEC EPIC funds spent, or projects amended to reduce the original budget. No projects were terminated in 2024.

As of December 31, 2024, there were no uncommitted funds from the first, second, third, or fourth EPIC investment plans. Table A-7 in Appendix A summarizes the unencumbered project funds for each EPIC investment plan. CEC plans to encumber the balance from the 2021–2025 investment plans by June 30, 2027. Chapter 5 provides a list of anticipated solicitations for 2025.

Interest Accrual

In 2024, the CEC accumulated about $17.9 million in interest from all funds in the EPIC account. Because of administrative limitations, instead of returning accumulated interest, the CEC takes accumulated interest into account when submitting invoices to the IOUs. After the accumulated interest is determined for the prior year, the CEC subtracts the amount of accrued interest from invoices it submits to the IOUs.[45]

45 Ibid.

CHAPTER 4:
EPIC Projects

Through EPIC, the CEC funds innovations in clean energy technologies and solutions to advance the safety, reliability, sustainability, and affordability of California's electricity system for the benefit of ratepayers. Using a competitive process, the CEC awards EPIC funds to projects that will accelerate the achievement of California's ambitious clean energy, GHG reduction, and climate adaptation policies.

The EPIC strategic portfolio of public-interest projects will support a faster, lower-cost, and more inclusive transition to 100-percent clean energy by supporting entrepreneurship and deployment of clean energy technologies in California communities and providing public access to data and lessons learned.

EPIC advances innovations for resilience and safety, energy equity and affordability, and decarbonization of California's building, industrial, agricultural, water treatment, transportation, and electricity sectors. Since the beginning of the EPIC Program, the CEC has funded 543 project awards, investing about $1.4 billion to benefit California electricity ratepayers.

Summary of Project Data and Information

Appendix C of this report includes a detailed list of CEC's EPIC-awarded projects from the inception of the program through December 31, 2024. Additional project information is available on the Energize Innovation Project Showcase (https://www.energizeinnovation.fund/projects).

Appendix B (Tables B-1 through B-5) provides summaries for each EPIC investment plan, including the number of active, completed, and terminated (with funds spent) projects and total funding for 2024, broken out by strategic objective and initiative. Projects span from the first EPIC investment cycle, starting in 2012, through the current EPIC 4 investment cycle. Several projects are funded from multiple investment plans, or multiple strategic objectives and initiatives, or a combination. Appendix D provides a comprehensive list of the associated agreement number, investment plan, strategic objective, and funding initiative for projects in 2024.

In 2024, grant recipients completed 45 EPIC projects and submitted final project reports to the CEC. Once approved, finalized, and formatted for digital accessibility, each final project report is published on the CEC website at the Research and Development Reports and Publications Web page (https://www.energy.ca.gov/energy-rd-reports-n-publications). Table A-12 in Appendix A contains information about the final report status and links to published reports for projects completed in 2024.

Description of Projects by Strategic Objective

The sections that follow provide 2024 project overviews categorized by *EPIC 4 Investment Plan*[46] strategic objective. While not a comprehensive list of all projects funded and active in 2024, these sections showcase successes, challenges, lessons learned, and next steps from across the CEC's EPIC portfolio. To view detailed project data and information for all projects funded by EPIC through 2024, see Appendix C or the Energize Innovation Project Showcase.

Strategic Objective 1: Accelerate Advancements in Renewable Generation Technologies

Introduction

Strategic Objective 1, "Accelerate Advancements in Renewable Generation Technologies," focuses on R&D activities that advance key renewable energy technologies in support of SB 100 (De León, Chapter 312, Statutes of 2018) implementation. The objective includes two strategic initiatives: one for non-variable forms of renewable energy and one for variable forms of renewable energy. The four primary areas of CEC investments focus on offshore wind, biomass, geothermal, and solar PV energy generation.

Technologies that promote the growth and commercialization of renewable and zero-carbon energy sources are essential to meeting the state's 2045 climate goal of providing 100 percent clean electricity. Investing in research to speed the development of cutting-edge renewable generation technologies will result in reduced GHG emissions. Moreover, such investments can help lower renewable generation technology capital and operational costs, increase energy output, and improve the value proposition. All of these anticipated effects are key to implementing these technologies at scale and accelerating progress toward California's climate goals.

Progress and Successes

Significant progress under this strategic objective occurred in 2024. The 2024 research milestones are described by strategic initiative below.

Strategic Initiative: Advance Renewable Generation Technologies

FOSW

FOSW energy is poised to play an important role in diversifying California's clean energy portfolio, helping to advance climate goals. Assembly Bill 525 (Chiu, Chapter 231, Statutes of 2021) mandated CEC's *Offshore Wind Energy Strategic Plan*, which established OSW

46 Lew, Virginia, Anthony Ng, Mike Petouhoff, Jonah Steinbuck, Erik Stokes, and Misa Werner. 2023. The Electric Program Investment Charge 2021–2025 Investment Plan: EPIC 4 Investment Plan. California Energy Commission. Publication Number: CEC-500-2021-048-CMF-REV, https://www.energy.ca.gov/publications/2021/electric-program-investment-charge-2021-2025-investment-plan-epic-4-investment.

aspirational planning goals of 2 to 5 gigawatts (GW) for 2030 and 25 GW for 2045.[47] The U.S. DOE as of 2024 recognizes R&D as essential to achieving critical cost reductions for FOSW development, with a focus on technology, materials, and manufacturing advancements.[48]

On November 5, 2024, CEC staff hosted a webinar for more than 170 external attendees to provide an overview of seven EPIC-funded projects advancing FOSW designs and related technologies for environmental protection. The projects total $20.8 million in investment and were awarded in 2023 to support the design of mooring lines and anchors that secure FOSW turbines, as well as biological monitoring technologies. These projects include:

- EPC-23-003: $3.7 million awarded to Sperra, formerly RCAM Technologies, to develop two concrete anchor designs (suction and torpedo) for FOSW turbines using low-cost automated manufacturing methods.
- EPC-23-007: $3.4 million awarded to Triton Anchor to develop a cost-effective, high-uplift capacity anchoring system for FOSW turbines that ensure turbine foundations remain secure and stable.
- EPC-23-005: $3.2 million awarded to the University of Maine System to develop a taut-synthetic mooring system for deep-water FOSW turbines, with emphasis on reducing hardware and connections and increasing ease of installation, ultimately lowering costs.
- EPC-23-008: $2.5 million awarded to Alliance for Sustainable Energy, LLC, to develop comprehensive shared mooring system solutions that minimize costs, failure risks, and environmental impacts.
- EPC-23-001: $3.5 million awarded to Integral Consulting, Inc., to develop and integrate radar, 3D thermal tracker imaging, and blade-mounted sensors to detect and categorize seabird and bat flight patterns and collision avoidance maneuvers.
- EPC-23-002: $3.5 million awarded to LBNL to develop fiber optic sensors and advanced underwater acoustic sensors to monitor marine mammals.
- EPC-23-006: $2 million awarded to California State Polytechnic (Cal Poly) University, Humboldt, Sponsored Programs Foundation to develop sensing technologies and remotely operated vehicles that detect wildlife collisions and entanglement hazards.

In August 2024, NOWRDC released a competitive grant opportunity, following its block grant agreement under EPIC (EPC-22-009). The agreement leverages co-funding from states and federal agencies, such as U.S. DOE, New York, Massachusetts, and BOEM, to advance FOSW technologies. Grant applications were due in November 2024, and EPIC-funded subawards will be considered at a CEC Business Meeting in 2025.

47 Jones, Melissa, Jim Bartridge, and Lorelei Walker. 2024. Assembly Bill 525 Offshore Wind Energy Strategic Plan. California Energy Commission. Publication Number: CEC-700-2023-009-V1-CMF, https://www.energy.ca.gov/publications/2023/ab-525-offshore-wind-strategic-plan.

48 U.S. Department Of Energy. 2024. "Floating Offshore Wind Shot: Progress and Priorities," https://www.energy.gov/eere/wind/floating-offshore-wind-shot-progress-and-priorities.

Furthermore, CEC staff issued two RFIs in 2024 to improve understanding of deep-water FOSW, particularly the challenges and opportunities related to HVDC substations[49] and entangled debris monitoring technologies.[50] These RFIs guided the development of a $12 million solicitation released in February 2025, to *Advance Designs and Analysis of HVDC Substations and Environmental Monitoring for Floating Offshore Wind* (GFO-24-307). Staff also released a cost-share opportunity for a U.S. DOE Funding Opportunity Announcement (FOA, DE-FOA-0003334). The CEC issued an intent to award five projects. If federal grants are awarded, more than $15 million in federal funding would be leveraged from about $2 million in state ratepayer investments.[51]

The CEC published final reports for two OSW-related agreements in 2024, including for EPC-19-009, *A Numerical Modeling Framework to Evaluate Effects of Offshore Wind Farms on the California Upwelling Ecosystem*.[52] This study provided a framework for modeling the potential impacts of OSW development on upwelling, which occurs when deep, cold water rises to the surface of the ocean. The report recognizes that predictions of upwelling metrics under a variety of environmental conditions and offshore wind farm scenarios would enable the design of environmentally friendly wind farm configurations and management actions. This study has also informed subsequent evaluations funded by BOEM and the Ocean Protection Council. BOEM, in its 2024 California *Offshore Wind Draft Programmatic Environmental Impact Statement*,[53] frequently cited these two journal papers[54] resulting from this EPIC-funded project.

Solar Energy

More than 19 percent of in-state electricity generation is provided by solar resources, and CEC staff focused its 2024 variable renewable energy activity on identifying solar technology improvements. Staff conducted extensive research, held several meetings with key experts, and issued an RFI to inform a solicitation that supports solar energy development on uneven terrain, aiming to lower soft costs and ease land-use conflicts.[55] Staff analyzed the responses, conducted additional research, and anticipates releasing a grant solicitation for $6 million in

49 California Energy Commission. 2024. Request for Information Deep-Water High-Voltage Direct Current (HVDC) Substations for Offshore Wind, https://efiling.energy.ca.gov/GetDocument.aspx?tn=257721&DocumentContentId=93622.

50 California Energy Commission 2024. Request for Information: Entangled Debris Monitoring for Floating Offshore Wind Infrastructure, https://efiling.energy.ca.gov/GetDocument.aspx?tn=258498&DocumentContentId=94528.

51 California Energy Commission. 2024. "Notice of Letter of Intent," https://www.energy.ca.gov/sites/default/files/2024-10/GFO-21-901_FOA-3334_NOLOI_Results_Table_2024-10-22_ada.xlsx.

52 Raghukumar et al. California Energy Commission. 2024. A Numerical Modeling Framework to Evaluate Effects of Offshore Wind Farms on the California Upwelling Ecosystem. California Energy Commission. Publication Number: CEC-500-2024-006, https://www.energy.ca.gov/sites/default/files/2024-02/CEC-500-2024-006.pdf.

53 BOEM. 2024. California Offshore Wind Draft Programmatic Environmental Impact Statement. BOEM, https://www.boem.gov/renewable-energy/state-activities/20241021capeisvoli508c).

54 Raghukumar K., C. Chartrand, G. Chang, L. Cheung, and J. Roberts. 2022. "Effect of Floating Offshore Wind Turbines on Atmospheric Circulation in California." Frontiers in Energy Research 10, https://www.frontiersin.org/journals/energy-research/articles/10.3389/fenrg.2022.863995/full.

55 California Energy Commission. 2024. Request for Information Solar on Uneven Terrain, https://efiling.energy.ca.gov/GetDocument.aspx?tn=256700&DocumentContentId=92516.

2025. Staff also released a cost-share opportunity for a U.S. DOE FOA,[56] but no projects selected by CEC were ultimately awarded from this FOA.

The CEC published three final reports in 2024 relating to solar innovations, including for EPC-19-004, "High-Efficiency Perovskite Tandem Modules with Resilient Interfaces." This agreement successfully developed perovskite-on-silicon tandem solar cells using silver-free conductive adhesives, moving toward an efficiency of greater than 32 percent while reducing environmental impacts. The final report from EPC-19-002, *"Smart Greenhouse": Integrated Photovoltaics/Photosynthesis for Energy and Food,*[57] summarizes the project's successful integration of photovoltaics into a greenhouse roof using semitransparent organic solar cells, demonstrating increased plant growth while generating clean electricity. EPC-19-003's final report, *Processing and Architecture Design to Develop and Demonstrate Stable and Efficient Perovskite+Silicon Tandem Modules*,[58] describes how the project demonstrated stable perovskite solar cells and panels and scaled up to high-throughput industrial processes and commercial quality performance.

Strategic Initiative: Non-variable Renewable Energy

Bioenergy

Dead and dying trees can elevate the risk of catastrophic wildfires, which pose a significant threat to human safety, health, and the environment. Federal and state forest services, fire officials, local air districts, landowners, and rural communities, among others, have expressed a need to develop methods for turning forest biomass into value-added products, which in turn improves the cost-effectiveness of removing dead and dying trees. The CEC initiated EPIC's bioenergy portfolio in 2016 in response to Governor Edmund G. Brown Jr.'s emergency proclamation on the tree mortality epidemic.[59] EPIC supports four bioenergy research projects to demonstrate and evaluate environmentally and economically sustainable woody biomass-to-electricity systems. In 2024, these projects made progress on permitting, construction, installation, and funding, including additional funding from federal, state, and local government agencies to expand the initial EPIC-funded work.

- EPC-17-042: Camptonville Community Partnership secured a $8.3 million low-interest loan and a $7 million grant in 2024 from the Yuba Water Agency for the development and construction of the 5-megawatt (MW) Engeman Camptonville Biomass-to-Energy Plant. This additional funding supports the advancement of a low-emission, low-water-

56 California Energy Commission. 2023.GFO-21-901, "Cost Share for Federal Clean Energy Funding Opportunities" https://www.energy.ca.gov/solicitations/2022-03/gfo-21-901-cost-share-federal-clean-energy-funding-opportunities.

57 Yang, Yang, Ying Zhang, Yepin Zhao, and Jinsung Kim. 2023. "Smart Greenhouse": Integrated Photovoltaics/ Photosynthesis for Energy and Food. California Energy Commission. Publication Number: CEC-500-2024-017, https://www.energy.ca.gov/publications/2024/smart-greenhouse-integrated-photovoltaics-photosynthesis-energy-and-food.

58 Colin Bailie. 2023..Processing and Architecture Design to Develop and Demonstrate Stable and Efficient Perovskite+Silicon Tandem Modules. California Energy Commission. Publication Number: CEC-500-2023-057, https://www.energy.ca.gov/sites/default/files/2023-10/CEC-500-2023-057.pdf.

59 State of California. 2015. News release. "Governor Brown Takes Action to Protect Communities Against Unprecedented Tree Die-Off," https://archive.gov.ca.gov/archive/gov39/2015/10/30/news19180/index.html.

use, woody biomass power plant that is expected to process unsellable woody material from forest management and restoration activities in the Yuba River watershed. The generated power will support the community in the Camptonville area of Yuba County.

- EPC-17-021: Mariposa County Resources Conservation District received $2 million from the California Department of Forestry and Fire Protection for grading and installation of a water tank and hydrant at the biomass-to-energy conversion site in Mariposa (Mariposa County). Mariposa County Resources Conservation District also received $10 million from U.S. DOE to support the planning, design, permitting, construction, and operation of the biomass power plant, which can lower the risk of wildfires by providing an end use and regional market for forest thinning efforts. This project secured conditional use, building, and grading permits in 2024.
- EPC-17-019: The Burney-Hat Creek Bioenergy Project, led by Fall River Resource Conservation District, is in the final phases of completing the bioenergy power plant, including conducting cold commissioning[60] and receiving feedstock onsite. The project anticipates full commissioning and commercial operation by the middle of 2025, and the CEC has pre-certified this facility as eligible for California's Renewables Portfolio Standard (RPS).[61] In 2024, the facility received $2 million from the California Department of Forestry and Fire Protection to fund woody biomass transport and forest restoration and will receive about one-third of U.S. DOE's $30 million grant for West Biofuels' Community Scale Rural Bioenergy Facilities project. The U.S. DOE grant will support construction verification, operation, maintenance, and engagement activities.
- EPC-14-033: The North Fork Bioenergy Project, led by Watershed Research and Training Center, completed installation of the power plant's major structures, equipment, and instrumentation in 2024. The human-machine interface system[62] of the power plant is operational and supports troubleshooting and commissioning of the electrical distribution system as part of cold commissioning activities. Piping, mechanical and electrical systems, site cleanup, paving, fencing, and contractual closeout work are ongoing.

Geothermal and Lithium Recovery

More than 5 percent of California's in-state electricity generation is provided by geothermal resources.[63] Moreover, geothermal resources in the Salton Sea area of Imperial County have significant stores of lithium, a mineral used in batteries for EVs and energy storage. A 2024

62 A system that enables operators to interact with the machinery and control systems of the power plant.

63 California Energy Commission. 2023. "2023 Total System Electric Generation," https://www.energy.ca.gov/data-reports/energy-almanac/california-electricity-data/2023-total-system-electric-generation.

LBNL study estimated that the Salton Sea area possesses enough lithium to produce 11.3 million EV batteries per year.[64]

About 95 percent of the world's lithium is produced in just four countries — Australia, Chile, China, and Argentina — through either hard-rock mining or large evaporation ponds. These methods result in significant environmental impacts. While California has a substantial lithium resource contained in the mineral-rich geothermal brine that lies deep underground in the Salton Sea area of Imperial County, research and demonstration projects are needed to scale up and improve the cost-effectiveness of the recovery process. Direct lithium recovery in-state from geothermal brine is expected to have much lower environmental impacts, better cost-efficiency and safety, and a lower footprint compared with traditional methods of sourcing lithium outside California.

In-state lithium production may also lead to new manufacturing facilities across the battery supply chain and can increase tax revenues to benefit local communities. Advancing geothermal brine-related technologies to enable lithium recovery and improve the economics of geothermal power plants is therefore important for meeting California's clean energy goals.

In 2023, staff conducted extensive research, met with key experts, and issued an RFI to develop a $23 million solicitation relating to geothermal energy and mineral recovery from Salton Sea geothermal brines. In January 2024, staff released GFO-23-304 and received nine proposals. The first proposed award, "Integrated Smart Brine Management Approach to Reduce Geothermal Plant Operating Costs and Improve Mineral Recovery," was approved in December to fund development and demonstration of an advanced computer software prediction model that can help manage and reduce the corrosion and scaling impacts of geothermal fluids on geothermal power plant components. Optimizing geothermal brine management through the modeling software may also reduce the amount of associated chemical waste, further minimizing environmental impacts.

The CEC published three final reports[65] relating to geothermal energy and lithium recovery innovations, including from EPC-19-017, *Pilot Scale Recovery of Lithium from Geothermal Brines*.[66] This project demonstrated, at pilot scale, a cost-effective integrated process for recovering lithium from geothermal brines using a new high-capacity selective sorbent and an innovative new sorbent regeneration process. The composite sorbent comprises inorganic lithium-ion sieves and lithium-ion-imprinted polymers. The new sorbent regeneration process

64 Lew, Virginia, Ng, Anthony Petouhoff, Mike, Jonah Steinbuck, Erik Stokes, and Misa Werner. 2023. The Electric Program Investment Charge 2021–2025 Investment Plan: EPIC 4 Investment Plan. California Energy Commission. Publication Number: CEC-500-2021-048-CMF-REV. https://www.energy.ca.gov/publications/2021/electric-program-investment-charge-2021-2025-investment-plan-epic-4-investment.

65 Ventura, Susanna, Srinivas Bhamidi, Marc Hornbostel, Anoop Nagar. 2020. Selective Recovery of Lithium from Geothermal Brines. California Energy Commission. Publication Number: CEC-500-2020-020, https://www.energy.ca.gov/sites/default/files/2021-05/CEC-500-2020-020.pdf.

Fleming, Christina. 2024. BHERM — Lithium Recovery Demonstration Final Project Report. California Energy Commission. Publication Number: CEC-500-2024-094, http://www.energy.ca.gov/sites/default/files/2024-08/CEC-500-2024-094.pdf.

66 Anoop, Nagar, Susanna Ventura, Srinivas Bhamidi, and Marc Hornbostel. 2024. Pilot Scale Recovery of Lithium from Geothermal Brines. California Energy Commission. Publication Number: CEC-500-2024-020, https://www.energy.ca.gov/publications/2024/pilot-scale-recovery-lithium-geothermal-brines.

uses eco-friendly carbon dioxide and carbonic acid to directly form high-purity lithium carbonate. This project will help California meet its clean energy goals by reducing the cost and environmental impacts associated with geothermal energy generation.[67] Developing geothermal resources in Imperial County could also result in the creation of 7,000–9,000 new jobs, with many likely paying higher wages than the region's average.[68]

Impediments and Setbacks

EPIC's bioenergy and geothermal research efforts have faced challenges. For bioenergy projects, interconnection queues and permitting issues have consistently delayed project timelines and increased costs. Second, bioenergy projects have difficulty securing funding given the high capital costs associated with constructing bioenergy power plants. Last, the multiyear construction timelines for these large infrastructure projects make them particularly susceptible to delays caused by long equipment lead times and supply chain issues. During the pandemic, for example, essential components for bioenergy projects were delayed due to global supply chain disruptions. These challenges have led to agreement term extensions, and promising outcomes are only just emerging from agreements initiated years earlier.

For bioenergy projects, communities have raised concerns regarding combustion-based generators, which convert the gas produced by the gasifier systems into renewable electricity. The CEC takes these concerns seriously. The EPIC-funded systems all plan to meet or exceed local air district standards for stationary power generation. Through community engagement and education, many of these projects have garnered significant local community and local government support, such as the grant and loan from Yuba Water Agency for the Camptonville project referenced above.

Lithium recovery from geothermal brine requires field demonstrations to accurately test methods and technologies. The volatile properties of active geothermal brine depend highly on temperature, pH, and flow rate, all of which change if the brine is shipped to a lab. As a result, grant recipients must work with one of only three geothermal developers and operators in the Salton Sea region. These developers are focused on near-term commercialization, which may not be compatible with R&D activities due to timing and infrastructure needs. Several experts have expressed interest in a geothermal test well that will enable all technology providers to have a venue for improving cost and efficacy; however, no leading organization willing to share access to its site has been identified, nor has a funding source for such a test well. As a result of a timing mismatch between ongoing commercial scale development and R&D efforts, one EPIC-funded project was mutually terminated in 2023, and another project anticipates a site change in 2025.

Next Steps

Building on the two FOSW RFIs, *Deep-Water High-Voltage Direct Current (HVDC) Substations for Offshore Wind* and *Entangled Debris Monitoring for Floating Offshore Wind Infrastructure,*

67 Ibid.

68 Summit Blue Consulting. 2008. Renewable Energy Feasibility Study Final Report, https://www.iid.com/home/showpublisheddocument/3896/635648001335730000.

staff collected valuable input to guide solicitation development and released a $12 million grant solicitation in February 2025, titled *Advancing Designs and Analysis of HVDC Substations and Environmental Monitoring for Floating Offshore Wind* (GFO-24-307). Staff also expects making FOSW subawards under Grant Agreement EPC-22-09 that will be considered for approval at a 2025 CEC Business Meeting. The grant solicitation, titled *Geothermal Energy Operations and Lithium Innovation* (GFO-23-304), awarded four projects, one of which was approved at the CEC December Business Meeting. As of December 2024, the remaining funds are pending approval at upcoming CEC Business Meetings. Staff continues to regularly monitor U.S. DOE activity in 2025 and will evaluate FOAs for possible cost-share opportunities.

Strategic Objective 2: Create a More Nimble Grid to Maintain Reliability as California Transitions to 100 Percent Clean Energy

Introduction

Most energy storage systems today use LIB technologies that provide capacity for up to four hours, covering intermittency with renewable generation. Achieving 100 percent zero-carbon electricity cost-effectively will require innovations in these short-duration energy storage systems, in addition to LDES, which has the potential for 8 to 100 hours of firm dispatch, and seasonal energy storage, which may offer days or weeks of capacity.

Similar to the grid services that LDES can provide, zero-carbon fuels, including hydrogen gas or methane gas derived from biomass, have the potential to serve as clean, firm dispatchable resources when paired with devices that can convert them into electricity, such as fuel cells or gas turbines. Grid modernization — particularly to address grid congestion, enable the installation of more inverter-based resources, and enhance cybersecurity — will require a nimbler electric grid, futureproofed to manage increased variable generation and connection points.

Progress and Success Stories

Strategic Initiative: Clean, Dispatchable Resources

Zero-Carbon Fuels

The use of carbon-neutral fuels such as biomass and biofuels, as opposed to fossil energy sources, can have long-term positive impacts on the state's carbon footprint while reducing fire risk and offering economic opportunities.

West Biofuels, a California-based company focused on thermochemical biomass technology, is deploying its technology and expertise toward EPIC-funded bioenergy projects in Burney in Shasta County (EPC-17-019) and Mariposa in Mariposa County (EPC-17-021). Advancements in, and funding leveraged by, these projects in 2024 are described in the previous section detailing Strategic Objective 1.

The Forest Resource and Renewable Energy Decision Support System tool became publicly available on UC Davis's project Web page (https://forestdss.ucdavis.edu/pages/home) in 2024. The tool can assess long-term feedstock availability of forest biomass and assist preliminary

planning of more complex project feasibility studies. The research team intends to expand the functionality of this tool under a future project to include regional competitive analysis, risk assessment, additional supply chain and logistics options, and other enhancing features, as detailed in the final report of the project. The CEC also began efforts to advance clean dispatchable resources in 2024, launching a competitive solicitation in May and announcing a notice of proposed awards totaling nearly $8 million in EPIC funds in December for two projects that use biogas with onsite electric generation.

The first of these, Silicon Valley Clean Water, in partnership with Stanford University, will develop and demonstrate an integrated microgrid system that will flexibly dispatch clean, renewable generation from three biogas-fueled linear generators at a municipal wastewater treatment plant. The innovation lies in the Biogas Microgrid Controller that coordinates the energy recovery, generation, and wastewater treatment for the wastewater recovery resource facility at the facility scale. The Biogas Microgrid Controller operates as an integrated control system to enable a cohesive BTM microgrid for the wastewater facility's biogas electricity generation, battery energy storage, and electric loads. The controller uses AI and process models to automatically adapt control logic to changing conditions and provide robust filters to relay safe setpoint commands to the energy resources of a facility.

In addition, the project will include the deployment of three linear generators from Mainspring Energy with a nameplate capacity of 750 kW. The generators will provide their electricity onsite and be powered by excess biogas, which is currently being flared, from the anaerobic digester of the facility, thereby reducing GHG and pollutant emissions from the avoided flared gas. As a result, the project will meet 100 percent of the electric demand of the facility, reduce the peak demand of the facility by 600 kW, provide 100 to 250 kW of demand response capacity to the California grid, and eliminate on-site biogas flaring, which could reduce local air emissions in the surrounding disadvantaged community by up to 1,230 tons per year. The Biogas Microgrid Controller, which builds on previously funded work by U.S. DOE, offers numerous potential benefits locally through this project and more widely through potential scaling and replication.

The second grant was awarded to GTI Energy, which, in partnership with Mainspring Energy and 44 Energy, will develop and demonstrate a 250-kW nameplate capacity linear generator to operate on a variety of renewable fuels, including renewable gas. The project will enhance dispatchability and integrate a heat recovery system to produce full combined heat and power, or cogeneration, capability without degrading the performance of the base generator. It will also provide BTM electricity to meet the demand of the site's critical loads to help maintain the operation of California State University (CSU), Long Beach, which is considered a critical facility and event response and recovery shelter by Federal Emergency Management Agency.[69]

Anticipated project benefits include reducing emissions, generating electricity savings of up to $0.06 to $0.09 per kWh, recovering 197 kW of waste heat, and reusing the waste heat for water heating by heating 9,311 gallons per day from 65 degrees to 135 degrees Fahrenheit. Incorporation of the linear generator will increase the overall efficiency of the system by 80

69 Federal Emergency Management Agency. "Public Facilities That Are Considered Critical," https://emilms.fema.gov/IS0815/groups/12.html.

percent. As part of the community benefits and outreach efforts, the demonstration project plans to engage and provide real-world, hands-on experience through educational co-ops to low-income and minority CSU Long Beach students. By offering one to two paid cooperatives, the project can directly impact the employability and career prospects of under-represented students in technical fields. The demonstration aims to build confidence in IOU customers to have these systems installed as either base or reserve power systems that use renewable fuels to power efficient and effective operations, leading to wider technology adoption at other educational institutions and commercial and industrial facilities.

DERs

CEC staff released a $30 million grant solicitation in June 2024 to fund technology advancements in energy storage. Funded projects will advance short- to long-duration energy storage technologies and demonstrate innovative storage use cases that will support grid reliability. The CEC received more than 90 abstracts during Phase 1 of the solicitation, highlighting the interest in innovation and need for funding in this space. Of those received, 37 abstracts are moving forward for consideration in Phase 2, and five awards are anticipated in the first quarter of 2025.

The Port of Long Beach, which received EPIC grant funds in 2018, is nearing a project milestone with plans to commission a BESS-based microgrid designed to provide critical backup power to the port's Joint Command and Control Center. In collaboration with researchers at UC Irvine, the port's microgrid operators will collect data over a one-year period to assess the performance of the microgrid in various operation modes. Despite the significant technical, supply chain, and financial challenges the project has faced over the past few years, the CEC has been gathering important lessons learned and collecting valuable operational data about how microgrids and BESS can decarbonize port infrastructure in the state.

EPIC also continues to support the integration of distributed energy systems, including through developing microgrids in partnership with California tribes. Current projects expand upon previously funded EPIC awards and leverage available federal funding. For example, EPIC support is enabling the Redwood Coast Energy Authority's Tribal Energy Resilience and Sovereignty (TERAS) project. TERAS is developing an innovative network of community microgrids with four tribes in Northern California (Hoopa Valley, Yurok, Karuk, and Blue Lake Rancheria) to enhance the region's resilience, reliability, and progress on decarbonization. Specifically, the project seeks to measurably improve distribution system performance, decrease the frequency and duration of grid interruptions, and increase grid hosting capacity at a lower cost relative to conventional transmission and distribution system hardening solutions in rural and rugged terrain threatened by wildfire.

The TERAS project was selected by the U.S. DOE for an $88 million award through the Grid Resilience and Innovation Partnership Program and is required to provide an additional $88 million in cost-share funding. EPIC is supporting the TERAS project in meeting this cost-share obligation; the CEC released a notice of letter of intent for Redwood Coast Energy Authority in April 2024 committing $6 million to Redwood Coast Energy Authority through its federal cost-share solicitation (GFO-21-901). This illustrates the critical role EPIC plays in bringing federal funding to California and supporting tribal energy sovereignty.

Another CEC grant agreement, with RedoxBlox Inc., will demonstrate important thermochemistry advancements for energy storage. The company's novel thermochemical energy storage (TCES) system, when paired with an externally fired microturbine, is a low-cost, high energy-density solution. It has been demonstrated at smaller scales to date, and this EPIC project will be the first commercial demonstration of TCES coupled with a turbine to produce electricity. The waste heat from the turbine will power an absorption chiller to produce chilled water, allowing nearly 100-percent heat utilization. This innovative project will install a TCES on the UC San Diego medical campus, located within a low-income community, and serve the surrounding designated disadvantaged communities. The system will output a minimum of 100 kW for at least 24 hours, with a longer-term goal of providing up to 40 hours of duration. The technology is one of several in the CEC EPIC portfolio demonstrating the viability of longer duration energy storage, reaching key commercialization milestones critical for scale-up, energy affordability, and attainment of California's energy goals.

EPIC also invests in VPP approaches for demand flexibility (VPP-Flex), such as the proposed IAW FlexHub, which seeks to advance load flexibility as a clean, dispatchable resource and enhance the reliability, efficiency, affordability, and sustainability of the state's energy grid and its services. VPP-Flex projects focus on demonstrating how aggregations of flexible loads, such as commercial building HVAC and lighting systems, can function as VPPs, providing capacity and grid services during peak demand periods. By integrating and coordinating diverse resources, VPPs can reduce the need for costly infrastructure expansions and new power plants, ultimately lowering energy costs and emissions for the benefit of ratepayers.

These projects also aim to explore innovative methods for enabling demand-side flexibility, supporting California's transition to a cleaner and more resilient energy system. The proposed IAW FlexHub builds on the success of previous initiatives like CalFlexHub by targeting demand flexibility in the industrial, agricultural, and water sectors. Together, these programs help California grow its demand flexibility resource to meet the state's ambitious decarbonization and energy reliability goals, which include the state's goal of doubling load flexibility to 7 GW by 2030.[70]

Strategic Initiative: Grid Modernization

As described above, the CEC's EPIC Program has an active $30 million grant solicitation, *Energy Storage Innovations to Support Grid Reliability*, to spur grid innovation. An additional $20 million of funding in the Grid Modernization Strategic Initiative is committed to a solicitation under development titled, *Advanced Grid Technology Acceleration Projects,* which will support the development and demonstration of advanced grid technologies to improve the reliability, affordability, and efficient use of electricity infrastructure. This solicitation concept is currently under review and the solicitation is tentatively planned for release in Q2 of 2025.

70 California Energy Commission. 2023. "California Adopts Goal to Make More Electricity Available Through Smarter Use." https://www.energy.ca.gov/news/2023-05/california-adopts-goal-make-more-electricity-available-through-smarter-use.

Impediments and Setbacks

Across the energy storage industry, supply chain challenges have continued to impact projects in 2024, resulting in project delays and, in some instances, necessary grant agreement extensions. Several energy storage projects extended deployment timelines due to material and manufacturing delays related to storage housing and containers.

The energy storage landscape remained volatile in 2024. In August, Australian battery company and vendor, Redflow Ltd., entered the equivalence of Chapter 11 bankruptcy in the U.S. The company was originally scheduled to deploy its 1.5 MW and 6.6 megawatt-hours (MWh) zinc-bromine flow battery in partnership with the Barona Band of Mission Indians as part of a CEC grant agreement (EPC-23-037). No CEC funds have been spent to date, and a Stop Work Order (SWO) has been issued while the Barona Band of Mission Indians identifies a replacement battery vendor. The CEC will work with the tribe to remove the SWO if a viable battery vendor capable of meeting the original requirements of the GFO is secured and approved.

Next Steps

CEC expects to encumber $400,000 of funding under the Clean, Dispatchable Resources Strategic Initiative, pending completion of Sperra's negotiations with U.S. DOE for its project, "Low-Cost 3-D Concrete Printed, Modular, Marine Pumped Hydroelectric Storage System." CEC funding will leverage $4 million in federal funds from the U.S. DOE. The project will advance marine pumped hydroelectric technology and is preparing for a fully operational grid-connected pilot demonstration at the San Pedro ports in the Port of Los Angeles.

The CEC will encumber $6 million under the Clean Dispatchable Resources Strategic Initiative pending completion of Redwood Coast Energy Authority's negotiations with the U.S. DOE for the TERAS project. These funds will be used to meet the project's federal cost share requirements. Additional funding under this initiative could serve the Blue Lake Rancheria Tribe, which installed a microgrid in 2018 that EPIC initially funded in 2015. Since then, the microgrid has continued to generate lessons learned from its operation and provide critical and, in some instances, lifesaving services to the area. Future projects propose to expand and coordinate existing microgrid operations, as well as implement hardware and software controls that enable nested community microgrids. Once this approach has been successfully piloted at Blue Lake Rancheria, it will be scaled by the Hoopa, Yurok, and Karuk Tribes with three community-scale microgrids on the currently high-risk Hoopa 1101 distribution circuit.

In late 2025, the CEC will consider committing $14 million of Clean, Dispatchable Resources funding for a solicitation on green hydrogen and zero-carbon firm dispatchable resources, following the results of the green hydrogen roadmaps under development from RAND and E3.

Strategic Objective 3: Increase the Value Proposition of Distributed Energy Resources

Introduction

Distributed Energy Resources (DERs) are key components of California's clean energy future and economywide decarbonization. They have the potential to lower operating costs for the electric grid and deliver significant benefits to grid operators and end users, particularly in a high-renewables, high-electrification future. DERs encompass distribution-connected generation, EVs, energy storage, energy efficiency, and load flexibility technologies. This strategic objective includes two strategic initiatives: 1) DER integration and load flexibility and 2) transportation electrification.

In 2024, EPIC invested in innovations in technology, market structures, and communities that increase the value and benefit of DERs to IOU customers, making a tangible impact on the affordability of electricity for Californians. Notable achievements include the opening of the first truck stop for battery electric trucks; the opening of a VPP with novel market mechanisms in a disadvantaged community; and the construction of new solar-powered microgrids to support medium- and heavy-duty (MHD) ZEV charging. Additionally, an innovative LIB recycling process moved from the lab to the pilot stage, and new LIB repurposing projects began demonstrating their technologies.

Three new projects kicked off this year seeking to demonstrate innovative power electronics to improve the value proposition of solar backup power in homes and multifamily residences (EPC-24-016, EPC-24-017, and EPC-24-018). In addition, innovative zero-emission housing developments for the Next EPIC Challenge: Reimagining Affordable Mixed-Use Development in a Carbon-Constrained Future program (Next EPIC Challenge), will begin construction in 2025.

Progress and Success Stories

Strategic Initiative: DER Integration and Load Flexibility

Community-scale Demonstrations

EPIC has funded two rounds of design-build competitions to design and demonstrate DER integration at large scales. These projects seek to reimagine and advance equitable decarbonized housing at the neighborhood and community scales through integration of a variety of DER technologies. The first funding round was for Advanced Energy Communities and awarded in part to the City of Richmond's Advanced Energy Community project (EPC-19-005). The project team, led by the nonprofit organization, ZNE Alliance, coordinated with energy provider MCE to launch a VPP pilot within MCE's service territory in 2024. The project was featured in the magazine, *California Aggregator*.[71] This VPP pilot is launching alongside a VPP tariff that will provide on-bill credits for residential and commercial customers in exchange for remote control and dispatch capability.

71 CalCCA. 2024. "Virtual Power Plants Get Real." California Aggregator. https://cal-cca.org/wp-content/uploads/2024/12/California-Aggregator-Winter-2025.pdf.

Initially, this tariff will be a flat rate, providing credits based on the number and type of DERs installed and connected to the VPP. MCE plans to introduce dynamic tariffs with the VPP, thereby allowing participants to be paid and compensated based on actual electric market values. The VPP connects DERs like solar, battery storage, EVs, electric water heaters, and heat pumps into one system that strategically adjusts electricity usage by its connected devices — ideally, to move energy demand away from peak usage periods to lower-cost, less grid-strained, off-peak times. This aggregation function increases load flexibility of the grid, lowers energy costs for ratepayers, and promotes the integration of renewable energy sources like solar by aligning demand with periods of high renewable energy generation. The pilot aims to enroll up to 100 homes — ten of which will be completely rebuilt and ultimately offered to MCE customers who are lower-income, first-time homeowners.

The second funding round includes projects under the Next EPIC Challenge Solicitation (GFO-20-305), which initially awarded grants to 11 different design concepts for zero-emission, mixed-use affordable housing developments. Projects were required to use the latest and most advanced building decarbonization technologies, electrification design tools, and construction practices. The design phase concluded in 2024. Phase II of the Next EPIC Challenge subsequently started with awards given to three design projects, selected from among the original designs, to initiate construction and installation. These projects have begun the build-out and demonstration of housing developments that are affordable, equitable, emissions-free, and resilient to climate change impacts and extreme weather events. The developments are expected to provide up to 100-percent electric bill savings to residents through a combination of onsite generation, storage, and load management.

Long Duration Storage

The company Form Energy made important strides in accelerating progress for LDES. Form received EPIC funds in 2019 to demonstrate a prototype of its iron-air battery that can provide power on the 100-hour, multi-day time scale (EPC-19-041). In 2024, Form successfully commissioned its prototype battery module, located in Berkeley, resulting from the grant. Public research funding through EPIC enabled Form to significantly improve and validate its technology. The company's next effort, partially funded from the CEC's separate LDES Program, will deploy a pilot 500-MWh iron-air energy storage system at PG&E's Redwood Valley substation in Mendocino County.

Due in part to CEC's early support, Form achieved two major milestones since September 2024. First, it completed construction of its Form Factory 1 in West Virginia. Second, the U.S. DOE Office of Manufacturing and Energy Supply Chains selected Form Energy for an award negotiation of up to $150 million under the Bipartisan Infrastructure Law's Battery Materials Processing and Battery Manufacturing program, which Form will use to expand its annual manufacturing capacity up to 20 gigawatt-hours (GWh) by 2027. In October, Form secured $405 million in Series F financing, which helps to increase the company's valuation to more than $1.2 billion. Form's innovative technology and rapid expansion, funded in part by EPIC, present an opportunity to deploy affordable, multi-day, utility-scale energy storage solutions to help California and other states use 100 percent of clean energy generated from DERs. The

company's recent achievements, seeded five years prior by EPIC, illustrate the potential impact of clean energy public research funding.

Load Flexibility

Reductions in load during hours of peak demand have exceptional value to utility operators and grid stability and thereby can provide significant benefit to ratepayers. The California Load Flexibility Research and Development Hub, known as CalFlexHub, which was partially funded with $16 million from agreement EPC-20-025, made strong progress in developing and evaluating price-responsive, flexible load end-use technologies for customers and the grid. Critical knowledge was gained from deploying a large and diverse set of laboratory and field tests to gather data on the use of hourly dynamic pricing to modify electric load shapes. The technology demonstration portfolio for the Hub has grown to 21 active or completed projects across homes, commercial buildings, campuses, and EV charging sectors.

The CPUC requires that all IOUs, large municipal utilities, and community choice aggregators (CCAs) make hourly dynamic rates available for customers by 2027 for utility bill-saving opportunities. CalFlexHub has demonstrated that automation tools streamlining receipt and response to dynamic prices may enable meaningful customer participation if they opt into such rates. Examples of demonstrated technologies include heat pump water heaters, smart thermostats, commercial HVAC systems, integrated thermal energy storage, model-predictive controls, EV charging management, and pool pumps. Field tests are taking place at more than 100 individual sites with more than 18 technology partners; about half of the sites are in either disadvantaged or low-income communities.

One specific field test example is the installation of smart thermostats at 30 single-family homes. These devices have the capability to receive and respond to 24-hour, day-ahead dynamic prices and accordingly adjust the temperature setpoints for summer precooling. This load shift delivered about 2.7 kWh energy savings per home during a two-hour target period from 6 p.m. to 8 p.m. In another project during summer 2024, 120-volt heat pump water heaters were installed at ten single-family homes that received experimental price signals through communication ports. These price signals incentivized preheating water during times of the day with low electricity rates, resulting in a 52 percent load shift away from high-price hours and a 46-percent electricity cost reduction. The results demonstrate the significant potential of these devices and technologies to improve affordability and grid operations as they achieve higher market uptake.

Deploying demand flexibility technologies broadly in concert with dynamic pricing to guide their use can provide substantial value to customers and the electric grid. Current utility dynamic rate pilots are evaluating the ability of automation service providers to reliably dispatch capacity when called upon. Valuation research has also shown that flexible technologies can reduce the late afternoon ramp, also known as the Duck Curve, which poses a challenge to grid management. Work for the CPUC based on the CalFlexHub valuation models demonstrates a technical potential of 5 to 8 GW of flexible load under wide-scale dynamic pricing in California. Achieving that potential requires accurate dynamic prices, flexible technologies, and business models to capture value.

Utilities actively collaborate with the CalFlexHub. LBNL worked with SCE under a CalFlexHub cost-share agreement to establish six research tasks, including multiple technology development efforts and demonstrations, emerging thermal storage technology analysis, and business model assessment. The CalFlexHub team has published four papers and hosted an informal session at the 2024 ACEEE Summer Study. The third CalFlexHub annual symposium in 2024 included 19 plenary and panel sessions and attracted more than 200 in-person and virtual attendees, representing more than 175 companies from 23 countries.

Strategic Initiative: Transportation Electrification

With more than 1.5 million plug-in electric vehicles (PEVs) on the road today and more than 15 million expected by 2035 to meet the state's climate goals, PEVs represent both immense load growth and a potential flexible resource to benefit the grid and ratepayers. According to the *Electrification Impacts Study*[72] prepared by Kevala for the CPUC under the High Distributed Energy Resources Proceeding, up to $50 billion of traditional distribution grid infrastructure upgrades will be needed by 2035 in unmitigated transportation electrification load scenarios. Based on the CPUC's Public Advocates Office analysis, the estimated cost of distribution grid upgrades to the IOUs by 2035 could fall to $26 billion if unnecessary upgrades are avoided and peak load is mitigated by spreading charging outside of peak hours, amongst other contingencies.[73] Advancements in enabling technologies and VGI strategies are essential to realizing the full benefits of zero-emission vehicles, such as mitigating peak load growth and reducing or deferring the need for grid upgrades to support transportation electrification. EPIC-funded transportation electrification projects are demonstrating innovations that achieve lower costs, load-flexible capabilities, and ratepayer benefits.

The electrification of MHD fleets, through their replacement of fossil-fuel trucks and unique electric consumption patterns, offers energy and non-energy benefits to IOU ratepayers, charging infrastructure developers, utilities, and local communities disproportionately impacted by transportation corridor emissions.

EPIC-funded projects under this strategic initiative are demonstrating DER solutions that facilitate faster and more cost-effective deployment of charging infrastructure for MHD electric trucks and buses. For example, EPIC funded two fully commissioned, large-scale solar microgrids to support electric truck charging infrastructure projects. The first system is located at Sysco Corporation's food distribution warehouse in the City of Riverside (EPC-20-046) and is currently finalizing its construction design. The second microgrid is located at a public electric truck stop in Bakersfield, California (EPC-21-006) and was developed by the company WattEV. After receiving its initial EPIC award in 2020, WattEV's 21st Century Truck Stop in Bakersfield finished installation in December 2024 and began testing and commissioning, making the

72 Kevala. 2023. Electrification Impacts Study, Part I: Bottom-Up Load Forecasting and System-Level Electrification Impacts Cost Estimates. https://cdn.prod.website-files.com/62a236e9692c48cff36898da/6462917ab8a790b6b85f5fbb_CPUC%20Kevala%20EIS%20Part%201.pdf

73 CPUC Public Advocates Office. 2023. Distribution Grid Electrification Model: Study and Report. https://www.publicadvocates.cpuc.ca.gov/-/media/cal-advocates-website/files/press-room/reports-and-analyses/230824-public-advocates-distribution-grid-electrification-model-study-and-report.pdf

possibility of long-range zero-emissions freight transport along the Interstate 5 and State Highway 58 corridors an achievable reality.

EPIC-funded projects also made headway on the design, permitting, procurement, and construction of three additional solar microgrids with electric truck and bus charging infrastructure. Sites are located at a transit bus depot in Gardena in Los Angeles County (EPC-20-038), a public truck stop in Ontario in San Bernardino County (EPC-20-042), and a school bus depot in San Jose in Santa Clara County (EPC-20-040).

Several projects focused on LIB reuse and recycling technologies reached new milestones in 2024. The most exemplary of these is Smartville, which reached higher technology readiness and commercialization levels under two EPIC-funded projects. Under the grant funding opportunity titled, *Low-Cost and Easy-to-Integrate Second-Life Battery HUB* (EPC-19-038), the company successfully completed a demonstration of repurposed EV batteries to support building loads at the UC San Diego Library Annex. Under the more recently awarded project, "Accelerate Development of Smartville Second-Life Battery Repurposing Platform" (EPC-22-003), Smartville successfully completed design of its second generation Smartville 360™ Second-Life BESS and established a low-rate initial production (LRIP) facility capable of assembling one fully operational unit per day.

Another project, with the San Diego State University Research Foundation, successfully commissioned a demonstration of its second-life battery energy storage system in April 2024. The project, "Cost-Effective Integration of Second-life EV Batteries with Solar PV Systems for Commercial Buildings" (EPC-19-053), installed its system at the UC San Diego Library Annex using the same battery enclosure that Smartville demonstrated in EPC-19-038.

The final project funded from the solicitation, *Enabling EV Battery Circular Economy* (EPC-19-055), led by Rejoule, obtained a fire safety permit from Los Angeles County and its second-life battery energy storage pilot system has been granted permission from the utility to operate at the American Museum of Contemporary Art in the City of Claremont.

UC San Diego's Sustainable Materials & Energy Laboratory is pioneering technology advancements in LIB recycling. The direct recycling technology under development is more efficient, scalable, and economical than current EV battery recycling methods, transforming end-of-life EV batteries from a liability to a valuable and cost-effective source of critical materials that can improve the life cycle and deployment of EVs and energy storage. The initial laboratory demonstration of this technology is near completion (EPC-21-008), with the final report expected in 2025. In April 2024, a second EPIC awarded project (EPC-23-023) to support this work successfully launched with $10 million of co-funding from U.S. DOE. The project will expand the earlier EPIC-funded effort to the pilot scale, with a goal of being able to intake and upcycle approximately 100 kilograms of second-life EV batteries per day. This innovative process can more effectively regenerate critical cathode materials from both manufacturing scraps and spent batteries, reducing costs and delivering ratepayer benefits.

Impediments and Setbacks

CEC originally awarded four Phase II Next EPIC Challenge projects. However, the "Santa Ana Environmental Justice Innovation Zone" (EPC-21-022) project by Innovative Housing Solutions

was canceled prior to agreement execution due to the sale of half of the proposed development site. CEC plans to reallocate those designated funds to another successful design project from Phase I. Another Next EPIC Challenge Phase II awardee, for the project, "Net Positive Resilient All-Electric Affordable Housing at the Corona Station Residence in Petaluma" (EPC-21-028), relocated its site from the City of Santa Cruz to the City of Petaluma during the design phase to improve the project's expected affordability of the housing units planned for construction.

The challenges for CalFlexHub center on the lack of an existing dynamic pricing program in the state. Customers want predictable and affordable utility bills, but current research shows that customers see opting into dynamic pricing rates as risky. To address this enrollment problem, customers will likely need bill protection and a "counterfactual bill" to trust third parties to deliver bill savings for participating in a dynamic pricing program. Other customer concerns include understanding the user interface of the technology and trusting the technology vendor. Enabling large-scale adoption of automated, dynamic, and price-responsive devices and technologies will remain challenging until these issues are addressed.

Many EPIC-funded companies working to commercialize the use of second-life EV batteries for stationary applications are still in the process of obtaining UL certifications, specifically UL 1974, a prerequisite for UL 9540 and UL 9540A, which is typically required for fire safety permits. All relevant EPIC recipients expressed that the current UL 1974 certification requirements are cumbersome and do not scale well. ReJoule is following UL 1974 procedures wherever possible and is seeking full certification under its recently awarded federal cost-share agreement. Without these certifications, ReJoule satisfies its fire department requirements by submitting not only a detailed hazard mitigation report and a request for alternate means and methods, but also a computational fluid dynamics analysis of thermal runaway testing performed by a nationally recognized testing laboratory. RePurpose Energy is also pursuing UL 1974 certification and developed a proprietary fire suppression system that meets UL 9540 requirements.

EV battery repurposing projects and companies, like Smartville, also faced challenges in establishing a reliable supply chain for end-of-life EV batteries, particularly in coordinating with original equipment manufacturers and vendors to ensure the safe delivery of batteries for repurposing. SB 615 (Allen and Min), introduced in the state Legislature in 2023, provided one possible solution to this problem by requiring vehicle battery suppliers to report specified information about their batteries to the California Department of Toxic Substances Control and to fully fund the collection cost of batteries for which they are required to ensure end-of-life management. The bill passed the Legislature in September of 2024 but was vetoed by the Governor. The reason for the veto stems from the significant burden SB 615 would place on the California Department of Toxic Substances Control (rather than EV suppliers and others) to enforce the bill's requirements and establish a method for reporting EV battery transactions.

As battery repurposing companies supported by the CEC have attempted to transition to full-scale commercialization of their technologies, challenging market conditions, such as competition with new batteries produced with virgin materials and difficulty securing private capital to support scale-up and continued R&D, have slowed progress. These issues highlight

the need for continued innovation, stronger industry collaboration, and more conducive market conditions to support future battery repurposing initiatives.

Projects demonstrating V2B technologies encountered several common challenges that highlight the nascent market's need for clearer utility guidelines and stronger manufacturer support. One challenge was submetering, including the lack of IOU-certified meter data management agents (MDMAs) and the prohibition of submetering for net energy metering (NEM) customers. Other challenges comprised delays in UL 1741 SB certification for bidirectional-capable EV supply equipment (EVSE) and interoperability issues between EVSEs, PEVs, and backend software.

Submetering of EVSE for V2B technologies would improve the financial case to install these technologies but has proven challenging given current regulations and the lengthy time it has taken the IOUs to develop submetering plans. This specifically caused problems on Gridtractor's on-farm mobile microgrid project (EPC-22-004). Submetering is defined in CPUC Decision 22-08-024 as "arrangements in which a submeter measures Electric Vehicle charging apart from the primary meter." It differs from a separate meter in that a submeter is located on the customer side of the meter and allows the IOU to use separate rates for the main meter and submeter on the same customer bill. An MDMA is required for customers to participate in submetering, but potential MDMAs have been reluctant to sign up because of concerns with cumbersome requirements, such as the annual field testing of submeters.

Currently, no MDMAs are approved by the IOUs for submetering. Submetering is also not allowed for customers on NEM rates. The CPUC did not approve submetering for customers on NEM rates in Decision 22-08-024, due to concerns about the complexity of billing customers accurately. On-the-ground learnings through EPIC projects like EPC-22-004 have been shared with CPUC and may contribute to future revisions of the submetering protocol. CEC also seeks to fund projects to address the "lack of access to cost-effective, accurate, and flexible submetering solutions" in GFO-24-302, which is referenced below.

Several projects were impacted when they did not meet CPUC's Electric Rule 21 (Rule 21) requirements, which govern how generation facilities can connect to an IOU's distribution grid or required unexpected grid upgrades.

Multiple EPIC-funded bidirectional charging projects experienced confusion with the applicability of Rule 21 for backup-only V2B use cases. For example, one project with the Center for Transportation and the Environment (EPC-22-006) aims to demonstrate bidirectional charging with an electric transit bus to provide backup power to a community center and bus depot. The team originally sought to demonstrate this use case without applying for Rule 21 interconnection. However, the team learned that this would prohibit the bidirectional charger from operating when the grid is operational, even for unidirectional charging. The team decided to pivot and apply for Rule 21 interconnection. Bidirectional charging projects have also been impacted by industry delays in offering bidirectional EVSE products certified to UL 1741 SB as required by Rule 21, with few exceptions and challenges resolving interoperability issues.

The lack of existing utility infrastructure coupled with restrictive grid interconnection rules led MHD vehicle-charging infrastructure developers to pursue less-than-ideal solutions to power their sites. On WattEV's 21st Century Truck Stop project (EPC-21-006), lack of existing utility infrastructure led the company to pursue a fully off-grid charging solution with its 25 MW microgrid. They initially sought up to 25 MW of charging capacity from the utility but were only approved for approximately 5 MW of charging capacity. To receive more power for charging capacity, a new substation would have been required, and this would have substantially delayed completion of the project. Restrictive grid interconnection rules also limited the 21st Century Truck Stop. WattEV decided not to interconnect its 4-MW solar PV array with the utility's electrical grid because it was more cost-effective to curtail the system's excess power than to interconnect a power generation source greater than 1 MW.

Sysco Riverside's MHD vehicle fleet charging facility (EPC-20-046) also experienced problems with the Rule 21 power generation source limit of 1 MW. The company originally planned a greater than 1 MW microgrid solution but ultimately reduced it to less than 1 MW to avoid triggering potential grid upgrades and additional studies to accommodate the increased load on a circuit.

The CPUC initiated Interconnection Rulemaking R.17-07-007 in 2017 to consider revisions to Rule 21 to account for the increased amount of DERs and energy storage on the grid. As part of this rulemaking, the CPUC has attempted to provide more flexibility to future projects by allowing DERs to perform within existing hosting capacity constraints while avoiding grid upgrades using Limited Generation Profiles. These profiles allow for larger DER generation systems to use a power control system to control the amount of power they export to the grid during certain times. Greater flexibility in Rule 21 will mitigate the challenges experienced by WattEV and Sysco Riverside on their, and future, projects.

Utilities currently lack processes to consider how solar microgrids paired with EV charging infrastructure might function as an integrated system and mitigate the need for distribution upgrades. As a result, two projects, the Sysco Riverside project and MOEV's Gardena Transit Authority project (EPC-20-038), separated their energization and interconnection processes, leading to project delays, inefficient BTM solar microgrid designs, and a risk of overbuilding utility infrastructure. These suboptimal buildouts of DER systems to avoid infrastructure and interconnection regulatory issues limit their potential performance and value to the grid.

Next Steps

Under the Strategic Initiative: DER Integration and Load Flexibility in 2024, the CEC executed three new agreements under the solicitation GFO-23-302, "Power Electronics for Zero-Emission Residential Resilience." These projects will demonstrate emerging power electronic technologies that improve affordability and simplify the installation of zero-emission backup power systems for residential applications, both single-family and multifamily.

The first agreement is NeWorld Energy's, "Energy Quarterback Development and Demonstration" Project (EPC-24-016) for $2 million to demonstrate a meter collar device that extends the meter connection, pairs with any utility meter, can be installed in under an hour, and reduces the cost of integrating DERs in residential buildings. This innovation can transform

individual residential buildings with solar and storage into their own "mini-microgrids" that have automated grid islanding capability and greater access to resilience and cost savings. The systems contain an Energy Management System with a smart thermostat, a modular plug-and-play sub-panel, bi-directional EV charging capability, and easy potential integration with VPPs, Distributed Energy Resource Management Systems, and utility Demand Response Programs. The technology will be deployed at two multifamily residential locations in the City of Sonora and ten single-family homes in National City, California.

The second project is Prospect Silicon Valley's, "Enhancing Building Resilience and Affordability through Distributed Smart Home Panels with Portable Batteries: Packaged Solutions for Electrification Challenges" project (EPC-24-017), which will use $1.7 million of EPIC funds to demonstrate how distributed load-shedding smart panels and modular plug-in batteries can be centrally controlled to expand panel capacity at power-constrained multifamily housing developments. The demonstration aims to avoid triggering utility service upgrades, which are often costly and time-consuming, while also providing resiliency and reliability services to customers and the grid. The demonstration will take place at two affordable housing apartment complexes in Humboldt County.

The third project is Zimeno, Inc.'s, "Monarch Electric Load Distribution" project (EPC-24-018). The company, which does business as Monarch Tractor, will use $2 million in EPIC funds to demonstrate a smart panel integrated with an EVSE, an automatic transfer switch, and inputs for inverter-based generation at six family-owned farms across California. The project will also demonstrate how the technology can be paired with electric pickup trucks and tractors that have bidirectional charging capabilities to provide resiliency to rural residences.

Next steps for CalFlexHub include conducting several new dynamic price testing projects, including a microgrid at a community college and a major EV original equipment manufacturer. CalFlexHub will also continue to partner with IOUs and CCAs that are using the CalFlexHub-developed Open Automated Demand Response 3.0 for their new dynamic pricing programs.

In 2024, the CEC released multiple solicitations under the Strategic Initiative: Transportation Electrification. In January, the CEC released a $21.6 million solicitation, *Grid-Supportive Transportation Electrification* (GFO-23-306), targeting innovations that enable managed charging in response to distribution grid conditions; electrical service upgrade avoidance for EV charger installations; improved efficiency and scalability of high-power charging stations; and more flexible siting of charging infrastructure. The projects will accelerate the deployment of charging infrastructure while reducing costs for ratepayers. Nine awards from this solicitation were announced as of December 2024,[74] and initial project activities will begin in early 2025.

In October, staff released a $12.6 million solicitation, *Enabling Electric Vehicles as Distributed Energy Resources* (GFO-24-302), for projects that address VGI knowledge gaps, reduce costs for bidirectional charging enabling equipment, and develop submetering solutions to facilitate VGI. Proposed awards are planned to be announced in Q2 2025. This solicitation was heavily informed by ongoing VGI collaborations with the CPUC, IOUs, and other CEC divisions and

74 California Energy Commission. 2024. "GFO-23-306 - Grid Supportive Transportation Electrification" https://www.energy.ca.gov/solicitations/2024-01/gfo-23-306-grid-supportive-transportation-electrification.

programs. These collaborations include monthly coordination calls with CPUC Energy Division staff, regular engagement with PG&E and SCE VGI subject matter experts, cross-division meetings with other CEC staff working on load flexibility and VGI, and technical advisory committee (TAC) meetings for CEC's active EPIC V2B projects.

The eight approved projects awarded under *Grid-Supportive Transportation Electrification* (GFO-23-306) are:

- EPC-24-022: NeoCharge's project, "NeoCharge Home: Enabling Equitable EV Adoption through Dynamic Load Management," will develop and demonstrate an innovative solution designed to address challenges related to installing residential EV chargers at locations facing capacity constraints. NeoCharge Home integrates smart load management software with a clamp-on current transformer, which is a sensor installed on the home panel that measures and manages loads in real time to stay within capacity limits. The system will dynamically manage EV charging based on panel capacity constraints, real-time service transformer loading data, vehicle telematics data, and localized marginal emissions data. This management strategy will allow EV owners to install Level 2 charging without the need for costly electrical panel upgrades, saving homeowners up to $3,575 per installation. The technology will be demonstrated at up to 200 residential locations, including multiple customer pairs connected to the same distribution grid infrastructure, with a focus on low-income and disadvantaged communities. NREL will verify the benefits of NeoCharge Home on distribution grid infrastructure, energy savings, and emission reductions.
- EPC-24-026: GoPowerEV Inc.'s, "Transformer-Level Automated Load Management for EV Charging in Multi-Unit Dwellings," will develop and demonstrate a system for multi-unit dwelling charging installations. The system uses automated load management and a distribution equipment monitoring system to manage power demand from EV chargers and ensure that local distribution grid equipment, such as service transformers, are not overloaded. The system will mitigate the need for costly infrastructure upgrades in grid-constrained areas and remove barriers to deploying EV chargers at multi-unit dwellings. The project includes demonstrations at four multi-unit dwelling sites in disadvantaged or low-income communities that will contribute to increasing equitable access to EV charging while mitigating impacts on the distribution grid.
- EPC-24-024: Intertie Incorporated's, "Deployment and Demonstration of a Novel DC-Coupled Fast Charging Technology with Low Grid Impact in the Central Valley" will develop and demonstrate an innovative direct current (DC) hub technology at a gas station serving EVs along Highway 5 in Fresno County. The project will use Intertie's DC hub architecture to efficiently supply locally generated power for DC fast chargers and reduce grid capacity requirements. Powered by a 200-kW solar PV array, 746 kWh energy storage, and a power electronics module, the system will enable DC fast chargers to decouple from the grid, all while being optimized by Intertie's energy management system software. This approach eliminates the need for expensive grid

upgrades, offering a scalable solution that simplifies, accelerates, and reduces the costs for the deployment of high-power charging infrastructure.

- EPC-24-025: RockeTruck, Inc.'s, "Electric Vehicle Direct-Current Hub", will develop and demonstrate an advanced medium-voltage DC power distribution architecture to improve the efficiency of high-power EV charging stations. The system will convert medium-voltage alternating current power from the grid to DC power using a solid-state transformer. The DC power is then distributed to EV chargers through a DC transit bus, thereby eliminating the need for multiple power conversions at each charger, reducing energy losses, and simplifying integration of DERs. The system will be installed at a cargo transfer facility to charge electric drayage trucks operating around the Port of Long Beach and Port of Los Angeles.
- EPC-24-029: Bidirectional Energy's project, "Grid Supportive Bidirectional Vehicle-to-Everything Residential EV VPP," will advance residential bidirectional EV charging technology by developing a bidirectional EVSE interoperable with multiple EV models. The system will also demonstrate capability for increasing grid capacity utilization with installations at both a capacity-constrained multi-unit dwelling and single-family residential homes. A target of 30 percent of the demonstrations will be in disadvantaged and low-income communities. The project team consists of an exciting partnership between an aggregator (Bidirectional Energy), EVSE manufacturer (Emporia), EV original equipment manufacturers (Honda and Volkswagen), and workforce development group (Treehouse). This multi-party partnership will be valuable in accelerating affordable market adoption of nascent residential bidirectional EV charging technology.
- EPC-23-023: Weave Grid, Inc.'s project, "Residential EV Deferred Distribution Upgrade Project," will advance their Distribution Integrated Smart Charging Orchestration (DISCO) platform that dynamically manages EV charging schedules to minimize peak load on distribution grid assets while also considering bulk system needs, ideally bringing costs down across the value chain. The project will also demonstrate DISCO's bidirectional charging capabilities to provide further distribution system value. The demonstration project involves enrollment of up to 3,000 EV participants in partnership with SCE, including at least 900 residents from disadvantaged and low-income communities. Up to 20 bidirectional chargers will be installed in these areas. LBNL will perform third-party measurement and verification to assess DISCO's ability to reduce peak load on the distribution grid.
- EPC-24-031: UC San Diego's project, Green Construct Charge: Grid-Supportive Mobile Charging Stations for the Electrification and Decarbonization of Construction Electric Vehicles, will develop and demonstrate an integrated mobile charging station solution for charging electric construction equipment at construction sites with limited or constrained grid capacity and access. The mobile charging station solution consists of a mobile battery energy storage system that can be charged using existing charging infrastructure at off-peak times and then moved to a construction site to charge the construction electric equipment. The mobile charging station solution enables market

adoption of electric construction equipment with minimal distribution grid impacts. A demonstration will be conducted on construction sites at the UC San Diego campus.

- EPC-24-023: IXP LLC's project, "Mobile Electric Vehicle Charging Site" will develop and demonstrate a mobile EV charging system designed to provide scalable and flexible EV charging solutions in areas where traditional fixed infrastructure is limited or not feasible to deploy. The technology will be supported by a modular and mobile battery energy storage system that can charge at low power using existing electrical infrastructure. Key innovations include an adaptive energy management system to optimize power distribution across phases to simultaneously support both alternating current Level 2 and DC fast charging. This project will be demonstrated at five strategically chosen locations with limited grid capacity and/or charging infrastructure construction constraints. The project will demonstrate how mobile charging solutions can increase EV charging access at challenging sites, leverage existing infrastructure, and mitigate the need for grid upgrades.

One other announced award under GFO-23-306 is scheduled to be considered for approval at a CEC Business Meeting in 2025:

- Current Trucking's project, "Valley Charging Center for Flexible Transport Electrification," will demonstrate dynamic load control technology that maximizes use of existing grid capacity, enabling rapid electric truck charging deployment without the need for costly grid upgrades. By leveraging this technology to participate in SCE's Load Control Management Systems pilot program, the project can access several MW of flexible capacity. In partnership with SCE and EPRI, the project will produce insights through a detailed case study and augment EPRI's role in bringing together the electric utility and commercial transportation industries through their EVs2Scale2030 program. Additionally, the project will provide critical data to inform regulatory decisions around the future of Load Control Management Systems and flexible service connections, which are promising solutions for streamlining transportation electrification across California.

Strategic Objective 4: Improve the Customer Value Proposition of End-Use Efficiency and Electrification Technologies

Introduction

Strategic Objective 4 focuses on improving the customer value proposition of end-use efficiency and electrification technologies in the industrial and building sectors. Advancements in energy efficiency alongside electrification of energy uses in the industrial and building sectors are key to meeting the state's clean energy and climate goals. EPIC funds have been critical in advancing the TRL of promising innovations in both industrial and building decarbonization.

New technology advancements are needed for the industrial sector to enable electrification of high-temperature process heating, as are manufacturing and process changes that reduce

reliance on fossil fuels while lowering emissions. In buildings, technology innovations can promote the affordable replacement of fossil-fuel equipment and appliances with high-efficiency electric systems for cooking, clothes drying, and space and water heating.

Strategic Initiative: Accelerate Electrification and Improve Energy Efficiency in the Industrial Sector

California's industrial sector accounts for roughly one-third of the state's gas consumption and one-sixth of its electricity consumption. The industrial sector produces more than 20 percent of the state's GHG emissions, and emission reductions in this sector are essential to meeting the 2030 targets as set forth in SB 350 (de León, Chapter 547, Statutes of 2015). New technology advancements are needed to enable electrification of high-temperature process heating, which accounts for 85 percent of gas use in industry; use of waste heat with high-temperature electric heat pumps; and use of green hydrogen derived from renewable power. More demonstration projects are also needed to validate innovations in manufacturing and industrial processes to reduce consumption of fossil fuels and associated emissions.

Examples of needed advancements include solutions for:

- Switching from energy-intensive thermal separations, such as distillation and evaporation that usually involve fossil fuel combustion for heating, to electrically-driven, less energy intensive non-thermal separations, such as those made possible by novel membranes;
- Incorporating electricity-driven carbon capture and utilization to reduce process emissions; and
- Changing materials formulation to reduce process emissions, such as in cement production.

The primary ways to increase the value proposition and business case for industrial decarbonization are to improve energy efficiency and reduce capital and operating costs. Technology demonstrations and technology transfer efforts are needed to promote adoption by increasing awareness of decarbonization opportunities, highlighting successful approaches, and overcoming risk aversion.

Strategic Initiative: Accelerate Electrification and Improve Energy Efficiency in the Building Sector

California's homes and businesses account for approximately 25 percent of the state's total GHG emissions. This includes emissions from electricity use for heating, cooling, lighting, and appliances, as well as emissions from onsite combustion of fossil fuels. Additionally, refrigerants used in building cooling systems, refrigeration systems, and heat pumps contribute to building-related GHG emissions. Decarbonizing buildings is critical for California to meet its climate goals, which includes reducing statewide GHG emissions to 40 percent below 1990 levels by 2030. Additionally, the CEC is working to achieve the Governor's ambitious goal of building 3 million climate-ready homes and deploying 6 million heat pumps by 2030.

To meet these targets, advancements in several key areas of technology are necessary:

- Improving Building Performance: Poorly performing buildings can lead to higher costs for building owners, homeowners, and residents. Installing appliances and technologies in buildings that are not properly retrofitted broadly undermines the value proposition of electrifying the building sector and may lead to challenges like oversized equipment requirements and increased operational costs.
- Electrifying without Necessary Capacity Upgrades: Many existing buildings have limited electrical capacity and cannot upsize their electrical systems due to high costs or technical infeasibility. Providing pathways to electrify buildings without requiring extensive and often expensive electrical infrastructure upgrades will spur proliferation of electric appliance technologies.
- Identifying Low-GWP Refrigerants for Heat Pumps: Current refrigerants used in heat pumps often have high GWP. Refrigerants that leak or are not recovered at end-of-life can greatly undercut the emissions reductions and climate benefits of heat pumps.
- Decarbonizing Large Buildings: Multistory buildings with wide footprints face unique decarbonization challenges. For example, heat pump systems for larger buildings are more complex to design and may not be as cost-effective. Identifying solutions and installation methods that reduce costs or simplify planning are necessary to support the decarbonization of these buildings.

Funding projects that address these issues will move California closer to achieving its ambitious climate goals while ensuring a just and economically viable transition for building owners, occupants, and ratepayers.

Progress and Success Stories

Strategic Initiative: Accelerate Electrification and Improve Energy Efficiency in the Industrial Sector

In 2024, CEC staff focused on engaging with specific cohorts in three focus areas: industrial and commercial cold storage, cement and concrete industry, and decarbonization of heating.

Nelumbo Inc.'s Ice-Nein Evaporator Coating (EPC-24-014) is an example of a successful commercial cold storage demonstration project. Based in the City of Hayward, the company developed Ice-Nein, an advanced coating for refrigeration coils that reduces energy consumption during the refrigeration defrost cycle. The surface modification uses an advanced ceramic coating to reduce the formation of frost, slow frost growth rate, and enhance frost removal. Since de-icing coils is a major energy load in cold storage facilities, potentially accounting for up to 20 percent of their energy usage, reducing ice formation could yield significant energy, GHG, and cost savings in California facilities. The project's goal is to advance the TRL of the advanced coating technology from TRL 7 to TRL 9. Accordingly, the company is planning a full-scale pilot project with a prototype that has been demonstrated at near commercial scale. Demonstration and validation will occur at Daylight Foods, an existing grocery distributor in Union City.

Another success story is San Leandro's C-Crete Technologies (EPC-24-020). This first-of-its-kind demonstration project for the concrete industry will convert more than 20 tons per day of abundant non-carbonate rocks, such as zeolite, into binders capable of replacing 100 percent of Portland cement in concrete. The novel binder, with C-Crete's eco-friendly activators and its electrified production process — an innovative alternative to traditional industrial kilns — will produce zeolite-based concrete for testing by Vulcan Materials. At pilot scale, this process would eliminate more than 12 tons of GHG emissions daily. With its potential to dramatically decarbonize cement production, currently responsible for roughly 7 percent of California's GHG emissions, this technology could revolutionize the industry. When fully scaled, it could leverage billions of tons of native zeolite rock and reduce millions of tons of GHG emissions annually.

Staff made site visits to three California industrial facilities: Lineage and California Steel in Fontana and CalPortland in Victorville. This work ultimately resulted in two grant funding opportunities: GFO-22-301, "Commercialization of Industrial Decarbonization," for which $42.7 million was awarded to seven projects; and GFO-23-301, "Energy Efficiency and Load Flexibility in Industrial and Commercial Cold Storage Facilities," for which $9.3 million was awarded to four projects.

Collectively, these 11 projects addressed major research areas identified in the *EPIC 4 Investment Plan*, including load flexibility, thermal energy storage, energy efficiency, advanced separations, and electrification of industrial processes. Their efforts also catalyzed nearly $30 million in private match funding. These field demonstrations helped industrial sector end users become both more familiar with emerging decarbonization technologies and primed to promote future deployments. Related interactions during this year's activities, including meeting with the California Nevada Cement Association and visiting sites for California Steel and Lineage industrial cold storage, are informing the scope of the fifth EPIC Investment Plan.

Strategic Initiative: Accelerate Electrification and Improve Energy Efficiency in the Building Sector

The CEC approved and launched six new research agreements in 2024 to support the affordable decarbonization of large buildings. These agreements exclusively use ultra-low GWP refrigerants with a rating of less than 10; by comparison, common refrigerants have much higher GWP ratings, such as R-410A with a GWP of 2088. The projects will showcase the application of ultra-low GWP refrigerant heat pumps in advancing decarbonization for large buildings. The building types demonstrated in these projects include hospitals, large research centers, and other commercial facilities.

In addition, the CEC awarded a $4.7 million grant, with $2.5 million in match funding, to Build it Green (EPC-23-005) to develop a novel decision-making tool for electrifying homes with limited electrical panel capacity. This project will produce an open-source, power-efficient design calculator and online user interface, which will be freely accessible to all single-family households in California. As upgrading the electrical panel can be one of the costliest barriers to home electrification, the tool will aim to support ratepayers in avoiding panel upgrades, when feasible, and reducing costs. The tool will collect household-specific information, perform electrical load calculations, evaluate design solutions, and present users with a set of least-cost, power-efficient electrification plans. These plans will address electrification challenges in

existing homes, such as limited electrical capacity, affordability, and physical space constraints for electric appliances. The tool will comprehensively evaluate solutions that integrate load control strategies, energy efficient appliances, space-saving designs, and other innovative and cost-saving approaches. It will also provide detailed cost assessments for electrical infrastructure upgrades, when deemed necessary, and representative costs for various electrification technologies and controls. To ensure broad acceptance by electricians and local code authorities, the tool will comply with the National Electric Code for advanced metering infrastructure (section 220.87) or seek to align with an inventory of the home's installed equipment (section 220.83).

EPIC-funded building decarbonization projects have garnered significant interest from U.S. DOE's Building Technologies Office. CEC staff has presented EPIC's groundbreaking research and initiatives at multiple U.S. DOE conferences, sharing California's leadership in building electrification. Furthermore, six research projects were showcased at the ACEEE Summer Study event, covering topics ranging from low-GWP heat pump water heaters to innovative plug-load control strategies.

Awarded projects for two innovative building decarbonization solicitations in 2024 will package HVAC solutions to maximize efficiency, smart integration, and cost and GHG savings. Under GFO-23-308, CEC intends to award four grants totaling $5.9 million that will develop and demonstrate the impact of a DC-powered, heat pump space HVAC in a self-contained module that includes solar PV and energy storage. This DC HVAC nanogrid module is intended for applications in residential and commercial settings.

Under GFO-22-308, the CEC awarded six projects totaling $19.4 million to develop decarbonization solutions for HVAC systems in large commercial buildings, with an emphasis on technology advancements, energy efficiency, replicability, and the use of ultra-low global warming potential refrigerants.

Impediments and Setbacks

The ratio of electricity prices to fossil gas prices is a key factor affecting the deployment of electrification technologies in the buildings and industrial sectors. Another issue is end users' unfamiliarity with emerging technologies and desire to see them demonstrated in real-world conditions in California before they are willing to consider deployment themselves.

The CEC projects described above are strong examples of pathways for addressing the latter impediment. Regarding the high cost of electricity, CEC EPIC research not only focuses on reducing the upfront costs of electrification but also emphasizes the need to lower operational expenses. The CEC encourages research projects to evaluate the total life-cycle cost of electrification methods and places a strong emphasis on improving building or industrial process performance to reduce ongoing operating costs.

Industrial decarbonization projects typically have large sites and require complex analyses, and the funding available is modest compared to the needs. Depending on the industry, energy accounts for approximately 10 to 20 percent of operational expenses, making the adoption of decarbonization technologies a lower priority for industrial parties. High electricity costs compared to the cost of fossil fuels complicates the situation even further.

Current codes and safety regulations — such as those governing electrical load calculations and safety limits for flammable refrigerants like propane — can pose barriers to certain building decarbonization approaches. The CEC is actively collaborating with research organizations across California and the U.S. to identify viable pathways to overcome these regulatory challenges.

Next Steps

Most of the funds allocated for this objective have already been encumbered. In the upcoming year, consideration for remaining funds related to industrial decarbonization includes developing an industrial electrification roadmap, analyzing energy consumption for typical industrial processes, and identifying research gaps and opportunities.

Staff released a building decarbonization solicitation in March 2025 and anticipates releasing a second solicitation by middle of the year as the final investments under this initiative for the *EPIC 4 Investment Plan* funding cycle. These solicitations will focus on two key areas: developing low-GWP refrigerant heat pumps for homes and demonstrating cost-effective building envelope technologies.

Strategic Objective 5: Enable Successful Clean Energy Entrepreneurship Across California

Introduction

EPIC investments made under Strategic Objective 5 foster a robust and inclusive statewide entrepreneurial ecosystem that supports innovators through the early to middle stages of the energy technology innovation pipeline. The objective aims to grow the California clean energy sector, provide resources to bring new inventions from idea to commercialization, increase ratepayer benefits, and accelerate achievement of the state's climate and energy goals. EPIC resources and investments are pivotal for overcoming market obstacles, commercializing innovations, and sustaining an inclusive clean energy economy.

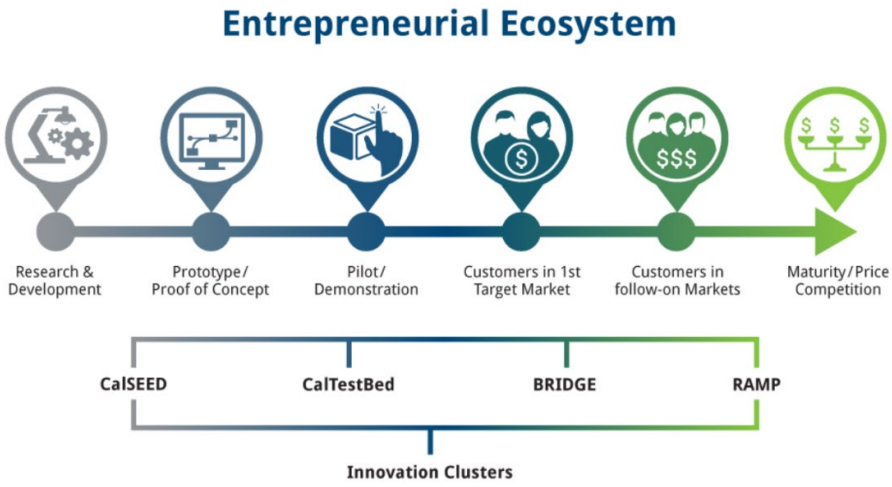
The EPIC entrepreneurial ecosystem,[75] formally known as the California Energy Innovation Ecosystem, comprises four unique programs and an innovation network:

- CalSEED Initiative
- CalTestBed Initiative
- Bringing Rapid Innovation Development to Green Energy (BRIDGE) Program
- Realizing Accelerated Manufacturing and Production (RAMP) Program
- REICs, including the Southern California Energy Innovation Network (SCEIN), Los Angeles Cleantech Incubator (LACI), Activate Berkeley, and BlueTech Valley (BTV)

Figure 4 illustrates the ecosystem components and their connections. Combined, these efforts establish an innovation roadmap strengthened with resources and expertise to bring breakthrough ideas to commercialization and scale.

75 California Energy Commission. 2024. "Entrepreneurial Ecosystem."Energize Innovation. https://www.energizeinnovation.fund/energy-innovation-101/entrepreneurial-ecosystem.

Figure 4: California Energy Innovation Ecosystem



Source: California Energy Commission staff

Progress and Success Stories

In 2024, EPIC entrepreneurial funding continued to successfully mobilize diverse resources to help innovators in California advance clean energy technologies. By the close of 2024, the EPIC entrepreneurial ecosystem had supported more than 440 companies. Collectively, these companies attracted more than $5.5 billion in additional funding from private and public sources, including nearly $1.5 billion in 2024, and employed more than 6,500 people since 2021, contributing workforce and economic benefits to California. Below are summaries of outcomes from each of the five programs in 2024.

CalSEED

A $66 million CEC EPIC award in 2016, designed for disbursement over ten years, established the CalSEED program. Managed by nonprofit New Energy Nexus, CalSEED offers two stages of grant funding to California clean energy entrepreneurs working on early-stage innovations. Early-stage is defined as technology at a concept to basic prototype level, or with a TRL between 2 and 4. The first funding stage, Concept Awards, provides up to $200,000 to innovators and is conducted through open solicitations. The second stage, Prototype Awards, provides funding of up to $500,000 and is only available to companies that have received a Concept Award. CalSEED also offers the following services to its Concept Awardees:

- A powerful network of technical and industry experts, investors, prospective partners, and utilities.
- Mentorship from experienced clean energy entrepreneurs.
- Access to operational and technical resources, such as guidance on contracting protocols, budgeting, market-fit, and impact evaluation.
- Webinars and online training to enhance business development and fundraising skills.
- Introduction to cutting-edge facilities for lab-scale technology development through the REICs.

- Participation in Cleantech Open's Accelerator.[76]
- Inclusion in an entrepreneurial community of fellow CalSEED awardees.

CalSEED awarded a total of $3.4 million to 17 California companies in 2024. The latest cohort of companies and technologies to join CalSEED are:

- Three Rivers Power, LLC: Innovation to increase the power density of power conversion electronics.
- SolGrapH Inc.: Novel cylindrically-layered graphite that can increase the life and recyclability of LIBs.
- Aris Hydronics Inc.: A modular heat pump system for multi-family buildings that combines space heating and cooling with water heating, and can be installed on a 20-amp, 110-volt panel slot.
- Wayside: A battery pack made from a recyclable enclosure that simplifies end-of-life material recovery.
- We Think Global Inc.: A portable PV-enabled clarification system that can recover, isolate, and purify a large range of metals and critical minerals from a variety of waste streams including mine tailings, industrial waste, and brine.
- Cryodrives, LLC: A heavy-duty, variable frequency electric drive system that can replace a diesel engine.
- AmpTrans Inc.: A digital platform optimizing MHD electric fleet charging.
- KVA Technologies: Electrified production of high-performance alloys for industrial use.
- Calectra Inc.: An electrically conductive, air-stable brick that serves as the heating and storage element to a thermal energy storage system.
- OpenRoad Technologies Inc.: A fast-charging battery system for EVs that can be installed using consumer-grade wiring.
- 17 Inc.: A novel technology that uses clean energy to produce green ammonia.
- Gridwave PBC: A low-cost, modular, solar EV charging station for medium- and heavy-duty vehicles.
- Navion Energy Inc.: On-site rapid EV charging system using sodium batteries.
- Coulomb Technology: A zinc ion-based battery system to support MHD charging.
- Sol Robotics Inc.: A compact wireless inductive charging system that can harvest energy directly from the electromagnetic field generated by overhead power lines.

76 Cleantech Open's accelerator program provides startups with a robust program of customer discovery, extensive mentoring, training, investor meetings, startup-corporate matching, and showcasing at both the regional and national levels.

- EcoRecycleTech: A solid-state LIB cell that facilitates easy repair, repurposing, and automated disassembly.
- Manara Materials LLC: High-purity nickel and vanadium recovery from spent oil refinery waste.

Past CalSEED awardees who achieved significant milestones in 2024 include:

- Antora Energy, based in Sunnyvale, uses renewable electricity to heat low-cost blocks of solid carbon to glowing hot temperatures in an insulated battery module. The stored heat can then be used in industrial processes or converted directly into electricity using Antora's thermophotovoltaic technology.[77] In 2024, Antora raised $150 million in Series B funding and was selected by the federal ARPA-E Program for a $14.5 million award. This funding will enable Antora to ramp up production of its factory-made thermal batteries to deliver zero-emissions energy to customers.
- TyFast, based in San Diego, makes high-performance LIBs for use in heavier applications, such as trucking, mining, and construction. In May 2024, it was one of 40 companies that presented at the NREL Industry Growth Forum. In October, U.S. DOE awarded Tyfast a Small Business Innovation Research award of $200,000 to expand its technology to rideshare vehicles and taxis.

CalTestBed

A $22 million EPIC award in 2018 established approximately ten years of funding for the CalTestBed Program. Managed by nonprofit New Energy Nexus, which also manages CalSEED, CalTestBed has awarded $16.5 million in vouchers to 63 startups since 2021, including approximately $3.6 million in testing vouchers to 12 California-based companies in 2024. Vouchers can be redeemed at participating world-class testing facilities to test prototypes at TRLs 5 to 7. The number of participating testing facilities in CalTestBed has grown from an initial group of 29 facilities in 2021 to more than 70 facilities in 2024. The latest cohort of 12 companies to join CalTestBed in August 2024 are:

- Eventix at LBNL: Technology that converts biomass waste into hydrogen, biofuel blend stock, biochar,[78] and wood vinegar.[79]
- Flex Power Control at UC Davis: A 10-kW bidirectional charging system, expandable to 30kW, connecting an EV and a home.
- Evoloh at LBNL: A novel anion exchange membrane electrolyzer that produces green hydrogen more affordably than current technologies.

77 Thermophotovoltaic technology converts heat directly into electricity using PV cells. These systems are similar to solar cells but are designed to work with infrared radiation from heat sources (like waste heat) instead of sunlight.

78 Biochar is a type of charcoal made by heating organic material (like plant waste) in an oxygen-limited environment. It is added to soil to improve health and fertility, retain water and nutrients, and reduce GHGs by sequestering carbon in soil.

79 Wood vinegar is a liquid byproduct of charcoal production, used in agriculture and gardening to enhance soil and plant growth

- Evolectric at UC Riverside: Hardware and software to retrofit existing combustion engine vehicles with new battery-electric powertrains.
- Kfobix at UC Irvine: Coating that prevents ice formation on power lines and wind turbines, potentially avoiding costs from damaged lines and enhancing electrical distribution safety, resiliency, and renewable energy efficiency.
- Twelve at LBNL: Novel membrane electrode assemblies (MEAs) for CO_2 electrolysis to transform CO_2 into jet fuel and other low-carbon products at scale.
- Relyion at UC Riverside: EV battery repurposing.
- Unigrid at UC San Diego: A sodium-ion 18650 cylindrical battery cell.
- Tyfast at UC San Diego: High-performance, non-flammable LIB with ten times greater cycle life and charging capabilities in below-freezing temperatures.
- Nelumbo at UC Davis: Advanced heat pump technology with improved efficiency in frosty conditions.
- McEachern Laboratories at UC Riverside: A grid stability measurement solution that reduces wildfire risk and increases solar PV and battery storage deployment capacity.
- ChargePodX at UC Riverside: Portable Level 3 DC Fast Charging for EVs using existing Level 2 charging infrastructure.

Element Energy, a member of the first CalTestBed cohort, made noteworthy progress in 2024 deploying and scaling its battery technology. In partnership with LG Energy Solution Vertech, Element Energy commissioned the largest BESS project in the world in November 2024 using repurposed EV batteries at a wind farm in West Texas. 900 repurposed EV batteries have provided the wind farm with 53 MWh of energy storage. The project received $7.9 million in funding from the U.S. DOE under the Bipartisan Infrastructure Law.

BRIDGE

Through the BRIDGE Program, CEC provides supplemental funding to clean energy companies that have garnered prior public and private funding to rapidly develop or demonstrate their innovative clean energy technologies. BRIDGE specifically targets AR&D projects at TRL 6 or below and TD&D projects at TRL 7 or 8. The CEC released solicitation GFO-23-318 for the third round of BRIDGE funding in July 2024. Eligible technology categories included:

- Energy efficiency,
- End-use electrification,
- Energy storage,
- AI/machine learning/advanced sensing,
- Advanced power electronics/power conditioning, and
- Zero- and negative-carbon emission generation (renewable generation).

This solicitation attracted 65 applications and nearly $26 million is available for individual awards of $1 million to $4 million, to be announced in 2025.

Eos Energy Storage, LLC has been the recipient of three EPIC awards since 2014. The company produces zinc-based batteries that provide backup power on the 8-to-12-hour timescale with no risk of thermal runaway. Its latest agreement, "Utility Demonstration of Non-Flammable, Aqueous-Zinc Battery Storage: Innovation Scale-Up to Alleviate T&D Congestion and Mitigate Wildfire Risks" (EPC-18-023), was awarded in 2019 from the first BRIDGE solicitation. That project completed in 2023 and successfully demonstrated its third-generation technology system, Eos Z3, at a San Diego Gas and Electric facility in the City of Pala. Eos plans to scale its annual manufacturing capacity of this technology to 8 GWh by 2026, all of which will occur in the United States. This effort is being supported by a more than $300 million loan from the U.S. DOE Loan Programs Office finalized in December 2024 and up to $315 million in loans from Cerberus Capital Management LP. The latter has claimed Eos to be "the United States' first scalable non-lithium BESS platform."

Eos's technology was awarded LDES program funds to install a microgrid project with the Viejas Band of Kumeyaay Indians in Alpine, California. Eos was initially contracted to supply 35 MWh of energy storage to the project, but in July 2024 reached an agreement to supply an additional 25 MWh of energy storage to the site for a total of 60 MWh. Eos's Z3 technology will also be used at another LDES-funded, 48-MWh project at Marine Corps Base Camp Pendleton in Oceanside, California, awarded in December 2024. The cost efficiencies, safety profile, durability, and scale-up potential of Eos's technology are likely to result in significant ratepayer benefits.

RAMP

The RAMP Program supports companies with validated technologies or prototypes ready to enter early-stage production. In 2024, the CEC executed eight new agreements totaling $20 million from its fourth RAMP funding round. The CEC received 50 applications, highlighting the continued need for and interest in funding to scale clean energy technology manufacturing sustainably and affordably in California. The eight recipients and their awarded projects are:

- EPC-24-007: Sylvatex, Inc. Water-free cathode active material manufacturing process.
- EPC-24-001: Swift Solar, Inc. Perovskite tandem photovoltaics for EV integration applications.
- EPC-24-003: Rincell Corporation. Silicon anodes for LIBs to improve energy density and performance.
- EPC-24-002: Stasis Energy Group. Thermal energy storage integrated with HVAC systems to enable load-shifting in commercial buildings.
- EPC-24-009: Current Ways, Inc. On-board bidirectional converter to enable low-cost vehicle-to-everything capabilities in EVs.
- EPC-24-004: Sonocharge Energy, Inc. Acoustic wave technology for lithium-ion batteries to increase charging speed and cycle life.
- EPC-24-008: BoxPower Inc. Containerized solar microgrid with rapid deployment of resilience capabilities.

- EPC-24-006: Harvest Thermal. Heat-pump and water-heater controller enabling residential load shifting.

Regional Energy Innovation Clusters

Beginning in 2016, EPIC provided $10 million awards to each of the four REICs located in California. Each REIC has developed a unique program to support clean energy entrepreneurs in its region, but they share a common goal of supporting clean energy entrepreneurs and their innovative technologies that meet EPIC objectives with TRLs ranging from 2 to 8. This spans technologies from early-stage proof of concept through system development and up to the technology commercialization process with secured external funding and other commercialization services. Figure 5 shows the REICs' locations and the counties they serve. The REICs are as follows:

- **Activate Berkeley** (previously Cyclotron Road), administered by the nonprofit Activate Global in partnership with LBNL's Cyclotron Road program, serves the nine Bay Area counties as well as Santa Cruz and Mendocino counties;
- **BTV**, administered primarily by California State University, Fresno in partnership with five other universities in the CSU system and the Sierra Small Business Development Center in Truckee, serves 39 counties of the Central Valley and the North Coast of California;
- **SCEIN**, administered primarily by the nonprofit Cleantech San Diego, serves San Diego, Imperial, Riverside, and San Bernardino counties; and
- **LACI**, administered by the LACI nonprofit, serves Los Angeles, Orange, Santa Barbara, and Ventura counties.

Figure 5: EPIC Regional Energy Innovation Clusters

Source: California Energy Commission

Activate Berkeley

Activate Berkeley, previously known as Cyclotron Road, operates a two-year fellowship program that provides entrepreneurs with intensive entrepreneurial education and access to world-class research expertise at LBNL. EPIC funding helped to originally establish the program at the City of Berkeley for entrepreneurs developing breakthrough materials and hardware devices in conjunction with LBNL in energy efficiency, energy storage, distribution, grid management, and power generation. Since the REIC's inception in 2015, 74 companies have participated in the program. The nonprofit organization Activate Global used Cyclotron Road as the basis for its entrepreneurial fellowship model, which has extended the two-year entrepreneurship program to locations in Boston, Houston, New York, and a remote fellowship for U.S.-based entrepreneurs called Activate Anywhere. Five new companies joined Activate Berkeley in 2024 with promising innovations in the energy sector:

- Calectra: An electrically conductive, air-stable brick that serves as the heating and storage element to a thermal energy storage system.
- EELI Technology: Advanced lithium extraction and purification solutions.
- Expand Power: A compact smart transformer that provides enhanced controllability and safety monitoring over standard transformers.
- Praio: Synthetic protocells to replace traditional energy- and carbon-intensive chemical engineering processes with more efficient biocatalytic processes.
- Topolight: Novel semiconductor lasers that can improve energy efficiency and affordability in data transmission and manufacturing.

Past Activate Berkeley cohort participants achieved notable milestones in 2024, including the following:

- Twelve signed the largest European airline e-SAF commitment with International Airlines Group and secured more than $645 million in private funding for its first-of-a-kind e-SAF production facility. More detail is included in the RAMP section below.
- Brimstone was selected by U.S. DOE Office of Clean Energy Demonstrations for a $189 million federal award under the Industrial Demonstrations Program to finance the construction of the first commercial-scale plant deploying its zero-emissions cement technology. The company is expanding its West Oakland-based R&D facility and plans to hire more staff. Brimstone also received one of *Time Magazine's* "America's Top Greentech Companies of 2024" awards[80] and was featured in the Netflix documentary, "What's Next? The Future with Bill Gates."
- Fervo Energy is building the largest next-generation geothermal plant capable of producing 400 MW. Fervo uses advanced drilling techniques and a geothermal energy storage technology known as the FervoFlex system to rapidly expand the potential of

80 "America's Top Greentech Companies of 2024." 2024. Time. https://time.com/collection/americas-top-green tech-companies-2024/.

geothermal energy as a firm, dispatchable zero-carbon energy source. The FervoFlex technology won one of *Time Magazine's* awards for "Best Inventions of 2024."[81]

- Anthro Energy creates a polymer electrolyte for LIBs that improve their safety and performance. In February 2024, Anthro announced the closing of an over-subscribed $20 million Series A[82] funding round, from which it plans to build a San Francisco Bay Area-based pilot production facility to commercialize and scale advanced battery technologies. In October, Anthro Energy won a $24.9 million award from the U.S. DOE Office of Manufacturing and Energy Supply Chains to convert an existing site in Louisville, Kentucky, into the first large-scale, U.S.-owned and operated advanced electrolyte production facility.
- CalWave is a company developing California's first at-sea, long-duration wave energy project off the San Diego coast. CalWave's PacWave site will be the first federally approved, commercial scale, utility grid-connected wave energy site in the nation. Construction of one of its two sites off the coast of Oregon is nearly complete, with terrestrial and subsea cable installation finished in October 2024. The maximum output of this site is expected to be 20 MW. CalWave also signed a memorandum of understanding with the AltaSea facility at the Port of Los Angeles to work toward establishing a local wave energy industry and building more projects off the coast of California.
- AeroShield Materials, makers of energy efficient windows, received a $14.M grant from ARPA-E and closed a $5 million funding round.

BTV Innovation Cluster

The BTV Innovation Cluster at California State University, Fresno identifies entrepreneurs who are developing technology solutions to address the region's acute needs in the energy-water-food nexus. The cluster provides entrepreneurs with the necessary tools and business guidance to commercialize clean energy solutions. In addition to Fresno State, BTV collaborates with the Sierra Small Business Development Center in Truckee and five other California State Universities: CSU Bakersfield, CSU Monterey Bay, Sacramento State, Chico State, and Cal Poly Humboldt. These organizations collectively serve 39 counties across the Central Valley and North Coast.

BTV provides access to free or low-cost commercialization services, including technology evaluation, proof-of-concept validation, office space, testing facilities, networking opportunities, and participation in a cohort-based accelerator program called the Valley Ventures Accelerator. The accelerator provides customized advisory services to ventures seeking support with funding, business development, and revenue generation. Across seven

81 Maynard, Micheline. 2024. "Geothermal Energy Advances: FervoFlex." Time. https://time.com/7094813/fervo-energy-fervoflex/.

82 A Series A round (and Series B round) is an investment in a privately held start-up company after it has shown progress in building its business model and demonstrates the potential to grow and generate revenue. The average range is $1 million to $30 million (see "Glossary of Funding Types," https://support.crunchbase.com/hc/en-us/articles/115010458467-Glossary-of-Funding-Types).

cohorts, the Valley Ventures Accelerator has supported 79 companies. In 2024, BTV added four new companies focusing on clean energy:

- Edgecom Energy: Energy management platform for mid-sized commercial facilities, such as greenhouses and manufacturing plants, to reduce costs and emissions
- Triton Anchor: A low-weight, silently installed, modular anchoring system that works for OSW turbines
- Nexstera Tech: AI-enhanced radar technology to empower waste collection companies to identify batteries within curbside bins before they are emptied, enabling them to proactively eliminate this risk
- Argyle Earth: A system for food processors to convert their low-grade waste heat into electricity

Notable success stories from past BTV cohorts in 2024 include:

- EV Life, which empowers consumers to finance their EVs by bundling tax credits, rebates, and home charger installations into one low loan payment, expanded its tool in February to include used EVs, in response to the growing used EV market.
- Ceres Imaging DBA Ceres AI, which provides precision agriculture solutions with AI and machine learning that reduce water and energy use, announced a $25 million Series D funding round[83] in August.
- Nitricity, which electrifies the production of nitrogen fertilizer, launched a field test and received a $4 million grant from the U.S. Department of Agriculture Fertilizer Production Expansion Program in April 2024 to expand its existing fertilizer production facility in Fremont, California. In October 2024, U.S. DOE announced Nitricity as one of the 170 Voucher Program recipients, funded by the Bipartisan Infrastructure Law, which will receive vouchers for up to $120,000 for commercialization support.

LACI

LACI runs two key programs to support entrepreneurship focusing on energy, transportation, and the circular economy across Los Angeles, Orange, Santa Barbara, and Ventura counties. The 12-month Innovators Program caters to early-stage ventures that are pre-seed or pre-prototype with at least some proof of concept. The program provides workshops, advisory services, access to LACI's network of entrepreneurs, spaces to conduct business and research, and other resources to support the prototype development. The two-year Incubation Program supports pre-seed and seed-stage[84] companies with an investment readiness curriculum and provides mentorship, exposure to investors, and pilot preparation training. LACI also runs a Market Access Program to facilitate eligible partnerships for pilot demonstration projects, in

83 The Series C funding round (and beyond) is for later-stage and more established companies than Series A and B. These rounds are usually $10,000,000 or more (see "Crunchbase Glossary of Funding Types," https://support.crunchbase.com/hc/en-us/articles/115010458467-Glossary-of-Funding-Types).

84 A seed round is one of the first funding rounds, while the company is still young. Funding ranges from $10,000 to $2,000,000 and precedes the Series A round. A pre-seed round is a seed round with no institutional investors or a very low amount, often less than $150,000 (see above reference).

conjunction with the LACI Impact Fund and LACI Debt Fund. Thirteen new companies focusing on clean energy technologies joined LACI in 2024, including:

- Chargewheel: Patented battery and software technology that provides instant power to EV charging and data center sites.
- Reverse Energy Solutions: Solar panel recycling with custom-designed mobile processing machinery that cuts logistics costs by 90 percent.
- Pure Energy Stream: An integrated energy management system that recycles electricity, optimizes voltage, and reduces kilowatt consumption for cost savings while extending equipment life.
- RCAM Technologies DBA Sperra: 3-D printing concrete renewable energy infrastructure.

LACI participants achieved the following milestones, among other achievements, in 2024:

- AirVitalize, a company from Incubation Cohort 7, raised more than $155,000 in non-dilutive funding, including a grant as one of three American Society of Mechanical Engineers iShow North America competition winners.
- It's Electric, a company from Incubation Cohort 7, closed a $6.4 million seed round and was featured in Fortune Magazine.
- Reverse Energy Solutions, a company from Incubation Cohort 8, was named as a top 25 Climate Tech Startup to Watch by Trellis Group, formerly known as GreenBiz.
- New member ChargeWheel closed an $8 million fundraising round and was accepted into the Amazon Accelerator.
- New member Sperra received two federal awards. The company was selected for a $650,000 grant from the U.S. DOE Solar Energy Technologies Office in May to build its Solar Canal foundation, a dual-use solar application designed to generate renewable energy and conserve water by mounting solar panels over irrigation canals. The company was awarded a $4 million grant from the U.S. DOE Water Power Technologies Office in October to design, fabricate, and test a 600-kWh pumped storage hydropower energy storage system off the coast of Southern California. The project was also supported with $3.7 million from the German Ministry for Economic Affairs and Climate Action.

SCEIN

SCEIN is a program for startups based in San Diego, Riverside, San Bernardino, and Imperial counties that are developing solutions to help California meet its clean energy goals. The program, managed by Cleantech San Diego, provides access to the resources of regional partner organizations and offers industry connections to accelerate the commercialization of emerging energy technologies. Eligible companies must possess a California business address; operate out of or have near-term plans to do business in San Diego, Imperial, Riverside, or San Bernardino counties; and be developing energy-related technologies with the ability to benefit California's electric ratepayers under one of five general categories:

- Energy efficiency,
- Renewable energy generation,
- Energy storage,
- Smart grid and energy services, and
- Clean transportation

Companies accepted into the program receive a range of services including industry connections, one-on-one mentoring, regulatory and policy guidance, and access to research and testing facilities. One new company joined the SCEIN network in 2024:

- Airbuild: Integration of the photosynthetic ability of microalgae with PV cells, companies, and governments to sequester carbon, generate energy, and filter wastewater onsite.

Highlights from SCEIN-supported companies in 2024 include:

- Community Energy Labs is bringing to market the first AI-powered, clean building control platform tailored toward operators of public buildings such as schools and municipal buildings. Community Energy Labs was awarded a Cooperative Research and Development Agreement in January from Pacific Northwest National Laboratory. This collaboration will enable research to validate a wider variety of Machine Learning frameworks and test them in buildings with complex systems and thermal dynamics beginning in winter 2025.
- Helicoid Industries makes composite materials, like those found in windmill blades and other manufactured products, lighter, stronger, more impact-resistant, more energy efficient, and capable of being manufactured at a lower overall manufacturing cost. Helicoid raised an additional $2 million in private funding in 2024.
- Unigrid, a maker of sodium ion batteries, was accepted into the new CalTestBed cohort in August 2024 and completed a $12 million Series A funding round in June. The company received additional funding from LG Technology Ventures.

Examples of California Energy Innovation Ecosystem Success

Highlights for four companies that received EPIC funding through various California Energy Innovation Ecosystem programs are shared below. Their work in 2024 advanced ratepayer benefits through cost savings and sustainability innovations.

Twelve (formerly Opus 12) is a Berkeley-based chemical company that has participated in multiple ecosystem programs, including CalSEED, CalTestBed, Activate Berkeley, and RAMP. Twelve uses CO_2, water, and renewable electricity to produce building blocks for chemical products used in a wide array of applications, from polycarbonate to sustainable aviation fuel. Twelve's core technology is the CO_2 electrolyzer, which converts CO_2 into carbon monoxide. The primary functional component of the CO_2 electrolyzer is the membrane electrode assembly (MEA). The MEA is a sandwich structure composed of a cathode, anode, and polymer exchange membrane. During electrolyzer operation, a current is applied to a stack composed of many dozens of MEAs, catalyzing the carbon transformation reaction. In 2024, Twelve completed a CEC RAMP grant (EPC-20-035) and successfully installed, commissioned, and

validated an LRIP pilot line for fabricating MEAs. This pilot line, located in Alameda, will enable Twelve to quadruple production of MEAs.

Twelve is constructing a first-of-its-kind, demonstration-scale CO_2 transformation plant that will use MEAs produced by the RAMP-funded pilot line to produce e-SAF. Twelve's e-SAF reduces jet fuel life-cycle emissions by 90 percent. Multiple agreements with commercial airlines are already in place for fulfillment in 2025, and International Airlines Group has agreed to purchase 260 million gallons of e-SAF over the next 14 years.

Twelve has raised more than $645 million in private investments to support electrolyzer manufacturing and deployment of additional carbon transformation plants. Recently, Twelve was awarded a $28.5 million 48C Qualifying Advanced Energy Project Tax Credit from the U.S. Department of Treasury and U.S. DOE for the design and construction of a stack manufacturing facility in Alameda.

The company's rapid growth and tremendous amount of private funding raised demonstrates how the EPIC-funded entrepreneurial ecosystem programs play a key role at critical points in the development process to advance technologies critical to meeting California's climate goals — in this case, in the notoriously difficult-to-decarbonize sector of aviation.

Skyven Technologies is a Fresno-based company specializing in decarbonizing industrial process heat with steam-generating heat pump technology and an energy-as-a-service business model. Skyven is a former BTV member and received BRIDGE and RAMP awards from CEC's EPIC funding. In 2024, Skyven completed its BRIDGE project (EPC-20-018), a $1.1 million award to develop an AI-driven platform, Galileo. The Galileo AI platform performs site-specific, techno-economic analysis to scope industrial decarbonization projects in 24 hours, compared to the typical four months of costly engineering analysis. The platform can streamline industrial decarbonization assessment and planning across a wide array of facilities and unique site processes.

During Skyven's BRIDGE project, Galileo analyzed decarbonization measures for a dairy plant and ethanol facility, and recommended measures such as steam-generating heat pumps, condensing economizers on steam boilers, and intelligent steam traps. Galileo additionally scoped projects at more than 135 manufacturing facilities across the United States in a variety of sectors, including chemicals (ethanol, sugar beets, plastics), pulp and paper (paper mill, consumer paper goods), and food and beverage (dairies, breweries, snack products). To date, three facilities have signed thermal energy services agreements with Skyven to implement decarbonization measures scoped using the Galileo tool. The commitments are expected to reduce annual GHG emissions by approximately 53,000 metric tons compared to business-as-usual operations.

In March 2024, U.S. DOE selected Skyven for award negotiations up to $145 million to demonstrate the economic viability and technical capability of steam-generating heat pumps.[85] Steam-generating heat pump technology electrifies steam production and can be deployed in place of gas boilers used by a variety of industrial customers for process heat. Because

85 U.S. DOE. "Industrial Demonstrations Program Selections for Award Negotiations: Heat." https://www.energy.gov/oced/industrial-demonstrations-program-selections-award-negotiations-heat.

process heat accounts for almost one-third of total energy-related emissions in the manufacturing sector, the displacement of gas boilers by industrial-scale heat pumps will not only drastically help industrial facilities reduce GHG emissions but also improve air quality in and near the facilities. Skyven has already proven the efficacy of this technology in custom-engineered installations. With the RAMP grant (EPC-22-012), Skyven seeks to scale deployment of the industrial steam-generating heat pumps and substantially lower installation costs by bringing a packaged, pre-engineered family of systems into LRIP.

Sonocharge Energy, Inc. is a SCEIN graduate and previously received CalSEED Concept and Prototype awards. RAMP funds awarded in 2024 will now support the manufacturing scale-up of Sonocharge's Surface Acoustic Wave technology, which transmits acoustic waves inside LIB cells. This wave causes the lithium ions in the battery solution to constantly mix within the cell and can completely prevent dendrites, or lithium-ion buildup, on the anode. Needle-like dendrite growth on the surfaces of anodes in LIBs can lead to short circuits and premature battery failure; preventing dendrites in a battery is a critical strategy in improving battery longevity, affordability, and safety.

This technology is expected to reduce LIB costs by 30 to 40 percent, double the battery cycle life of conventional LIBs, and reduce EV fast charging times to 15 minutes or less — all significant ratepayer benefits. Safety is also enhanced by eliminating lithium dendrites, thereby reducing the possibility of thermal runaway and battery-related fires. The RAMP project aims to achieve scalable production of 500 MWh annually, paving the way for mass commercialization. These manufacturing advancements could enable widespread adoption of Sonocharge's technology, which could generate $34 billion in cost savings and reduce GHG emissions by 4 gigatons by 2050. In June 2024, Sonocharge announced an $8.5 million Series A funding round.

South 8 Technologies is a previous CalSEED Concept awardee, a participant in SCEIN, and a recipient of BRIDGE and RAMP awards. South 8's breakthrough technology is a liquefied gas electrolyte, known as LiGas, which is compatible with multiple lithium-based battery chemistries. In March 2024, South 8 completed its BRIDGE project (EPC-18-021) to develop, test, and demonstrate a LRIP line for a lithium metal battery utilizing LiGas. During the project, the company further developed the LiGas from its Gen 1 chemistry to Gen 3 chemistry, yielding improvements in cycle life, temperature, and power performance while also reducing its cost, vapor pressure, and GWP. Project efforts also reduced the size and mass of its battery cells. In August 2024, South 8 completed its RAMP project (EPC-20-016), constructing a fully operational pilot line and demonstrating the recyclability of its batteries and the LiGas electrolyte in multiple lithium-based battery chemistries.

This technology has garnered public recognition and several additional awards. In February 2024, South 8 completed an ARPA-E-funded project demonstrating its LiGas technology's compatibility with a lithium nickel manganese oxide (LNMO) battery, which is a potential next-generation EV battery chemistry. South 8's technology improved energy retention of LNMO batteries at -20°C from less than 5 percent on a standard LNMO cathode to 96 percent in the LNMO cathode using LiGas. In April, South 8 announced a partnership with battery company NanoGraf on a $15 million contract from the DOD's Family of Advanced Standard Batteries

Program to deliver higher energy, safer, lighter, and domestically produced batteries for American military in the field. In September, South 8, in partnership with Chico-based Nanotech Energy, was awarded the PowerForward Battery Manufacturing Grant, funded by the CEC's Clean Transportation Program, to expand ZEV battery manufacturing in California. The grant will help scale South 8's LiGas electrolyte manufacturing and integrate it affordably into existing battery cell manufacturing. In December, South 8's LiGas was recognized as one of *Time Magazine's* Inventions of the Year.[86]

Impediments and Setbacks

Supply chain problems, unexpected lengthy delivery times for equipment, and interconnection queue delays were commonly reported challenges for projects in 2024. Furthermore, broad macroeconomic conditions such as inflation and high interest rates have increased overall costs for many project activities, including labor, materials, and equipment. These conditions place pressure on projects to complete their tasks with smaller budgets than originally scoped during more favorable economic conditions. Downstream customers of clean energy technologies are subsequently affected as well, as project durations take longer, or materials or partners are modified to enable the project's full execution.

Next Steps

The CEC plans to release two GFOs under Strategic Objective 5 in 2025. The first, expected in early 2025, is for the establishment of a battery pilot manufacturing line capable of manufacturing and testing a variety of emerging next-generation lithium-ion-based technologies. This pilot line will be a shared-use facility allowing battery innovators to bring their innovative components, leverage the manufacturing capacity and on-site staff of the pilot line, and ideally leave with fully operational battery cells. Battery companies may provide the battery cells to potential customers for evaluation or use them to support their ongoing technology development, accelerating scale-up for safer, more reliable, and more cost-effective lithium battery technologies while enabling more in-state manufacturing and workforce development.

CEC participated in several conferences in 2024 to help develop this effort. Staff attended the California Battery Summit on March 15, hosted by the City of Fremont in partnership with the CEC, GO-Biz, LBNL, Ava Energy, and RK Logistics, and the California Battery Manufacturing Summit on September 18-19. The latter event was organized by LBNL, Stanford Linear Accelerator Center National Accelerator Laboratory, and Lawrence Livermore National Laboratory in partnership with the CEC, GO-Biz, and the State Treasurer's Office, with additional support from the UC System, Fraunhofer USA, and the California Mobility Center. CEC staff moderated an event panel on scaling up battery manufacturing innovation to pilot lines, gaining additional input from battery manufacturing experts to help inform the upcoming solicitation. CEC hosted a scoping workshop on September 20 to provide a dedicated forum for information sharing and feedback.

86 Maynard, Micheline. 2024."Best Inventions of 2024: A Longer-Lasting Charge South 8 LiGas." Time. https://time.com/7094815/south-8-ligas.

The second grant funding opportunity will seek to pair entrepreneurs with research institutions, such as national labs and universities, to support the commercialization of clean energy intellectual property developed at those institutions. The GFO is currently being developed and is anticipated to be released later in 2025.

Strategic Objective 6: Inform California's Transition to an Equitable, Zero-Carbon Energy System that is Climate-Resilient and Meets Environmental Goals

Introduction

Strategic Objective 6 of the *EPIC 4 Investment Plan* aims to ensure the grid is resilient and reliable in the face of climate change. Activities under this objective support California's broader environmental goals, with particular attention to health and equity concerns, as well as related ratepayer benefits associated with California's transition to a 100 percent clean energy future. In 2024, research under this objective developed analytical tools that can transform copious climate projection data into inputs for energy policy, planning, and modeling. These climate-informed inputs offer more granular insights into climate vulnerability and resilience, such as how climate change may impact energy demand and supply. EPIC-funded research also complements efforts by research and governmental institutions to better understand how new clean energy technology deployments can potentially affect species and ecosystems.

Progress and Successes

EPIC recipients and staff engaged utility representatives, researchers, universities and national labs, California-based small businesses, government institutions, and community-based organizations in implementing this strategic objective. Robust external engagement supported the execution of ongoing agreements, integration of research findings and data products into clean energy transition efforts, and development of future investment opportunities. Highlights include the integration of climate and weather data and analytics into CEC's electricity demand forecasting efforts, as well as adaptation integration into planning efforts led by the CPUC and IOUs. These data have been further adopted by the Governor's Office of Land Use and Climate Change as foundational support for California's Fifth Climate Change Assessment. Another highlight from this portfolio is the USGS' recognition of EPIC-funded research on the "Lake Effect" hypothesis associated with solar PV installations.

Strategic Initiative: Climate Resiliency

EPIC funds under the Climate Resiliency strategic initiative supported ongoing efforts in 2024 to integrate publicly available weather data and projected climate data from EPIC studies into electricity demand forecasting. These efforts inform the development of climate adaptation and energy resilience policy, in addition to energy system modeling, needed to meet SB 100 goals. EPIC funded several relevant projects, including the Cal-Adapt Analytics Engine (AE) led by Eagle Rock Analytics under the project, "A Co-Produced Climate Data and Analytics Platform to Support California's Electricity Resilience Investments" (EPC-20-007). Additionally,

Lumen Energy Strategy is leading a project titled, "Advancing California's Electricity Resource Planning Tools to Assess and Improve Climate Resilience" (EPC-22-001), also known as Weather Adapted Resource Planning (WARP) to Resilience.

The Cal-Adapt AE provides crucial data and analytical products that inform demand forecasting activities by the CEC, as well as modeling, research, and regulatory efforts by other state agencies. In late 2023 and early 2024, the Cal-Adapt AE team at Eagle Rock Analytics held a series of working groups and webinars. The goal was to convene data and tool developers, users, scientists, decision-makers, and other key experts in the energy sector to discuss priorities, methodologies, and policy contexts for climate and weather data application in support of electricity sector resilience. Throughout 2024, the AE team met with IOU and CPUC technical leads to discuss the Adaptation Rulemaking proceeding (R.18-14-019) and production cost modeling to support CPUC's Integrated Resource Planning efforts. The AE team also produced analytical resources to support both the filings of the IOUs' Climate Adaptation and Vulnerability Assessment (CAVA) and the implementation of a Global Warming Level Framework for the Adaptation Rulemaking.

The Cal-Adapt AE and the WARP to Resilience teams presented on the integration of climate-informed data into California's Energy Demand forecast at the CEC IEPR Commissioner Workshop on Energy Demand Forecast Methodology Updates on July 30, 2024. The WARP to Resilience team also met with CEC's demand forecast team throughout the year. These meetings informed the CEC's development of new inputs, assumptions, and tools to capture the impacts of climate change on electricity demand and an electric grid that is transitioning to a higher proportion of renewable energy, scalable storage, and distribution- and customer-sited resources.

Strategic Initiative: Environmental Sustainability

In 2024, EPIC published and shared findings from a study on avian behavior near solar PV generation sites. USGS, funded by EPC-16-064, published the final report in June titled, *Investigating the Influence of "Lake Effect" from Utility-Scale Photovoltaic Solar Facilities on Avian Behavior in California.*[87] The Lake Effect Hypothesis suggests that utility-scale solar facilities attract birds by mimicking the visual cues that birds use to locate water bodies, potentially resulting in avian fatalities. Results from the USGS research are largely consistent with the Lake Effect Hypothesis and could be influential in identifying mitigation approaches for reducing impacts to birds associated with PV infrastructure. If such approaches are demonstrated to be effective, they could facilitate more buildout of utility-scale solar facilities by lowering permitting and mitigation costs while reducing impacts to avian populations. More at-scale renewable generation will allow California to achieve its ambitious clean energy goals, all while helping to increase ratepayer affordability and reduce air pollution.

Another 2024 publication under this initiative is titled, *Building Healthier and More Energy-Efficient Communities in Fresno and the Central Valley: Developing a Holistic Community Action Plan to Improve Access to Clean Energy Technologies.* Through a combination of

87 Diehl, Robert, Bruce Robertson, and Karl Kosciuch. 2024. Investigating the "Lake Effect" Influence on Avian Behavior From California's Utility Scale Photovoltaic Solar Facilities. California Energy Commission. CEC-500-2024-055.

community outreach, policy analysis, and technical modeling, researchers estimated about $70 million in public health benefits from transitioning all passenger vehicles in Fresno County to zero-emission vehicles. The researchers also drafted a substantive action plan for greater climate equity for disadvantaged communities in Fresno. Additional study results found that low-cost, do-it-yourself air filters can be effectively deployed at a wider scale.

Substantial progress was made in a first-of-its-kind EPIC study, "Cooking Electrification and Ventilation Improvements for Children's Asthma." The project team is conducting a randomized trial to investigate the health implications of cooking electrification and related interventions in the homes of children with asthma in disadvantaged and low-income communities. By late fall of 2024, more than 50 homes in Kern and Fresno counties were enrolled in the study, with baseline air quality monitoring and health surveys completed in most homes. Achieving these milestones required coordination across field, medical, laboratory, and analytical teams; collaboration with electricians; and the procurement and installation of cooking ranges, cookware, and 120-volt appliances, among other logistics. The research team built and deployed wireless monitoring systems specific to this study and successfully addressed error codes that appeared on several of the ranges.

Impediments and Setbacks

Under the Climate Resiliency Strategic Initiative, projects EPC-20-007 and EPC-22-001 reported challenges relating to the integration of data products portraying projected climate change, which typically are time- and resource-intensive. Data integration is limited by the current state of best available science, which in turn is limited by sparse observations of several weather-related variables important to understanding a high-renewable energy sector.

Under the Environmental Sustainability Strategic Initiative, the project titled, "Cooking Electrification and Ventilation Improvements for Children's Asthma" (EPC-21-033), encountered technical delays in finalizing a method to measure the impacts of kitchen electrification on asthmatic children. The delays are associated with scheduling inspections by electricians and late receipt of inspection reports.

Next Steps

Moving into 2025, a suite of new agreements and solicitations will continue to strengthen the scientific foundation for advancing a resilient, equitable, affordable, and environmentally sound energy transition. The following noteworthy agreements were executed under Strategic Objective 6 in 2024.

The Cal-Adapt: Analytics Engine project received a second EPIC award for $3,500,000 (EPC-23-024) in May. This new agreement leverages substantial advancements supported by the EPC-20-007 agreement to accelerate the delivery of scientifically rigorous, data-driven analyses for IOUs, policy makers, and researchers in the electricity sector who need actionable, curated, open climate data products tailored for resilience planning. Goals for the new agreement include a seven-fold increase in analytical resources through co-production and robust public participation, leveraging more than $2 million in match funds related to cloud computing data and processing. Ultimately, this agreement will build institutional and

analytical capacity to make use of open data portraying projected climate change, which in turn advances California's cost-effective, reliable, and resilient transition to zero-carbon energy.

In November, the CEC approved the agreement, "Evaluation and Optimization of Orographic[88] Cloud Seeding to Enhance Precipitation in California" (EPC-24-027). This applied research effort will combine new process-informed observational analysis with modeling that includes the physical processes required to simulate the impacts of "cloud seeding" — an approach that has been used in California for more than 70 years to enhance precipitation — from dispersal of the seeding agent to springtime runoff into hydroelectric reservoirs. Research results will enhance the efficacy of cloud seeding efforts through improved scientific understandings, including determining the optimum conditions and locations in California where cloud seeding would most effectively augment snowpack and runoff.

The following solicitations under Strategic Objective 6 were under development, were released, or led to executed agreements in 2024:

- The $6 million GFO titled, "Modeling and Monitoring Air Quality and Co-Benefits of Energy Interventions to Inform Clean and Equitable Energy Transition," is expected to be released by the middle of 2025. The solicitation proposes to fund research to improve existing ambient air quality modeling and measurement approaches, and to quantify the air quality implications and related human health impacts of clean energy interventions across energy use sectors. The research will support development of new tools to monetize non-energy benefits of clean energy interventions. CEC held a public scoping workshop to help inform the GFO development in January 2024.
- On August 28, 2024, CEC staff held a public pre-application workshop in support of a $3 million solicitation (GFO-24-301) titled, "Environmental Sustainability of a Clean Energy Transition (Enviro-SET)." This solicitation will fund AR&D projects that support California's transition to an equitable, zero-carbon energy system that is climate resilient, meets environmental goals, and delivers multiple ratepayer benefits. The solicitation seeks to fund four groups of projects with distinct goals:
    - Developing automated mapping of solar energy footprints and modeling land suitability for agrivoltaics.
    - Assessing and minimizing environmental and biological resource impacts of clean energy deployments.
    - Testing bird-friendly windows for decarbonized buildings.
    - Identifying biologically appropriate exterior lighting.
- In October 2024, the CEC awarded $3 million to the County of Ventura as part of the solicitation, "Non-Energy Impacts and Process Evaluation of Integrated Energy Retrofit Packages in California's Residential Buildings" (GFO-23-310). The "3C-BEACH" research will identify and assess non-energy benefits of home electrification — such as

88 Related to the physical geography of mountains.

affordability, comfort, and health — and evaluate residents', contractors', and others' experience with the retrofitting process. The research will inform strategies for retrofitting or replacing gas-fueled appliances with electric appliances. Retrofit opportunities include upgrades to mechanical ventilation, building envelopes, and more efficient electrical appliances. The assessment will span the counties of Ventura, Santa Barbara, and San Luis Obispo, and evaluate the benefits of electrification for affordability, comfort, and health.

- The solicitation, "Non-Energy Impacts and Process Evaluation of Integrated Energy Retrofit Packages in California's Residential Buildings from EBD Program," entered the scoping phase in late 2024, with an anticipated release by the middle of 2025. This solicitation is expected to support a $3 million effort to evaluate the non-energy impacts of building retrofits, leveraging the opportunity to study the impacts and benefits of the CEC's Equitable Building Decarbonization Direct Install Program.

CHAPTER 5: Conclusion

Key Results

The CEC's EPIC Program continues to invest in promising clean energy innovations while leveraging existing federal, public, and private capital to maintain and accelerate the development of novel technologies to benefit California ratepayers. EPIC activities have included continued progress in completing project agreements funded under prior investment plans while concurrently planning, scoping, disbursing, and managing grant opportunities detailed in the CEC's *EPIC 4 Investment Plan*. In addition, many companies and projects funded in prior years began to achieve technology validation, at-scale deployment, early-stage manufacturing, and product commercialization in 2024, enhancing the affordability, accessibility, sustainability, resilience, and safety of the clean energy transition.

Notable through 2024 include:

- $1.4 billion invested across 543 public R&D projects since program inception in 2011.
- Private companies that have received EPIC funding collectively attracted more than $18.9 billion in additional private funding through 2024.
- Grant recipients completed 45 EPIC projects in 2024.
- 60 percent of TD&D funding has been awarded to projects located in and benefiting disadvantaged and low-income communities through 2024.
- $30.4 million of TD&D funds have been invested on California Native American tribal lands through 2024.

Additionally, grant recipients from more than 200 EPIC projects that were either active or completed during the 2024 calendar year reported the following technological impacts:

- A collective total of 2.1 gigawatt-hours of electricity consumption avoided by projects in 2024, as reported by 20 respondents.
- More than 1,000 full-time-equivalent jobs collectively enabled by EPIC funding during 2024, as reported by 156 respondents.
- More than 3,500 metric tons of carbon dioxide equivalent emissions collectively avoided by projects in 2024, as reported by 25 respondents.

As shown in Table A-7 in Appendix A, EPIC has encumbered a cumulative total of nearly $1.4 billion in approved plan project funds. As outlined below, the CEC has a series of solicitations in progress and plans to encumber the remaining funds on schedule.

Issues

Some key challenges across the portfolio are continuing to have major impacts on project progress. Interconnection queues and permitting issues remain a barrier for clean energy infrastructure buildout, particularly demonstration projects with complex systems or novel technologies. These factors have created hurdles in securing and retaining host sites. Other regulatory barriers, especially related to safety certifications for battery storage systems and building decarbonization refrigerants, may hamper progress. Long equipment lead times and supply chain issues are persisting, causing delays as grantees struggle to obtain necessary materials and equipment to manufacture their products or implement their projects. Inflation and rising electricity rates relative to fossil gas may also inhibit headway, with projects and companies needing to accommodate budget shifts, raise money for unforeseen needs, or reassess their cost-effectiveness. The lack of a dynamic pricing program and clear submetering rules may impact the financial and technical viability of technologies with the ability to flex load, such as energy storage and electric vehicles.

Next Steps for the EPIC Investment Plan

EPIC Funding Opportunities in 2025

In 2025, CEC anticipates releasing solicitations for EPIC funding opportunities that advance the state's transition to clean energy. Table 5 summarizes the anticipated 2025 EPIC funding opportunities. Anticipated solicitations are posted on the CEC funding web pages.[89]

Table 5: EPIC 2025 Funding Opportunities

Title	Anticipated Release Dates
Applications of Open Data to Support Climate Resilience in California's Electricity Sector	January 2025
Advancing Designs and Analysis of HVDC Substations and Environmental Monitoring for FOSW	February 2025
Developing Next Generation, All Electric Heat Pumps Using Low Global Warming Potential Refrigerants	March 2025
Enabling Load Shifting and Energy-efficiency in Indoor Farms	March 2025–June 2025
Non-Energy Impacts and Process Evaluation of Integrated Energy Retrofit Packages from ERD Program	May 2025–July 2025
Modeling and Monitoring Air Quality and Co-Benefits of Energy Interventions	May 2025–July 2025
Advanced Grid Technology Acceleration Projects	June 2025–August 2025

89 California Energy Commission. 2025. "Solicitations." https://www.energy.ca.gov/funding-opportunities/solicitations?field_solicitation_status_target_id%5B37%5D=37&field_solicitation_type_target_id=All&field_division_1_target_id=All .Filter status for "Anticipated/Upcoming" and "Energy Research and Development." Solicitations under the EPIC Program are indicated within the links to individual solicitations.

Title	Anticipated Release Dates
Emerging Solar Energy Technologies (EPIC IV)	July 2025–September 2025

Source: California Energy Commission staff

EPIC 5 Investment Plan

CPUC Commissioners voted to adopt the strategic goals for EPIC 5 in March 2024.[90] In March 2025, the CPUC issued a ruling seeking comments on Energy Division staff's proposal on 13 strategic objectives for EPIC 5. After considering comments, the CPUC will adopt final strategic objectives. CEC staff will develop its EPIC 5 (2026–2030) investment plan according to the adopted strategic objectives and then submit the plan to CPUC for approval.

Conclusion

The CEC looks forward to building on EPIC successes to date in 2025 and further accelerating clean energy innovation in the development pipeline after a productive year in 2024. EPIC advances can enable California to meet its clean energy mandates and aspirations more quickly, equitably, affordably, effectively, and efficiently. EPIC investments provide critical validation to policy makers, private sector investors, and ratepayers regarding the performance, cost savings, and safety of new clean energy technologies. Results generated through EPIC, a publicly funded research program, can also increase the pace of innovation and technology scale-up across public and private sectors by sharing lessons learned broadly and openly. The CEC EPIC benefits to ratepayers are vast and will have positive, far-reaching, and transformative impacts to Californians' pocketbooks, environment, health, and safety for years to come.

90 D. 24-03-007.

LIST OF ACRONYMS

Acronym	Definition
AB	Assembly Bill
ACEEE	American Council for an Energy-Efficient Economy
AE	Cal-Adapt Analytics Engine
AI	Artificial intelligence
AR&D	Applied research and development
ARPA-E	Advanced Research Projects Agency-Energy — a United States Department of Energy Program advancing high-impact energy technologies by providing funding, technical assistance, and market readiness
BESS	Battery Energy Storage System
BMC	Biogas Microgrid Controller
BOEM	Bureau of Ocean Energy Management
BRIDGE	Bringing Rapid Innovation Development to Green Energy
BTM	Behind-the-meter
BTV	BlueTech Valley
Cal Poly	California State Polytechnic University
CalEnviroScreen	California Communities Environmental Health Screening Tool
CalFlexHub	California Load Flexibility Research and Development Hub
California ISO	California Independent System Operator
CalSEED	California Sustainable Energy Entrepreneur Development Initiative
CARB	California Air Resources Board
CCA	Community choice aggregator
CEC	California Energy Commission
CNRA	California Natural Resources Agency
CO_2	Carbon dioxide
CPUC	California Public Utilities Commission
CSU	California State University
DACAG	Disadvantaged Community Advisory Group
DBA	Doing business as
DC	Direct current
DER(s)	Distributed energy resource(s)

Acronym	Definition
DISCO	Distribution Integrated Smart Charging Orchestration
DOD	U.S. Department of Defense
DVC	Disadvantaged vulnerable community
Enviro-SET	Environmental Sustainability of a Clean Energy Transition
EPIC	Electric Program Investment Charge
EPRI	Electric Power Research Institute
ERDD	Energy Research and Development Division (CEC)
eTRUC	Electric Truck Research and Utilization Center
e-SAF	Low-emission sustainable aviation fuel
ESJ	Environmental and social justice
ETCC	Emerging Technologies Coordinating Council
EV	Electric vehicle
EVSE	Electric vehicle supply equipment
FOA	Funding Opportunity Announcement
FOSW	Floating offshore wind
GFO	Grant funding opportunity
GHG	Greenhouse gas
GoBiz	Governor's Office of Business and Economic Development
GW	Gigawatt
GWh	Gigawatt-hour
GWP	global warming potential
HVAC	Heating, ventilation, and air conditioning
HVDC	High-voltage direct current
IAW FlexHub	Industrial, Agriculture, and Water Demand Flexible Research and Deployment Hub
IEPR	Integrated Energy Policy Report
IOU	Investor-owned utility
kW	Kilowatt
LACI	The Los Angeles Cleantech Incubator
LBNL	Lawrence Berkeley National Laboratory
LDES	Long-duration energy storage
LIB	Lithium-ion battery
LNMO	Lithium nickel manganese oxide

Acronym	Definition
LRIP	Low-rate initial production
MDMA	Meter Data Management Agent
MEA	Membrane electrode assembly
MHD or M/HD	Medium- and heavy-duty
MW	Megawatt
MWh	Megawatt-hour
NASEO	National Association of State Energy Officials
NEM	Net energy metering
Next EPIC Challenge	Reimagining Affordable Mixed-Use Development in a Carbon-Constrained Future Program
NOWRDC	National Offshore Wind Research and Development Consortium
NREL	National Renewable Energy Laboratory
OSW	Offshore wind
PEV	Plug-in electric vehicle
PG&E	Pacific Gas and Electric Company
PICG	Policy + Innovation Coordination Group
PV	Photovoltaic
R&D	Research and development
RAMP	Realizing Advanced Manufacturing and Production for Clean Energy Technologies
REIC	Regional Energy Innovation Cluster
RFI	Request for Information
SB	Senate Bill
SCE	Southern California Edison Company
SCEIN	Southern California Energy Innovation Network
SLAC	SLAC National Accelerator Laboratory
SWO	Stop Work Order
TCES	Thermochemical energy storage
TD&D	Technology demonstration and deployment
TRL	Technology readiness level
U.S. DOE	United States Department of Energy
UC	University of California
UL	Underwriters Laboratories

Acronym	Definition
USGS	U.S. Geological Survey
V2B	Vehicle-to-building
V2G	Vehicle-to-grid
VGI	Vehicle-to-grid-integration
VPP	Virtual power plant
WARP	Weather Adapted Resource Planning
ZEV	Zero-emission vehicle

GLOSSARY

For additional information on commonly used energy terminology, see the following industry glossary links:

- California Energy Commission Energy Glossary, available at https://www.energy.ca.gov/resources/energy-glossary
- California Air Resources Board Glossary, available at https://ww2.arb.ca.gov/about/glossary
- California Public Utilities Commission Glossary of Acronyms and Other Frequently Used Terms, available at https://www.cpuc.ca.gov/glossary/

Advanced Research Projects Agency-Energy (ARPA-E): ARPA-E is a United States Department of Energy Program advancing high-impact energy technologies by providing funding, technical assistance, and market readiness.

CalSEED: The California Sustainable Energy Entrepreneur Development Initiative (CalSEED) is an EPIC-funded program administered by nonprofit New Energy Nexus that provides small grants to entrepreneurs and researchers to advance their clean energy concepts or prototypes.

CalTestBed: The California Test Bed Initiative is an EPIC-funded program administered by nonprofit New Energy Nexus that provides clean energy entrepreneurs access to testing facilities to accelerate technology commercialization.

Carbon capture, utilization, and storage: This term refers to the process of capturing carbon dioxide, either from a concentrated stream or from the atmosphere, then containing it for further use or storage.

Carbon dioxide (CO_2): Carbon dioxide, a naturally occurring gas, also referred to as carbon, is also a by-product of burning fossil fuels (such as oil, gas, and coal), burning biomass, land-use changes, and industrial processes (for example, cement production). It is the principal anthropogenic greenhouse gas (GHG) that affects the Earth's radiative balance. It is the reference gas against which other GHGs are measured and therefore has a global warming potential of 1.

Carbon neutrality: Carbon dioxide and other GHG emissions generated by sources such as transportation, power plants, and industrial processes must be less than or equal to the amount of carbon dioxide that is stored, both in natural sinks such as forests and mechanical sequestration such as carbon capture and sequestration. Executive Order B-55-18 established a target for California to achieve carbon neutrality by 2045 and maintain net negative emissions thereafter. For more information, see the CARB Carbon Neutrality Web page (https://ww2.arb.ca.gov/our-work/programs/carbon-neutrality).

Climate: Climate is the average course or condition of the weather at a place, usually over a period of years, as exhibited by temperature, wind velocity, and precipitation. The classical period for averaging these variables is 30 years, as defined by the World Meteorological

Organization. Climate in a wider sense is the state, including a statistical description, of the climate system.

Climate change: Climate change refers to a change in the state of the climate that can be identified (for example, by using statistical tests) by changes in the mean or variability (or both) of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic (human-induced) changes in the composition of the atmosphere or in land use. Anthropogenic climate change is defined by the human impact on Earth's climate, while natural climate changes are the natural climate cycles that have been and continue to occur throughout Earth's history.

Anthropogenic climate change is directly linked to the amount of fossil fuel burning, aerosol releases, and land alteration from agriculture and deforestation.

Community Choice Aggregator: The term used to describe a local government that procures power on behalf of its residents, businesses, and municipal accounts from an alternative supplier while still receiving transmission and distribution service from its existing utility provider.

Decarbonization: The process by which countries, individuals, or other entities aim to reduce or achieve zero fossil carbon emissions. This typically refers to a reduction of the carbon emissions associated with electricity, industry, and transport. Decarbonization involves increasing the share of no- or low-carbon energy sources (renewables such as solar and wind) and decreasing the use of fossil fuels.

Demand flexibility: The ability of customers to reduce or increase load in response to grid conditions, usually through a proxy price signal or system operator or utility signal and facilitated by automation.

Disadvantaged communities: Disadvantaged communities refer to the areas throughout California that most suffer from a combination of economic, health, and environmental burdens. These burdens include poverty, high unemployment, air and water pollution, presence of hazardous wastes, as well as high incidence of asthma and heart disease. One way that the state identifies these areas is by collecting and analyzing information from communities all over the state. CalEnviroScreen, an analytical tool created by the California Environmental Protection Agency, combines different types of census tract-specific information into a score to determine which communities are the most burdened or "disadvantaged." Disadvantaged communities are those designated as representing the 25 percent highest-scoring census tracts in CalEnviroScreen Tool 4.0. For more information, see the California Office of Environmental Health Hazard Assessment's CalEnviroScreen Web page (https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-40).

Disadvantaged Communities Advisory Group (DACAG): The Clean Energy and Pollution Reduction Act of 2015 (also known as Senate Bill 350) called upon the California Public Utilities Commission (CPUC) to help improve air quality and economic conditions in disadvantaged communities by, for example, changing the way the state plans the development and future operations of power plants, and rethinking the location of clean energy technologies to benefit

burdened communities. In addition, SB 350 required the CPUC and the CEC to create a group representing disadvantaged communities to advise the agencies in understanding how energy programs impact these communities and could be improved to benefit these communities.

Distributed energy resource(s) (DER): Distributed energy resources are any resource with a first point of interconnection of a utility distribution company or metered subsystem.

Distributed energy resources include:

- Demand response, which has the potential to be used as a low-GHG, low-cost, price-responsive option to help integrate renewable energy and provide grid stabilizing services, especially when several distributed energy resources are used in combination and opportunities to earn income make the investment worthwhile.
- Distributed renewable energy generation, primarily rooftop photovoltaic energy systems.
- Vehicle-grid integration, or all the ways plug-in electric vehicles can provide services to the grid, including coordinating the timing of vehicle charging with grid conditions.
- Energy storage in the electric power sector to capture electricity or heat for use later to help manage fluctuations in supply and demand.

Electric Program Investment Charge (EPIC) Program: The CEC's EPIC Program invests in scientific and technological research to accelerate the transformation of the electricity sector to meet the state's energy and climate goals. Investments of about $150 million annually support research and development in renewable energy, energy storage, electric system resilience, and electric technologies for buildings, businesses, and transportation. For more information, see the CEC EPIC Web page (https://www.energy.ca.gov/programs-and-topics/programs/electric-program-investment-charge-epic-program) and the CPUC Energy Research, Development, and Deployment Web page (https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/infrastructure/energy-research-development-and-deployment).

Electrolyzer: A device that uses electricity to split water into hydrogen and oxygen molecules.

End use, end user: End use refers to the final applications for which energy is ultimately used, such as heating, power generation, transportation, or a combination of these applications. An end user is the person who ultimately uses the energy (or associated innovation). This term is preferred over "user" because it provides more specificity, distinguishing the final user from other roles like developers or intermediaries.

Energy efficiency: Energy efficiency means adapting technology to meet consumer needs while using less energy. The CEC adopts energy efficiency standards for appliances and buildings, which reduces air pollution and saves consumers money. The CPUC regulates ratepayer-funded energy efficiency programs and works with the IOUs, other program administrators, and vendors to develop programs and measures to transform technology markets within California using ratepayer funds. For more information, see the CEC Energy Efficiency Web page and the CPUC Energy Efficiency Web page.

Environmental social justice (ESJ) communities: ESJ Communities are predominantly communities of color or low-income communities that are underrepresented in the policy setting or decision-making process, subject to a disproportionate impact from one or more environmental hazards, and likely to experience disparate implementation of environmental regulations and socioeconomic investments in their communities. It targets "Disadvantaged Communities" designated by the California Environmental Health Screening (CalEnviroScreen) Tool, all California tribal lands as defined in 18 U.S.C. 1151 subsection (a), low-income households with incomes below 80 percent of the area median income, and low-income census tracts with aggregated household incomes that are less than 80 percent of area or state median income.

Equity (energy equity): Energy equity is the principle of fairness in burden sharing and is a basis for understanding how the impacts and responses to climate change, including costs and benefits, are distributed in and by society in equal ways. It is often aligned with ideas of equality, fairness, and justice and applied with respect to equity in the responsibility for, and distribution of, climate impacts and policies across society, generations, and gender, and in the sense of who participates and controls the processes of decision-making.

Follow-on funding: This report uses the term "follow-on funding" to describe when an EPIC recipient receives subsequent EPIC funding from the CEC for a project that meets the statutory criteria under Public Resources Code Section 25711.5(h)(4)(A)-(F). Appendix A (Table A-10) provides a summary of these awards of follow-on funding.

Greenhouse gas (GHG): GHGs are those gaseous constituents of the atmosphere, natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of terrestrial radiation emitted by the Earth's surface, the atmosphere itself, and clouds. This property causes the greenhouse effect. Water vapor, carbon dioxide, nitrous oxide, methane, and ozone are the primary GHGs in the Earth's atmosphere. Moreover, there are several entirely human-made GHGs in the atmosphere, such as the halocarbons and other chlorine- and bromine-containing substances, dealt with under the Montreal Protocol. Besides carbon dioxide, nitrous oxide, and methane, the Kyoto Protocol deals with the GHGs sulfur hexafluoride, HFCs, and perfluorocarbons. In response to Assembly Bill 32 (California Global Warming Solutions Act of 2006), the definition of GHGs defined in Health and Safety Code Section 38505 includes nitrogen trifluoride in addition to those defined under the Montreal and Kyoto Protocols.

Global Warming Potential (GWP): GWP is an index to measure how much infrared thermal radiation a greenhouse gas would absorb over a given timeframe after it has been emitted to the atmosphere. The unit of measurement is expressed as a multiple of the radiation that would be absorbed by an equivalent mass of added carbon dioxide, which has a GWP of 1.

Investor-owned utility (IOU): Investor-owned utilities (IOUs) provide transmission and distribution services to all electric customers in their service territory. The utilities also provide generation service for "bundled" customers, while "unbundled" customers receive electric generation service from an alternate provider, such as a CCA. California has three large IOUs offering electricity service: Pacific Gas and Electric Company, Southern California Edison, and San Diego Gas & Electric.

Low-income communities: This term refers to communities within California census tracts with median household incomes at or below either of the following levels: 1) 80 percent of the statewide median income or 2) the applicable low-income threshold listed in the state income limits updated by the Department of Housing and Community Development and filed with the Office of Administrative Law pursuant to subdivision (c) of Section 50093 of the Health and Safety Code.

Methane: Methane (CH_4) is one of the six GHGs to be mitigated under the Kyoto Protocol and is the major component of natural gas. Emissions also occur as a result of dairy and livestock operations and disposal of organics in landfills, and the management of these organics represents a major mitigation option. Methane is a short-lived climate pollutant. Unlike carbon dioxide, which lasts for about 100 years in the atmosphere, reductions of methane can create a relatively quick reduction in global warming.

Photovoltaic (PV): This term refers to materials that generate an electric potential or current when exposed to sunlight.

Regional Energy Innovation Cluster: These four sites were funded by the CEC in 2016 as part of the creation of its California Energy Innovation Ecosystem and serve as physical locations to support local clean energy technology developers. Services provided onsite include research and laboratory facilities, meeting spaces to convene investors and share learnings, and immediate availability of technical and business consultation.

Smart thermostat: A smart thermostat is one that can be controlled with an internet-connected device such as a phone, tablet, or smart speaker.

Sustainability: A dynamic process that guarantees the persistence of natural and human systems equitably.

Transportation electrification: This term refers to the replacement of fossil fuels in the transportation sector with electrical power.

Utility: A utility is an organization supplying the community with electricity, gas, water, or sewage.

Vehicle-to-Everything (V2X): This term refers to leveraging bidirectional energy transfer capability to discharge energy from an electric vehicle to a variety of destinations including the electric grid, buildings, homes, or loads.

Vehicle-to-Grid (V2G): This term refers to leveraging bidirectional energy transfer capability to discharge energy from an electric vehicle to the electric grid.

Vehicle Grid Integration (VGI): This term refers to any method of altering the time, charging level, or location at which grid-connected light-duty electric vehicles, medium-duty electric vehicles, heavy-duty electric vehicles, off-road electric vehicles, or off-road electric equipment charge or discharge in a manner that optimizes plug-in electric vehicle or equipment interaction with the electrical grid and provides net benefits to ratepayers.

APPENDICES

The following appendices are available as a separate volume (Publication Number CEC-500-2025-028-APA-D):

- Appendix A: 2024 CEC EPIC Reporting Requirements and Budget Summaries
- Appendix B: CEC EPIC Project Summary Tables by Strategic Objective, Initiative, and Investment Plan in 2024
- Appendix C: All EPIC Projects Awarded (Cumulative through December 31, 2024) with Fiscal and Diversity Details
- Appendix D: 2024 EPIC Projects by Agreement Number with Strategic Initiative Details