CALIFORNIA ENERGY COMMISSION

California Energy Commission

**COMMISSION REPORT**

# Electric Program Investment Charge 2019 Annual Report

**Gavin Newsom, Governor**

**April 2020 | CEC-500-2020-009-CMF**

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# PREFACE

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

In 2012, the Electric Program Investment Charge (EPIC) was established by the California Public Utilities Commission to fund public investments in research to create and advance new energy solutions, foster regional innovation and bring ideas from the lab to the marketplace. The CEC and the state's three largest investor-owned electric utilities—Pacific Gas and Electric Company, San Diego Gas & Electric Company, and Southern California Edison Company—were selected to administer the EPIC funds and advance novel technologies, tools, and strategies that provide benefits to electric ratepayers.

The CEC is committed to ensuring public participation in its research and development programs. The CEC awards EPIC research funds to projects that promote greater reliability, lower costs, and increase safety for the California electric ratepayer and the following guiding principles:

- Providing societal benefits
- Supporting mitigation and adaptation of greenhouse gas emission in the electricity sector at the lowest possible cost
- Supporting California's loading order to meet energy needs first with energy efficiency and demand response, next with renewable energy (distributed generation and utility scale), and finally with clean, conventional electricity supply
- Supporting low-emission vehicles and transportation
- Providing economic development
- Using ratepayer funds efficiently

For more information about the Energy Research and Development Division, please visit the CEC's website at https://www.energy.ca.gov/programs-and-topics/topics/research-and-development or contact the CEC at 916-327-1551.

# ABSTRACT

The California Energy Commission (CEC) is the state's primary energy policy and planning agency. As part of its overall mission, the CEC administers several clean energy research and development programs that drive innovation and advance science and technology in the fields of energy efficiency, renewable energy and advanced clean energy generation, energy-related environmental protection, energy transmission and distribution, and transportation. The CEC is one of the administrators of the state's Electric Program Investment Charge (EPIC) program. In administering EPIC, the CEC funds research, development, and demonstrations of clean energy technologies and approaches that will benefit electricity ratepayers of California's three largest investor-owned electric utilities and lead to technological advancement and breakthroughs to overcome the barriers that prevent the achievement of the state's statutory energy goals. EPIC provides funding for applied research and development, technology demonstration and deployment, and market facilitation.

This report outlines the progress and status of CEC activities funded by EPIC from January 1, 2019, through December 31, 2019. It has been prepared in accordance with applicable California Public Utilities Commission decisions and California Public Resources Code Section 25711.5.

**Keywords**: Advanced generation, agriculture, buildings, California Energy Commission, California Public Utilities Commission, clean energy economy, climate change, decarbonization, demand response, disadvantaged community, distributed generation, Electric Program Investment Charge, electricity, electrification, energy efficiency, energy equity, energy policy, energy research, energy storage, entrepreneurial ecosystem, environmental, greenhouse gas, innovation pipeline, jobs, loading order, low-income community, ratepayer benefits, RD&D, renewable energy, resilience, safety, smart grid, transmission, transportation, U.S. Department of Energy, water

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# EXECUTIVE SUMMARY

## Overview of Program/Plan Highlights

California is working to address the new and severe consequences of climate change, such as the increasing risk of extreme wildfires near the wildland urban interface, while continuing to be ambitious with California's core mission of building a clean energy future. Building on success and lessons learned, the California Energy Commission (CEC) is leading the state to a 100 percent clean energy future. In 2019, CEC staff estimates 36 percent of retail electricity sales in California were provided by RPS-eligible renewable resources, but much work lies ahead to achieve the goal of 100 percent zero-carbon and renewable electricity by 2045 mandated by Senate Bill (SB) 100 (De León, Chapter 312, Statutes of 2018).

Through the EPIC program, the CEC catalyzes innovation to advance safety, reliability, and affordability in California's electricity system. The CEC awards EPIC funds through a competitive process to projects that will accelerate achievement of California's clean energy policies, selecting projects designed to be impactful within each of the targeted sectors.

Research has focused on technologies to promote building electrification, increase renewable energy generation, integrate more distributed energy resources, such as solar and energy storage, and bring innovation to the industrial and agriculture sectors.

The CEC shares knowledge gained from EPIC projects through publications, events, and online resources. For example,

- CEC staff conducted or participated in more than 50 public webinars and workshops in 2019.
- The CEC's Web page showcasing EPIC projects has been viewed online more than 120,000 times by more than 9,000 users through 2019.

Realizing the full impact of clean energy innovations can take several decades. For example, in its 2017 assessment of the Advanced Research Projects Agency – Energy (ARPA-E), the National Academies of Science stated, "Most transformative energy technologies require many years, often several decades, to go from nascent research to first marketable product." Fostering entrepreneurship and access to testbed equipment can accelerate clean energy innovation, attract investment to California, and stimulate job growth.

Accomplishments resulting from CEC EPIC research, development, demonstration, and market facilitation projects will grow as technologies mature and become commercially available. The following examples provide a small sample of accomplishments through 2019 and illustrate how EPIC research is advancing solutions to high-priority challenges facing California.

The highlights listed here are projects that have already successfully transitioned to the commercial market, codes and standards or influenced policy. Chapter 3 includes additional examples of EPIC projects with technological success.

The following highlights are grouped into themes that advance achievement of the pillars of California's key climate change strategy. The pillars set targets for key sectors of California's economy to reduce greenhouse gas emissions and adapt to climate change. For more information, see California Air Resources Board, September 20, 2016, The Governor's Climate Change Pillars: 2030 Greenhouse Gas Reduction Goals, available online at https://ww3.arb.ca.gov/cc/pillars/pillars.htm. Achieving these deep, transformative goals will require more than incremental change. The entrepreneurial ecosystem creates a framework that encourages clean energy startup companies to accelerate achievement of California's clean energy statutes.

## Entrepreneurial Ecosystem

- From a sample of 22 startup companies seeking private investment, estimates indicate total private investment nearly tripled after firms received an EPIC award, from about $260 million to more than $740 million.
- Later-stage EPIC recipients leveraged EPIC awards to attract nearly $180 million in federal and state (non-EPIC) funding. This amount includes $25 million of leveraged federal funds for an EPIC cost-share project expected to be considered for approval at a CEC business meeting in 2020.

## Resilience and Safety

- During a public safety power shutoff (a power shutoff initiated by a utility during extreme weather to reduce the risk of wildfire) in October 2019, the EPIC-funded microgrid at the American Red Cross shelter at Blue Lake Rancheria in Humboldt County provided an island of electricity (a place with electricity when surrounding areas did not have electricity). According to an article in *Microgrid Knowledge*, Blue Lake Rancheria facilities served about 10,000 people during the outage, including people who rely on medical devices that need electricity to operate.
- The California Public Utilities Commission (CPUC) directed the investor-owned utilities (IOUs) to use EPIC-funded Cal-Adapt as a source of data in Decision 9-10-054 under the climate adaptation rulemaking. The Cal-Adapt Web platform supports risk management and planning by providing access to the wealth of climate projections data and interactive visualizations that help utilities, local leaders, and state officials analyze energy sector vulnerabilities to climate change in California and take strategic actions to strengthen resilience.

## Advancing Energy Equity

- California is working to advance clean energy equity in disadvantaged and low-income communities, tribes, and rural communities. According to the California Air Resources Board (CARB), millions of Californians live in communities with

unhealthful levels of ozone and particulate matter. The final report for an EPIC-funded study, *Air Quality Implications of an Energy Scenario for California Using High Levels of Electrification,* published in 2019, indicates electrifying transportation, space heating, and industrial processes in California can provide public health benefits valued at more than $100 billion per year in 2050.

- Through December 2019, 29 percent of CEC EPIC technology demonstration and deployment funding has been invested in projects in disadvantaged communities—as defined in section 39711 of the California Health and Safety Code and the California Environmental Protection Agency based on census tracts with the top 25 percent scores from CalEnviroScreen—and an additional 36 percent has been invested in projects in communities that are low income but not disadvantaged.

## Decarbonization of Buildings, Industry, Agriculture, Water Treatment, Energy, and Transportation

- The CEC-funded Fremont fire station microgrids project demonstrated an approach to meet net energy metering requirements for battery storage systems at a lower cost. Based on information from this demonstration project, the CPUC changed its requirements to allow this approach for battery storage systems to be eligible for net energy metering. Lower cost battery system configurations will help California integrate high levels of variable renewable energy from solar and wind resources, an important advancement towards California's 100 percent clean energy standard.
- SunSpec Alliance developed a test framework and open-source software tools to enable rapid product development and safety testing of inverters and related products. Knowledge gained from this project informed CPUC requirements for communication capabilities for equipment that interconnects to and exports electricity to California's distribution grid. Manufacturers are required to comply with the new advanced inverter requirements by March 22, 2020. This project reduces the time necessary for manufacturers to document compliance.
- Improved day ahead photovoltaic (PV) energy forecasting methods developed and tested with EPIC funding and being used by the California Independent System Operator (California ISO) are projected to save California $176 million over the next 30 years.
- With EPIC funding, Nevados developed and tested a PV tracker for sloped terrain. Compared to conventional PV trackers, Nevados estimates its tracker triples the amount of land in California with technical potential for PV panels, and reduces the environmental footprint as the trackers do not require grading.
- California farmers use software solutions developed by PowWow Energy, Inc., a technology company with energy-saving software solutions for the agriculture and food sector, to manage irrigation of 105,000 acres, including about 90,000

acres in the San Joaquin Valley. This project demonstrated 13 percent energy savings and 9 percent water savings.

- EPIC funded Lawrence Berkeley National Laboratory (LBNL) to conduct a pilot of MyFleetBuy, a transportation fleet procurement analysis system. The project processed data on 10,000 vehicles and demonstrated significant savings for fleet electrification, that is, switching from vehicles with internal combustion engines to partially or fully electric vehicles. The subcontractor on the agreement, Green Light Labs, received subsequent funding from the National Science Foundation and was accepted into the EPIC-funded Los Angeles Cleantech Incubator (LACI) Innovators Program. The City of Fremont entered into a contract with Green Light Labs to use MyFleetBuy for municipal fleet electrification.

## Status of Electric Program Investment Charge Program

Research is a critical part of making the transition to clean energy faster, lower cost, and more inclusive. As the first wave of EPIC-funded research comes to completion, the CEC is scaling up technology diffusion efforts (such as workshops, demonstration projects, publications, and online tools) to ensure rapid uptake of results.

Over the years issues, challenges, and priorities have evolved. The CEC EPIC program addresses key themes listed as investment topics in Table ES-1. Many of these topics include technology demonstration projects to advance energy equity. Accomplishments from EPIC projects are summarized in Chapter 1 and Chapter 3, and further information is available in Appendix B and Appendix C.

Additional EPIC technology adoptions are expected in coming years as projects are completed and uptake continues through technology transfer; publications; inclusion in codes, standards, and protocols; continued research, development, and demonstration; and subsequent funding to bring technologies to market.

Renewal of the EPIC program beyond 2020 is under consideration at the CPUC in Rulemaking 19-10-005. The CEC looks forward to supporting the proceeding to renew the EPIC program and build on the ability of the program to shape California's clean energy market and enable the state to more effectively and efficiently meet its energy mandates and aspirations.

**Table ES-1: CEC EPIC Investment Topics and Portfolio Topics**

| Investment Topic | Portfolio Topics |
|---|---|
| Entrepreneurial Ecosystem | • Entrepreneurial support programs<br>• Technology testing and validation support<br>• Production scale-up support |
| Building a Safe and Resilient Energy System | • Microgrids<br>• Forest biomass<br>• Climate and weather prediction tools |
| Decarbonization: Improving Energy Efficiency in Buildings | • Grid-interactive efficient buildings<br>• Whole-building energy efficiency upgrades<br>• Low-carbon heating, ventilation, and air conditioning (HVAC) and refrigeration<br>• Solid-state lighting and advanced daylighting<br>• Plug loads<br>• Advanced window and building envelope technologies |
| Decarbonization: Innovation and Energy Efficiency for Industrial, Agricultural, and Water Sectors | • Low-carbon water treatment, water recycling, and desalination<br>• Smart manufacturing and agriculture<br>• Low-carbon process heating<br>• Waste to energy |
| Decarbonization: Enabling a More Decarbonized and Decentralized Electric Grid | • Variable renewable generation<br>• Dispatchable low-carbon generation<br>• Energy storage technologies<br>• Tools to streamline distributed energy resource and storage deployment<br>• Enabling technologies for virtual power plants and distributed energy resource aggregation |
| Decarbonization: Transportation Electrification | • Vehicle-grid integration<br>• Advanced battery technologies<br>• Electric vehicle infrastructure deployment tools |

Source: California Energy Commission staff

# CHAPTER 1:
# Introduction and Overview

## Background on EPIC

EPIC provides funding, networking, and knowledge-sharing opportunities that spur innovation in California to advance climate-change resilience and achieve California's clean energy goals while maintaining reliability, affordability, and safety.

The CPUC established EPIC to fund public investments in research to create and advance new energy solution, foster regional innovation and bring ideas from the lab to the marketplace. The CEC and the state's three largest investor-owned utilities—Pacific Gas and Electric Company (PG&E), San Diego Gas & Electric Company (SDG&E) and Southern California Edison Company (SCE)—were selected to administer the EPIC funds and advance novel technologies, tools, and strategies that provide benefits to electric ratepayers.

### Accelerating the Commercialization of New Technologies

Clean energy goals are moving markets in California. Projects funded by the CEC EPIC program bring together technical and commercial expertise to expedite learning needed to develop new products and bring them to market.

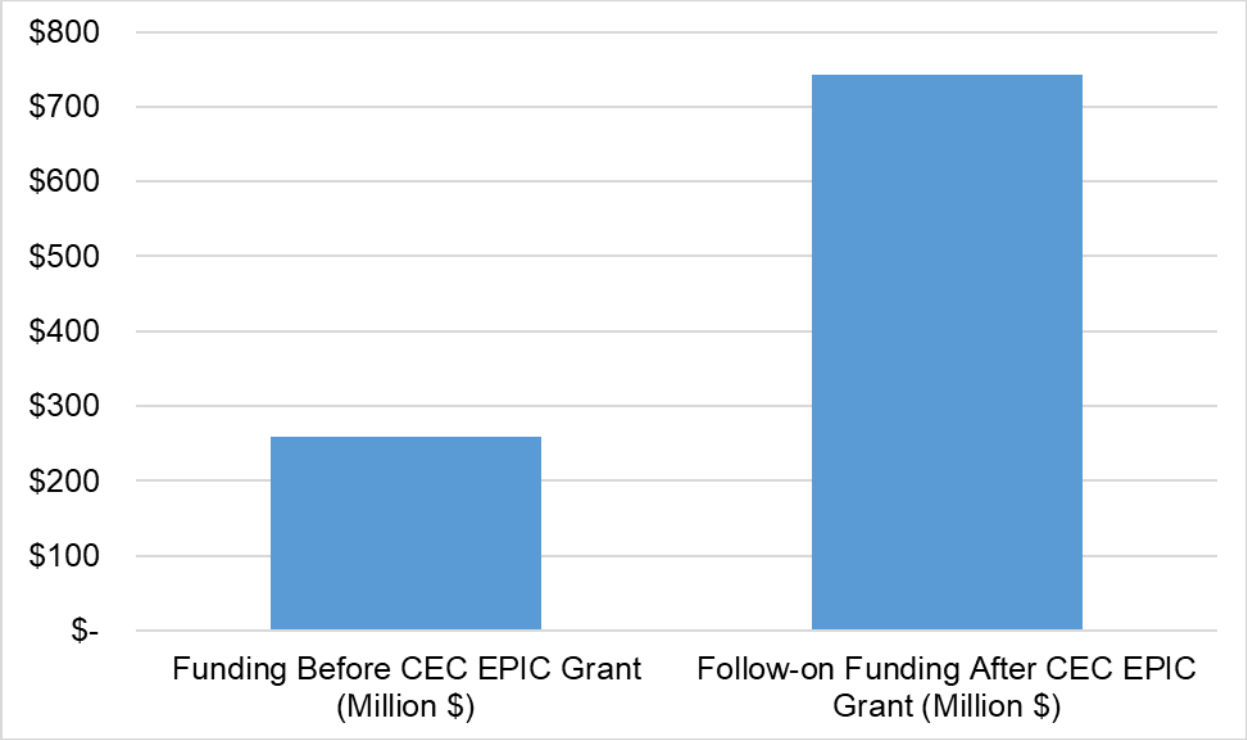
EPIC investments accelerate follow-on funding for clean energy startup companies. From a sample of 22 startup companies seeking private investment, available data indicate total private investment nearly tripled after firms received an EPIC award, from about $260 million to more than $740 million (Figure 1). Furthermore, five other startup companies went through successful exits, defined as a merger, acquisition, or secondary transaction.

In addition to attracting private investment, the CEC and other stakeholders have long recognized that one of the key benefits of state-funded R&D programs is the ability to attract and leverage federal funding to California. Leveraging federal funding provides efficient use of EPIC funding, one of the guiding principles of EPIC.[1]

Table 1 shows the match and leveraged funds attracted to California by CEC EPIC projects. For every project dollar, partners contributed more than 75 cents in match and leveraged funding as part of the project award.

1 The guiding principles for EPIC are stated in CPUC decision 12-05-037.

**Figure 1: Follow-On Private Funding for Selected Companies Before and After CEC EPIC Award (Million $)**




**Data do not include CEC funding, recipients that first received EPIC funding in 2019, CalSEED recipients, or CEC EPIC entrepreneurial ecosystem companies. This information is current as of January 3, 2020.**

Source: Pitchbook

**Table 1: Match Funds and Leveraged Funds by EPIC Investment Topic**

| Investment Topic | Match Funds ($Million) | Leveraged Funds ($Million) | EPIC Funding Awards ($Million) | Match plus Leveraged as Percent of EPIC Awards |
|---|---|---|---|---|
| Entrepreneurial Ecosystem | $58 | $7 | $143 | 45% |
| Resilience and Safety | $71 | $60 | $106 | 123% |
| Building Decarbonization | $86 | $24 | $170 | 65% |
| Industrial, Agricultural Innovation* | $79 | $41 | $113 | 107% |
| Grid Decarbonization and Decentralization | $75 | $32 | $154 | 69% |

| Investment Topic | Match Funds ($Million) | Leveraged Funds ($Million) | EPIC Funding Awards ($Million) | Match plus Leveraged as Percent of EPIC Awards |
|---|---|---|---|---|
| Transportation Electrification | $17 | $6 | $33 | 70% |
| **Total** | **$385** | **$171** | **$720** | **77%** |

**Match funds are funds contributed by partners as part of the project award. Leveraged funds are not the same as match funds. Leveraged funds are funds attracted from federal agencies or other interested parties that are external to the agreement to further develop the concept or technology.**

***Includes $25 million of leveraged federal funds for an EPIC cost-share project expected to be considered for approval at a CEC business meeting in summer 2020.**

Source: California Energy Commission staff

## EPIC Program Components

CPUC Decision 12-05-037, issued in May 2012, approved the CEC to administer 80 percent of EPIC funds. The CPUC has approved the CEC use of EPIC funds in the following investment areas:

- Applied Research and Development: Activities supporting precommercial technologies and approaches designed to solve specific problems in the electricity sector, including research leading to advancements in clean energy technologies, demand-side technologies, and renewable energy. Activities that address environmental and public health impacts of electricity-related activities and support clean transportation with links to electricity sector ratepayer benefits also fall into this area.
- Technology Demonstration and Deployment: Installing and operating precommercial technologies or employing operational strategies at a scale large enough and in conditions reflective of anticipated operating environments to assess functional and performance characteristics, and financial risks.
- Market Facilitation: Activities to support clean energy technology and strategy implementation. In the 2018-2020 CEC EPIC Investment Plan, the CEC focused on the following market facilitation activities: commercialization assistance, local government regulatory assistance and streamlining, market analysis, and program evaluation to support deployment and expand access to clean energy technology and strategies. In previous CEC EPIC Investment Plans market facilitation activities included incubating statewide clean energy innovation and entrepreneurship efforts, reducing barriers to launching emerging clean energy solutions, developing the workforce needed to achieve the state's energy goals, encouraging greater participation from diverse businesses and communities, regulatory assistance and

permitting, market research, program tracking, education and outreach, and strategy deployment. The CPUC Decision 12-05-037 clarifies that this category should not necessarily be limited to renewable energy and may include any other clean energy technologies or approaches or both.

Total EPIC funding for CEC activities is summarized in Chapter 2. EPIC investments are mapped or correlated to the different elements of the electricity "value chain," which is composed of grid operations/market design, generation, transmission, distribution, and demand-side management. Based on the guiding principles, each EPIC investment plan clearly matches strategic initiatives to the appropriate section of the value chain. Each project funded through EPIC also maps clearly to the appropriate section of the value chain, consistent with an approved EPIC Investment Plan. (See Appendix B, CEC EPIC Project Write-Ups, and Appendix C CEC EPIC Project Status Report.)

## EPIC Program Regulatory Process

The CPUC oversees the Energy Commission's administration of EPIC funds, including approving the Energy Commission's EPIC Investment Plans. In addition, the Legislature must grant the Energy Commission spending authority to disburse EPIC funds for project awards and use EPIC funds for administrative expenses.

This EPIC Annual Report is provided to the CPUC in accordance with CPUC EPIC decisions to date. To ensure consistent reporting among all four administrators, these decisions specify the outline and contents of this report, including individual project reporting requirements. The Energy Commission also provides this EPIC Annual Report to the Legislature, following California Public Resources Code Section 25711.5, and makes the report publicly available on its website.

## Coordination

In 2019, CEC continued to build partnerships and collaboration across diverse stakeholder groups, including activities to:

- Engage networks and partnerships.
- Coordinate with EPIC administrators and other energy innovation efforts.

### Engaging Networks and Partnerships

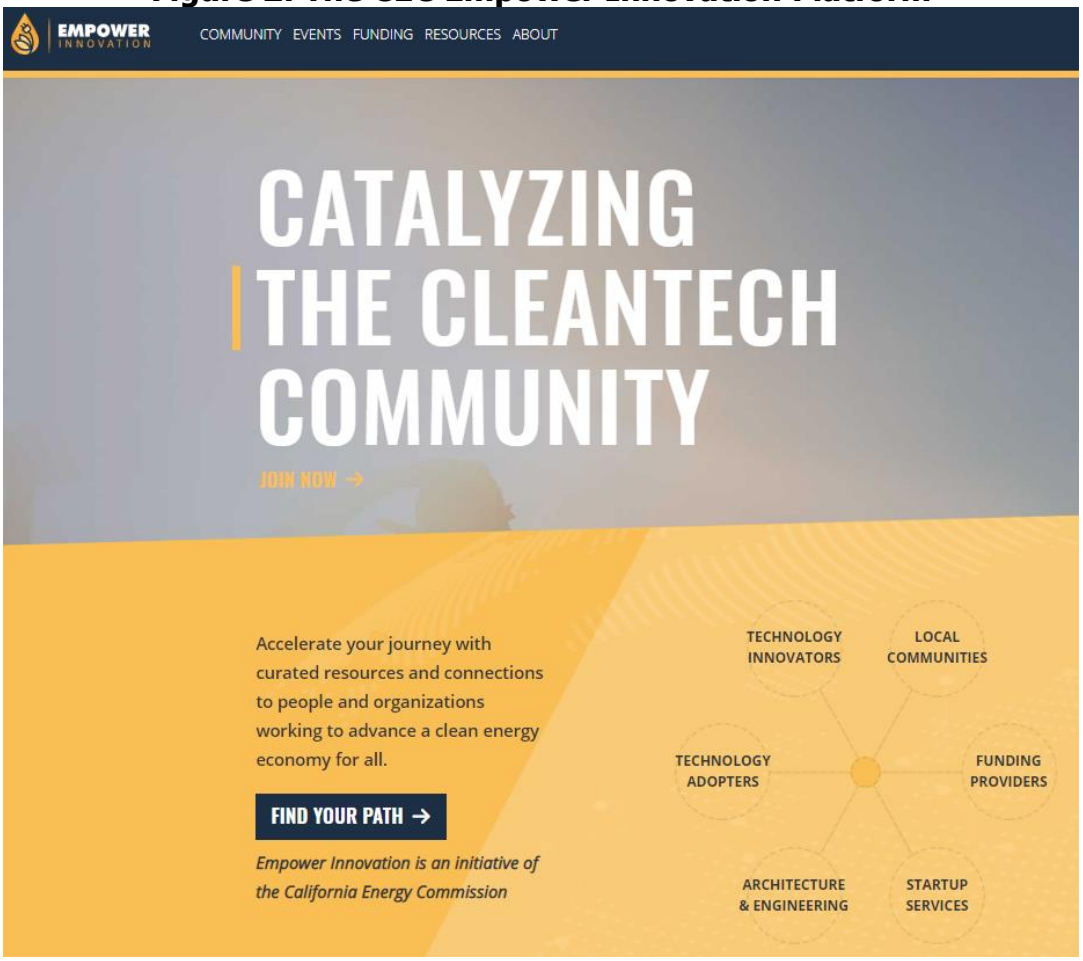
Over the past four years, more than 1,600 participants joined the CEC's LinkedIn Networking Hub community. Project teams were formed as members joined subgroups and participated in networking webinars hosted by CEC staff. In 2019, CEC staff hosted three EPIC LinkedIn networking webinars with a total of 42 attendees. The most popular subgroup is the Demonstrate Business Case for Advanced Microgrids Supporting CA's Energy & GHG Policies (GFO-17-302) with 136 subscribers.

To better serve the existing CEC LinkedIn Networking Hub community, the CEC launched Empower Innovation, the first social networking platform designed for professionals working on building a clean energy economy for everyone. The platform

was launched in 2019. After October 31, 2019, the CEC discontinued support for its LinkedIn Networking Hub and began posting new grant funding and networking opportunities on the Empower Innovation platform (Figure 2). To help with the transition, the CEC posted a short video for LinkedIn members of the CEC Networking Hub to learn about the new platform.

Participation in the new platform is growing quickly. In December 2019, the Empower Innovation platform[2] had more than 130 organizations and more than 8,700 page views, as well as announcements of more than $900 million in funding opportunities. CEC staff plans to hold four networking events to bring community organizations and other stakeholders representing low-income and disadvantaged communities onto the Empower Innovation platform.

**Figure 2: The CEC Empower Innovation Platform**



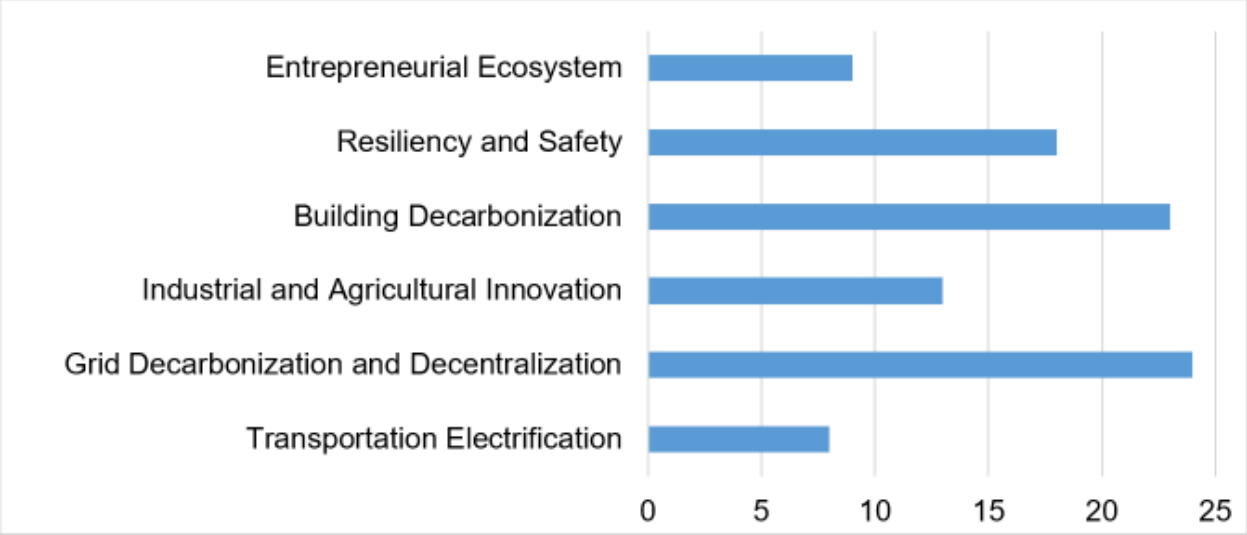

Source: California Energy Commission staff

2 The Empower Innovation Web platform is available online at https://www.empowerinnovation.net/.

### EPIC Projects Promote Partnerships

Participation from a broad range of stakeholders helps ensure products resulting from demonstration and market facilitation projects are informed by local insights and concerns. This information can help accelerate access and adoption of clean energy innovation across California. Figure 3 shows EPIC projects with three or more stakeholder group types. The stakeholder group types are based on the following categories: national laboratory, private (nonprofit), private company (for profit), municipality/local government, university, and utility.

**Figure 3: EPIC Projects with Three or More Stakeholder Group Types (Through December 2019)**




**This figure does not include CalSEED projects.**

Source: California Energy Commission staff

## Coordination With EPIC Administrators and Other Energy Innovation Efforts

Coordination among energy innovation efforts is important to ensure EPIC research projects address priority topics and critical funding gaps, as well as leverage other public and private funding sources. Coordination helps make the CEC EPIC program more effective and impactful for the California ratepayer by providing information needed to ensure the CEC portfolio of EPIC projects is strategically focused and sufficiently narrow to make advancement on the most significant technological challenges.

The CEC is committed to ongoing coordination and collaboration with the three IOU administrators of EPIC funds and other energy innovation stakeholders in developing and implementing EPIC Investment Plans. This section summarizes CEC coordination with the three IOU EPIC administrators and other energy innovation efforts.

## EPIC Administrator Coordination

CEC staff collaborated with the three IOU EPIC administrators (PG&E, SCE, and SDG&E) by conducting biweekly conference calls, coordinating notification and outreach for upcoming events, and participating in joint public workshops. The following activities highlight EPIC administrator coordination for 2019.

- The CEC held meetings with the IOUs to present research updates and discuss research opportunities in wildfire ignition prevention technologies, energy storage, and microgrids. These meetings also included coordination activities to prepare topics and agendas for the February 2019 EPIC Symposium and the November 2019 EPIC Fall Workshop and discussions on reconciliation of EPIC administrative payments.
- On February 19, 2019, the CEC hosted the 2019 EPIC Symposium in conjunction with the IOU EPIC administrators. The symposium showcased emerging clean energy technologies and insights from industry leaders, researchers, and government decision makers. The event included a cleantech pitch session with entrepreneurs discussing how their projects moved from idea to marketplace, a panel on innovation in vehicle-to-grid and vehicle-to-building technologies, and a panel discussing new ways to bring innovative clean energy technology projects and programs to disadvantaged and low-income communities.
- On November 8, 2019, SDG&E hosted the 2019 EPIC Fall Workshop on behalf of the four EPIC administrators. The focus of the workshop was to engage stakeholders in completed and planned research investments aimed at safety, clean energy, resiliency, affordability, and equity in a zero-carbon future. Some of the featured presentations included CPUC overview; IOU overview and status of EPIC research such as the wildfire ignition prevention technology demonstration, and the safety training simulator demonstration; and CEC overview of completed and planned research on energy storage and microgrids. Also, CEC staff introduced a new Web tool, Empower Innovation, which provides access to funding opportunities, curated resources and events, and connections to people and organizations.
- The CEC held two conference calls per month with the IOUs to share best practices in administering the EPIC research program. The CPUC requested that the IOUs develop a research administrative plan in which they were asked to collect best practices from peer R&D administrators, including the CEC. The CEC shared best practices on topics such as methods for measuring benefits of research and demonstration projects, demonstration of the CEC's Energy Innovation Website, and stakeholder engagement via scoping/preapplication workshops and project technical advisory committees.
- ET Summit 2019, October 21-22, 2019: This annual summit is sponsored by the Emerging Technologies Coordinating Council (ETCC), whose members include PG&E, SCE, SCG, SDGE, Los Angeles Department of Water and Power,

Sacramento Municipal Utility District and the CEC. The summit provides an opportunity to highlight CEC research and development activities and encourage commercialization and marketability of EPIC-funded technologies. Several CEC R&D projects were highlighted on the panels associated with scaling energy efficiency in commercial buildings, new HVAC technologies, trends in residential HVAC, water energy nexus, industrial process solutions, and emerging technology incubators.

- ETCC Webinar Series:
    - August 28: This webinar highlighted two CEC research and development projects focused on reducing energy associated with making fruit and vegetable concentrates and drying food products.
    - June 5: This webinar highlighted two CEC research and development projects along with IOU-sponsored projects associated with high-performance attics for zero-net-energy homes, and increasing energy efficiency of computer-gaming systems.
    - February 27: This webinar highlighted one CEC R&D project and IOU-sponsored projects associated with light-emitting diode (LED) track lighting, commercial HVAC systems, and the costs and benefits of solar water heating systems designed for community versus individual use.

**California State Agency Coordination**

In 2019, the CEC R&D Division engaged in several coordination efforts with other state offices involved in similar research demonstration and deployment (RD&D) activities.

On the topic of energy storage, the ERDD staff coordinated with the Governor's Office of Planning and Research (OPR) on the release of GFO-18-305–Developing Lessons Learned, Best Practices, Training Materials and Guidebooks for Customer Side of the Meter Energy Storage. Assembly Bill 546 (Chiu, Chapter 380, Statutes of 2017) authorizes OPR to provide a guidebook for energy storage to streamline the permitting process at the local level. This guidebook is expected to accelerate the commercial acceptance of energy storage systems in California and reduce the costs of energy storage system installations in areas like permit approvals and site-level design approvals by the responsible authority having jurisdiction for these types of projects.

On the topic of microgrids, CEC staff coordinated with the CPUC on public proceedings in support of the implementation of SB 1339 (Stern, Chapter 566, Statutes of 2018). The law requires the CPUC, in consultation with the CEC and the California ISO, to take specified actions by December 1, 2020, to ease the transition of microgrid technology from the current status as a promising emerging technology solution to provide a successful, cost-effective, safe, and reliable commercial product that helps California meet its future energy goals and provides electricity customers new ways to manage their individual energy needs. Staff provided background support detailing the lessons learned from EPIC-funded microgrid grants and the lessons learned from the

development of the draft roadmap for commercializing microgrids in California. Moreover, staff supported the CPUC public review process by providing a microgrid lessons learned presentation at a CPUC hosted public workshop.[3] The CPUC will consider this information in determining actions to advance the commercialization of microgrid technology. These actions include "developing standards, protocols, guidelines, methods, rates, and tariffs that serve to support and reduce barriers to microgrid deployment while prioritizing system, public, and worker safety, and avoiding shifting costs between ratepayers."[4] CEC staff support for the CPUC microgrid proceeding is expected to continue into 2020.

To advance innovation in the transportation sector, CEC's R&D staff shared research results with the CEC's School Bus Replacement Program on vehicle-grid integration for school buses, and development of the *California Vehicle-Grid Integration Roadmap* update on smart charging and bidirectional power flow.[5] Staff also participated in the interagency Transportation Research Roundup Group to coordinate research advancing clean energy vehicle-integration.

To advance innovation of renewable energy and advanced generation, CEC staff coordinated with the California Department of Food and Agriculture dairy digester research and development program, the California Bioresources Economy Summit, the multi-agency High Hazard Fuels Availability Study, a public workshop on offshore wind development, the CEC Lithium Recovery Initiative, and an inter-agency workgroup on disposal of PV panels and batteries for storage and electric vehicles.

### Coordination With Energy Research Agencies in Other States

In 2019, CEC staff held several Web-coordinating meetings with the New York State Energy Research and Development Authority (NYSERDA) staff to share lessons learned from active EPIC-funded energy storage and microgrid projects. NYSERDA advances energy innovation to expand New York's clean energy economy, reduce pollution and greenhouse gas emissions, and reduce customer energy bills.

During these meetings, CEC staff informed the NYSERDA staff of publicly available information on EPIC solicitations for energy storage research and asked NYSERDA to

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3 Gravely, Mike. December 12, 2019. "Lessons Learned from Energy Commission Microgrid Research Activities." CEC staff presentation at CPUC public workshop on R.19-09-009 Order instituting Rulemaking Regarding Microgrids Pursuant to Senate Bill 1339. https://www.cpuc.ca.gov/calEvent.aspx?id=6442463462.

4 CPUC. September 12, 2019. Order Instituting Rulemaking Regarding Microgrids Pursuant to Senate Bill 1339. Rulemaking 19-09-009. http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M314/K274/314274617.PDF.

5 For workshop material and related information on development of the *California Vehicle Grid Integration Roadmap* update, see https://www.energy.ca.gov/programs-and-topics/programs/california-vehicle-grid-integration-roadmap-update.

encourage the energy storage companies that are working with NYSERDA to participate in these EPIC solicitations.

The NYSERDA staff reviewed the publicly released EPIC energy storage grant funding opportunities. Furthermore, ERDD staff served as reviewers for NYSERDA energy storage solicitations during 2019. This review enabled EPIC staff to become aware of the current state of energy storage research activities in New York. These technical exchanges provided valuable knowledge on the current state of energy storage research.

In 2019, New York increased its target for installed energy storage from 1,500 MW by 2025 to 3,000 MW by 2030. This adjusted target makes New York and California the largest energy storage markets in the country. New York and California have developed a valuable partnership to share energy storage implementation data.

**Coordination With U.S. Federal Energy Research Agencies and Laboratories**

In 2019, CEC coordination with U.S. federal entities on energy innovation included the following activities:

- CEC and U.S. DOE Sandia National Laboratories (U.S. DOE Sandia) staff finalized an agreement for future coordination and sharing of information, which is scheduled to be considered at a CEC business meeting in early 2020. As part of this memorandum of understanding, U.S. DOE Sandia will provide the CEC technical support in evaluating field performance of energy storage systems installed at more than 30 sites. Moreover, U.S. DOE Sandia staff will provide technical reviews and comments on CEC energy storage proposals during 2020.
- CEC staff reached out to U.S. DOE Sandia staff to obtain technical assistance in developing an energy storage system performance monitoring and tracking capability. The CEC has more than 30 field sites that are demonstrating energy storage capability in different applications and use cases. All these energy storage systems have detailed performance tracking systems as part of the associated infrastructure. The CEC is interested in tracking the performance of these energy storage systems and understanding how different technologies (lithium-ion batteries, flow batteries, advanced chemistry batteries, thermal energy storage systems, and flywheels) perform in similar applications or uses. U.S. DOE Sandia will provide technical expertise on determining what specific measurements are valuable to track and report upon and how these data can be used in developing future energy storage research plans. The tracking of these data is expected to start in 2020.
- U.S. DOE: on September 5, 2019, CEC staff participated in United States-China Clean Energy Research Center for Water-Energy Technologies (CERC-WET) Industrial Advisory Group Meeting to discuss a variety of topics related to the energy-water nexus (energy use related to water and vice versa).

- U.S. DOE, Pacific Northwest National Laboratory, LBNL, and Idaho National Lab presented at a CEC staff workshop on November 19, 2019. The topic of the workshop was energy research innovations in water treatment, delivery, and energy recovery. Presenters and participants at the workshop identified research needs and opportunities for emerging water and wastewater technologies.
- U.S. EPA, LBNL, and CARB are included on the technical advisory committee for the project titled "SUper eMitters of Methane Detection Using Aircraft, Towers, and Intensive Observational Network (SUMMATION)." A kick-off meeting was held on July 6, 2019. The purpose of this project is to establish a persistent regional-scale methane emissions monitoring network in the southern San Joaquin Valley.
- U.S. Department of Energy and National Renewable Energy Laboratory (NREL): In the summer of 2019, the CEC joined the Plug and Process Load Strategic Working Group with DOE, NREL, UC Irvine's Calplug, and others. The team collaborates with researchers and industry experts to promote awareness and energy reduction through new plug-in technologies and strategies. The information-sharing will help inform future EPIC solicitations.
- ARPA-E Energy Innovation Summit: The ARPA-E Energy Innovation Summit was held near Denver from July 8 through11, 2019. CEC staff attended the event, where experts from different technical disciplines and professional communities discussed energy challenges and innovations with respect to industry, research, and policy. Participants discussed program concepts and "out-of-the-box" opportunities. Insights from the summit informed ongoing work by the CEC to coordinate with ARPA-E. Guided by an interagency MOU, the CEC and ARPA-E work together to move transformational energy technologies out of the lab and into the market. Common areas of R&D include energy efficiency, energy storage, transportation, DERs, and power electronics.

### Coordination Meetings With the U.S. Department of Defense

During 2019, CEC staff continued supporting the joint efforts with the U.S. Department of the Navy under the MOU signed in 2016 by the Chair of the CEC and the Assistant Secretary of the Navy for Energy, Installations, and the Environment.

- CEC staff held a kick-off meeting for the recently awarded EPIC grants for the microgrid on Naval Base Ventura County, Port Hueneme (EPC-18-001) and the microgrid grant awarded to Miramar Marine Corp Air Station (EPC-17-032). One of the highest energy priorities for the U.S. Department of the Navy is base reliability and resiliency. These two microgrids represent a substantial research project designed to demonstrate these improved reliability and resiliency features.
- CEC supported the Governor's Annual Military Council meeting in August 2019 and discussed the goals and objectives of the MOU going forward.

- In 2019, to ensure project stability and maintain future research schedules, the Department of Defense-Environmental Security Technology Certification Program (DOD-ESTCP) executive director agreed to work with the CEC by joining its DOD-funded microgrid on the Naval Base Ventura County, Port Hueneme, with the EPIC-funded microgrid demonstration project on the same facility. By joining these two similar but different efforts, DOD and the EPIC program will be able to leverage funding and receive a better research overall effort. These projects will share energy storage demonstration systems, system testing centers, and resulting data. Furthermore, by joining these efforts, the EPIC program will receive increased visibility into future DOD-funded energy-related research. During 2019, the CEC arranged subsequent coordination calls and technical discussions with the leadership and staff of the DOD-ESTCP Program to share full portfolios of energy storage research being managed by each. In 2019, the DOD-ESTCP Program funded six contractors to develop concept proposals for long-duration (seven-day) energy storage at six military bases. This study is one of the most comprehensive long-duration studies funded by the DOD.

To promote ongoing coordination between the CEC EPIC program and military facility planning in California, the CEC staff member serving as chief military advisor to CEC Chair Hochschild is staff member in the CEC Research and Development Division, where he leads staff working on energy storage and microgrids.

## Transparent Public Process and Competitive Solicitations

The CEC has a robust outreach strategy to shape research through public workshops on investment planning and solicitations. CEC staff conducted or participated in more than 50 public webinars and workshops in 2019. Components of the CEC outreach strategy include:

- Preapplication workshops and requests for comment
- Increasing diversity and equity in EPIC
- Sharing knowledge and lessons learned
- Geographic diversity to accelerate technological learning and technology diffusion
- Informing policies, proceedings, codes, standards, and protocols

### Preapplication Workshops and Requests for Comment

CEC staff holds preapplication workshops to discuss open solicitations in a public forum with potential applicants. These workshops provide an opportunity for potential applicants to ask questions and network. All questions and answers are posted online following the preapplication workshop. Examples of preapplication workshops in 2019 include:

- GFO-19-302. Advance to Next-Generation Wind Energy Technology (Next Wind).
- GFO-19-303. Geothermal Energy Overcoming Technology Hurdles and Enabling Recovery of the Mineral Lithium (Geothermal).

- GFO 19-304. Advanced Refrigeration and Heat Pumps for the Industrial Sector.

In some cases, CEC staff holds public workshops to solicit input on research roadmap development or draft competitive solicitations. In 2019, such workshops addressed:

- A workshop in January to launch the upcoming $50 million design-build competition for zero-emission mixed-use development.
- Three public workshops (held March 25, July 25, and September 17) to solicit public input for the Distributed Energy Resource Research Roadmap. Workshop participants provided input on a draft technical assessment, prioritization method, and summary of research ideas.
- A staff workshop in December to seek input from stakeholders on forthcoming solicitation regarding climate scenarios and analyses to support electricity sector vulnerability assessment and resilient planning.

In December, CEC staff issued a request for comments on how the targeted use of distributed energy resource technologies and strategies can be used to enable faster and more cost-effective integration of charging infrastructure for medium-and heavy-duty battery-electric vehicles.

## Increasing Diversity and Equity in EPIC

California's promise, successes, and innovation stem from the rich and diverse qualities and abilities of its people. The CEC is committed to:

- Ongoing outreach activities that inform small businesses, and women-, disabled veteran-, minority-, and LGBTQ-owned businesses, and economically disadvantaged communities about opportunities to participate in program solicitations and activities.
- Enhancing efforts to reduce barriers preventing low-income, disadvantaged, and tribal communities from accessing clean energy opportunities.

### Diverse Business Ownership

Women-owned, minority, disabled veteran and lesbian, gay, bisexual, transgender, queer (LGBTQ) businesses are encouraged to apply for CEC funding opportunities. In April 2015, the CEC adopted a resolution outlining its commitment to ensure all Californians have an opportunity to participate in and benefit from CEC programs that lead to job creation and training, improved air quality, and energy efficiency and environmental gains.[6]

In October 2015, AB 865 (Alejo, Chapter 583, Statutes of 2015) required the CEC to "develop and implement an outreach program to inform the most qualified loan and grant applicants, and contractors, including, but not limited to, women, minority,

6 CEC, April 8, 2015, Resolution 15-0408-3: Resolution Regarding Diversity Policy Statement. https://www.energy.ca.gov/commission/diversity/documents/pdfs/diversity_policy_resolution.pdf.

disabled veteran, and LGBT business enterprises, about workshops, trainings, and funding opportunities. The purpose of the program is to ensure that the commission recognizes the demographic shifts of the California marketplace and is nurturing the new and next generation of energy technology leaders."[7]

CEC staff has been using a voluntary survey of research workshop participants to inform outreach. For 2016-2019, these data show that more than 14 percent of research workshop participant survey respondents stated their company identified as one or more of the following: disabled veteran business enterprise, women-owned business, minority-owned business, or LGBT-owned business. In addition, more than 20 percent of survey respondents stated their company was a small business and more than 85 percent stated their company was in California.

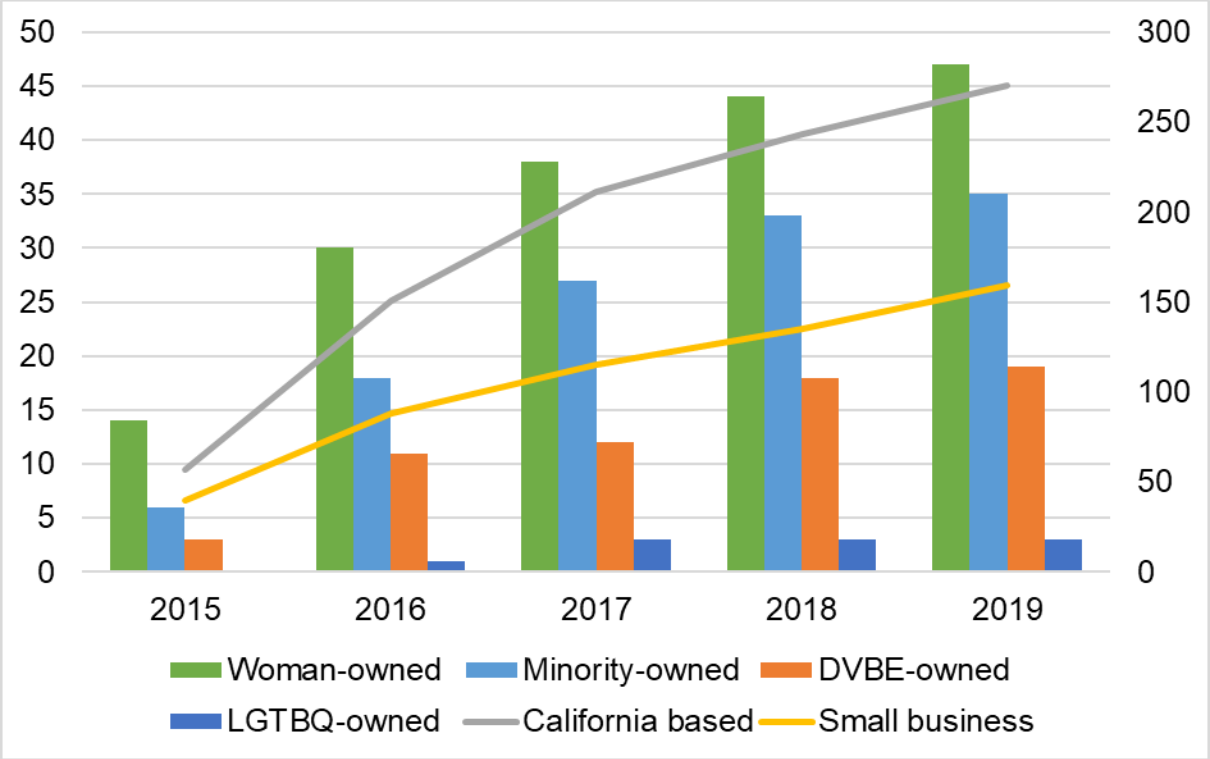
Out of 328 agreement recipients surveyed between 2015 and 2019, staff received responses from 267 (more than 80 percent). Data are self-reported by prime recipients and subcontractors responding to a volunteer survey administered by CEC staff. The data for disabled veteran-owned businesses includes data reported to the CEC separately for EPIC contracts.

Figure 4: shows EPIC agreements reporting one or more of the following as a prime or subcontractor:

- California-based entity
- Small business
- Women-owned business
- Minority-owned business
- Disabled veteran-owned business
- LGBTQ-owned business

7 See Public Resources Code Section 25230(b)(1).

**Figure 4: EPIC Award Recipient Business Ownership, Size, and Location (Prime and Subcontractors) 2015 through 2019 by Agreement**




**Self-reported survey data for EPIC agreements with one or more entities (prime or subcontractors) in each of the listed categories. The numbers of agreements reporting one or more California-based entities or small businesses (or both) are shown on the right axis. The numbers of agreements reporting one or more women-owned, minority-owned, DVBE-owned and LGTBQ-owned businesses are shown on the left axis.**

Source: California Energy Commission staff

## Energy and Equity: AB 523 Implementation

The CEC is committed to ensuring all Californians benefit from clean energy research. The CEC, consistent with legislative and CPUC direction, has prioritized energy equity in its research programs to ensure that the most vulnerable communities benefit from emerging clean energy technologies.[8] The CEC's EPIC program exceeded the requirements set forth in AB 523 (Reyes, Chapter 551, Statutes of 2017) for at least 25 percent of the technology demonstration and deployment funds to be expended on projects in and benefitting disadvantaged communities. Also, AB 523 requires an

8 In 2015, the Energy Commission 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/commission/diversity/documents/pdfs/diversity_policy_resolution.pdf. In 2016, the CEC's Low-Income Barriers Study recommended the CEC's EPIC program should target a minimum of 25 percent of technology demonstration and deployment funding for sites located in disadvantaged communities. See https://www.energy.ca.gov/sb350/barriers_report/.

additional 10 percent of the technology demonstration and deployment funds to be expended on projects in and benefitting low-income communities.

In March 2019, CEC EPIC staff helped conduct community-engagement meetings in Bakersfield and Madera in coordination with the CEC Public Advisor's Office and the CEC Fuels and Transportation Division. The meetings provided a high-level, educational overview to community members on CEC funding programs. Staff also helped lead break-out sessions to garner feedback on local energy-related challenges and possible solutions that could result in meaningful projects with direct benefits for the community. Self-Help Enterprises, a low-income housing program in Visalia, helped plan and conduct localized outreach for these meetings, and arranged guided tours of the communities for staff to better understand the communities' clean energy needs. Together with a December 2018 meeting in the San Diego area organized in coordination with I Am My Brother's Keeper, a community development corporation, these meetings are part of CEC outreach related to AB 865 and Assembly Bill 523.

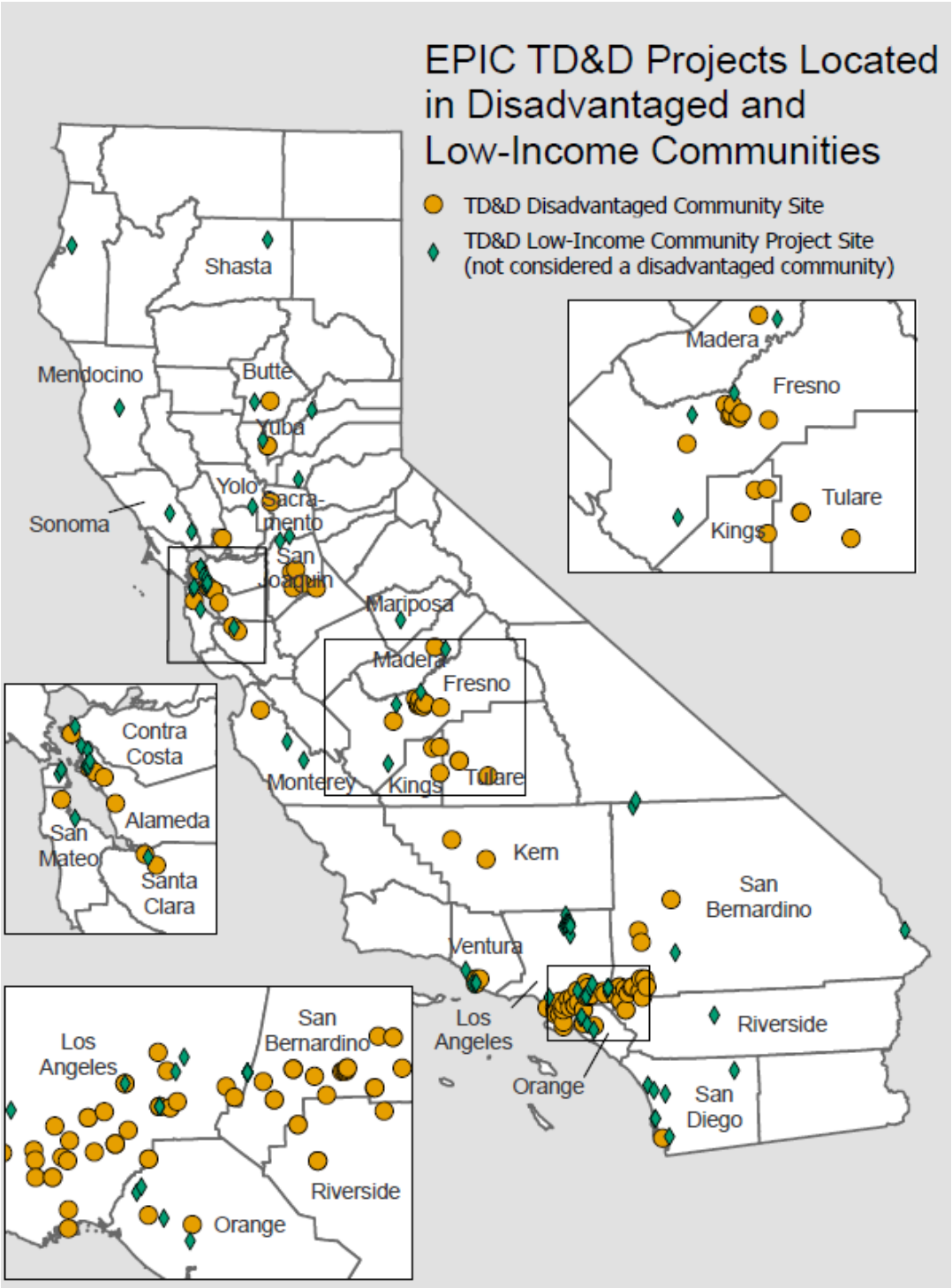
Additional outreach efforts to tribal, low-income, and disadvantaged communities in 2019 include the following:

- In February 2019, CEC staff issued a request for comments on proposed evaluation criteria for benefits and impacts to low-income and disadvantaged communities in EPIC grant funding opportunities. In developing the proposed criteria, staff considered input received from workshops held in Fresno and Diamond Bar the previous year, as well as input from CARB. The draft scoring criteria were revised to incorporate responses to the request for comments.
- In May 2019, CEC staff presented information on EPIC at the tribal funding workshop.
- At the November 2019 Disadvantaged Community Advisory Group[9] meeting, CEC staff presented information on the EPIC program and sought feedback to improve the program, including reaching out to diverse communities. Topics included the new Empower Innovation Platform and ideas to leverage the platform to increase disadvantaged and low-income community participation in EPIC funding opportunities. Staff also presented information on the new scoring criteria for projects that benefit disadvantaged and low-income communities.

Figure 5 shows the CEC EPIC project sites located in disadvantaged communities—as defined in section 39711 of the California Health and Safety Code and the California Environmental Protection Agency based on census tracts with the top 25 percent scores from CalEnviroScreen—and a separate marker for project sites that are low income but not disadvantaged. These data are through December 2019.

9 Following Senate Bill 350 (De León, Chapter 547, Statutes of 2015), the CPUC and the CEC created a Disadvantaged Communities Advisory Group (DACAG) to provide advice on programs proposed to achieve clean energy and pollution reduction.

**Figure 5: EPIC Project Sites in AB 523 Priority Communities**




Source: California Energy Commission staff

Most of California's disadvantaged communities are also low-income communities. To avoid double counting, such communities are included in the disadvantaged community category.

Through December 2019, technology demonstration and deployment projects funded by the CEC's EPIC program invested 29 percent of funds to projects in disadvantaged communities[10] and an additional 36 percent to projects in communities that are low income but not disadvantaged as defined by AB 523 using CalEnviroScreen.

In 2019, the CEC began including the new scoring criteria in EPIC technology demonstration and deployment solicitations to ensure that each project in a disadvantaged or low-income area is providing direct benefits to the local community. In addition, the CEC will continue to provide set-asides in applicable EPIC solicitations for projects in and benefitting disadvantaged or low-income communities or both. The new scoring criteria evaluate technology demonstration and deployment proposals on benefits to disadvantaged or low-income communities, community engagement efforts, and localized health impacts. For example, the scoring criteria for the 2019 grant funding opportunity on Advancing Next-Generation Heating, Cooling, and Water Heating Systems include the following:[11]

- Benefits to disadvantaged or low-income communities
    - Identifies and describes the energy and economic needs of the community based on project location, and what steps the applicant has taken to identify those needs.
    - Identifies and describes how the project will increase access to clean energy or sustainability technologies for the local community.
    - Identifies and describes how the proposed project will improve opportunities for economic impact including customer bill savings, job creation, collaborating and contracting with micro-, local, women-owned and/or minority owned, and small-businesses, economic development, and expanding community investment.
    - Identifies how the projects' primary beneficiaries are residents of the identified disadvantaged or low-income community (or communities) and describes how they will directly benefit from the project outcomes.

10 As defined in section 39711 of the California Health and Safety Code and the California Environmental Protection Agency based on census tracts with the top 25 percent scores from CalEnviroScreen. The CalEnviroScreen score is based on pollution indicators and socio-economic factors. For more information on the use of CalEnviroScreen for designation of disadvantaged communities, see https://oehha.ca.gov/calenviroscreen/sb535.

11 This example is from GFO-19-301. December 3, 2019. Application Manual. Grant Funding Opportunity GFO-19-301 – Advancing Next-Generation Heating, Cooling and Water Heating Systems. See https://www.energy.ca.gov/solicitations/2019-10/gfo-19-301-advancing-next-generation-heating-cooling-and-water-heating.

- Community engagement efforts
    - Identifies how community input was solicited and considered in the design of the project.
    - Identifies and describes how the impacted community will be engaged in project implementation.
    - Identifies and describes how and where the applicant will disseminate appropriate language and culturally appropriate education materials and career information.
    - Identifies how the project, if successful, will build community capacity.
- Localized health impacts
    - Summarizes the potential localized health benefits and impacts of the proposed project and provides reasonable analysis and assumptions.
    - Identifies how the proposed project will reduce or not otherwise impact the community's exposure to pollutants and the adverse environmental conditions caused by pollution and/or climate change. If projects have no impacts in this criterion, provide justification for why impacts are neutral.
    - Identifies health-related energy equity indicators and/or health-related factors in CalEnviroScreen 3.0[12] that most impact the community and describes how the project will reduce or not otherwise impact the indicators or factors.

## Sharing Knowledge and Lessons Learned

The CEC's EPIC program shares knowledge and lessons learned among technology innovators, technology adopters, architectural and engineering firms, startup services, funding providers, and local communities. This sharing is an important method for scientific and technological diffusion and accelerates uptake of scientific and technological achievements. Results are shared through multiple pathways. For example,

- Figure 5 shows participation in the EPIC symposiums hosted by the CEC continued to increase in 2019. With the exception of 2017, the CEC hosts a symposium each year in coordination with the three IOU EPIC administrators.[13] CEC staff estimates 800 people attended the 2019 symposium in person. The symposium brings together policy leaders, technology adopters, entrepreneurs, and others to discuss clean energy research, results, and challenges (Figure 6).

12 https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-30.

13 On October 18, 2017, Energy Commission staff joined the IOUs for the 2017 EPIC Fall Symposium in La Jolla (San Diego County) hosted by SDG&E. This public symposium provided an overview of EPIC program activities and showcased EPIC projects that support distribution system automation.

- The CEC shares EPIC project results online through the CEC Energy Innovation Showcase. Through December 2019, sample data from Google Analytics indicate the Energy Innovation Showcase has been viewed nearly 120,000 times by more than 9,000 people.
- The CEC posts a final report online for each EPIC project. As of December 2019, sample data from Google Analytics indicate the EPIC final reports available online (there are more than 50.) were viewed more than 6,800 times. Table 12 in Chapter 3 provides a list of all projects completed in 2019, including links to published final reports.
- Through December 2019, results of CEC EPIC-funded projects have been published in more than 230 academic publications with more than 1,300 citations. Researchers use and cite academic publications to learn and build upon recent advancements.

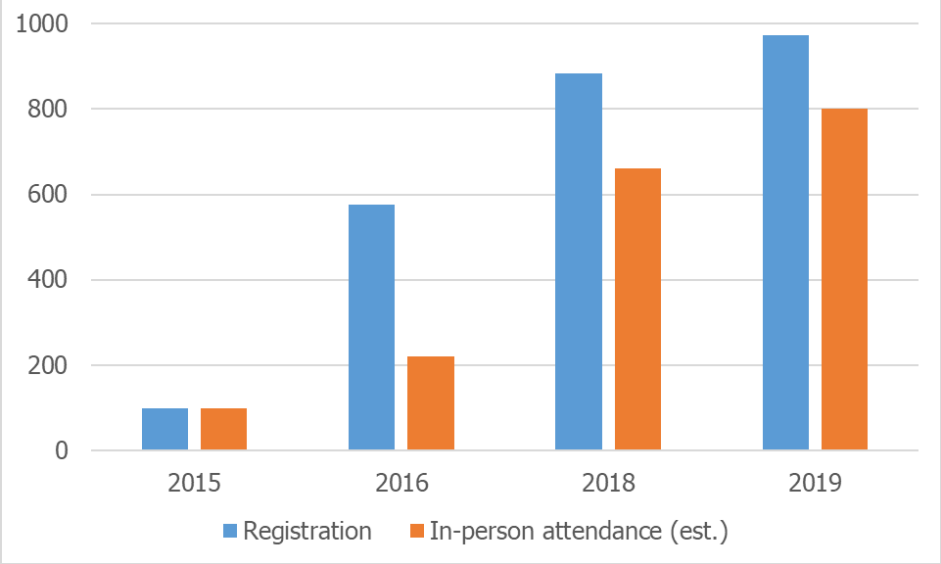
The CEC held several public events in 2019 to discuss project results on topics of interest, including climate adaptation, solar plus storage modeling, microgrids, wind energy, in-conduit hydropower (energy generated within water system conveyors, such as canals, aqueducts, and pipelines), and waste-to-energy. Also, CEC staff attended the CA-NV American Water Works Association Conference in October 2019. Staff provided information on CEC's R&D program to participants at the conference who represent water and wastewater agencies.

The CEC has plans under way to host a number of technology forums in 2020. The CEC anticipates holding quarterly workshops on topics of interest in coordination with the three investor-owned electric utilities with EPIC programs and the EPIC Policy + Innovation Coordination Group.[14]

Online tools and resources also help share knowledge generated through the CEC EPIC program. Table 2 illustrates uptake of a sample of EPIC-funded tools and resources currently available online and a number of tools coming soon. These tools can help utilities, decision-makers, innovators, and other stakeholders strengthen resilience, safety, and affordability. For example, Cal-Adapt has more than 23,000 users. The Cal-Adapt Web platform supports risk management and planning by providing access to the wealth of climate projections data and interactive visualizations that help utilities, local leaders, and state officials analyze energy sector vulnerabilities to climate change in California and take strategic actions to strengthen resilience.

14 In Appendix B to Decision 18-10-052, the CPUC listed recommendations from the Evergreen *EPIC Evaluation Final Report,* including convening topical workshops each quarter. See https://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=6442454674.

**Figure 6: CEC-Hosted Electric Program Investment Charge Symposium Trends**




Source: California Energy Commission staff

**Figure 7: Knowledge Sharing at the 2019 EPIC Symposium in Sacramento**


Source: California Energy Commission staff

**Table 2: Selected Online Tools and Resources by EPIC Investment Topic**

| Investment Topic | Online Tools and Resources and Use in 2019 |
|---|---|
| Entrepreneurial Ecosystem | • Empower Innovation (130+ organizations; 8,700+ views) https://www.empowerinnovation.net/. Access to funding and networking opportunities for clean energy in California.<br>• Founders Playbook (2,580+ users, 3,600+ views): http://playbooks.cyclotronroad.org/. A curated library of essential reading and example materials related to launching and growing a hardware-focused clean energy company. |
| Resilience and Safety | • Cal-Adapt (23,200+ users and 126,300+ views): https://cal-adapt.org/. Climate change data and visualization tools. |
| Building Decarbonization | • WISE (9,700+ users): https://www.wisewarehouse.org/. High performance building resources and training.<br>• OhmConnect (EPIC project helped grow signups from 15,000 to 300,000 in 2017. In 2019, OhmConnect had 600,000 signups): https://www.ohmconnect.com/. Coordinates time-dependent energy-use reduction and energy savings across a large group of ratepayers.<br>• Dr. Power (2,170+ users): https://corp.hea.com/dr-power. Advances energy efficiency by allowing residents to identify home appliances that use energy even when turned off.<br>• Manage Your Power (1,100 sessions): https://manage-your-power.com/. Convenient way for businesses to connect with qualified service providers to upgrade facilities or identify energy-saving opportunities. |
| Industrial and Agricultural Innovation | • Accelerating Drought Resilience (1,702 users): https://droughtresilience.com/. Insights and resources from water and wastewater technology providers and adopters in Tulare County.<br>• Waste-to-Energy Matching and Biositing Tool: https://biositing.jbei.org/. Shows available biomass within a user-specified distance from a potential biomass facility.<br>• In-conduit Hydropower Business Case Assessment Tool (coming soon) |

| Investment Topic | Online Tools and Resources and Use in 2019 |
|---|---|
| Grid Decarbonization and Decentralization | • Powernet (11 users for pilot-scale deployment): https://powernet.stanford.edu/. Pilot-scale system for participating residents to buy and sell local energy generation and time-dependent local reduction in energy use.<br>• Storage Vet (1,600 users): https://www.storagevet.com/. Estimates the value of potential energy storage installations based on location, operation, size, and technical capabilities.<br>• E3 Solar + Storage Modeling Tool (coming soon)<br>GridLAB-D optimization (EPIC-funded upgrades coming soon): https://github.com/gridlab-d/gridlab-d. Building on the existing GridLAB-D open-source software, EPIC funded development of a user-friendly interface for distribution grid modeling, model manager and converter, and optimization of the GridLAB-D computation engine to improve the performance for very large-scale simulation studies, such as studies to address distribution planning questions for renewable integration, energy storage, and demand response. GridLAB-D has been downloaded more than 91,000 times.<br>• iDERMS (coming soon)<br>• DER-VET (coming soon) |
| Transportation Electrification | • MyFleetBuy (10,000 vehicles): https://mygreencar.com/fleet/. Web portal for consulting services to compare costs, fueling, and return-on-investment for fossil-fuel, hybrids, and electric vehicles to inform ground transportation fleet procurement and operation.<br>• Smart Charging Infrastructure Planning Tool (SCRIPT) (coming soon) |

**Online tools and resources include databases, visualization tools, and research roadmaps.**

Source: California Energy Commission staff

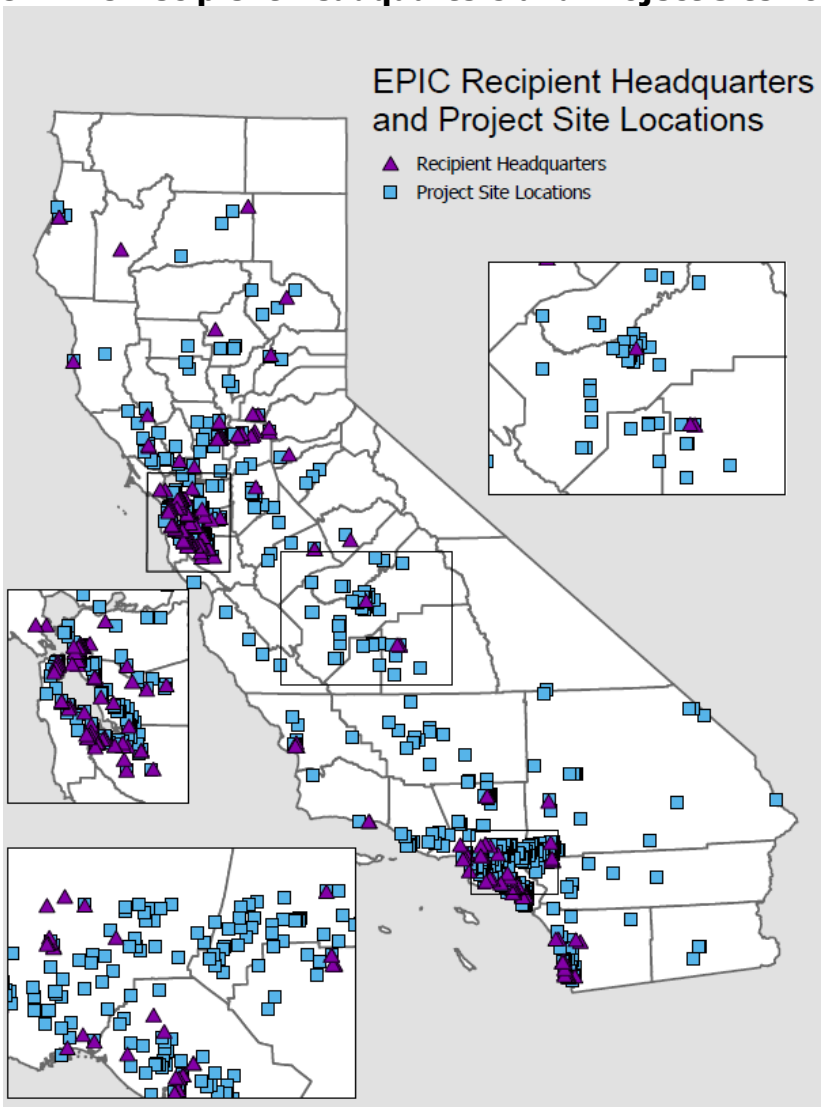
## Geographic Diversity to Accelerate Technological Learning and Technology Diffusion

Successful emergence and diffusion of clean energy innovations from lab to market require- technological learning and feedback from local installers, workers, early adopters, inspectors, and regulators. Technological learning happens primarily through the Technology Demonstration and Deployment program area, when new technologies

are tested in the real world under careful observation, measurement, and verification of performance.

Figure 8 shows CEC EPIC award recipient headquarters and project sites across California. This map includes active and completed CEC EPIC awards through 2019 for applied research and development, technology demonstration and deployment, and market facilitation projects. EPIC-funded technology demonstration and deployment projects are limited to California investor-owned electric utility service territories.

**Figure 8: EPIC Recipient Headquarters and Project Site Locations**




Source: California Energy Commission staff

## Informing Policies, Proceedings, Codes, Standards, and Protocols

EPIC research funded through the CEC has been instrumental in informing state policy and developing and demonstrating technologies on critical topics to further California's progress in meeting its clean energy mandates. The CEC informs state policy through

scientific research and by the collective learning from technology research projects. Table 3 lists selected improvements in codes, standards, and protocols advanced by EPIC project results. For example:

- A completed research project modeled the increasing risk of wildfires and related movement and how they will impact the electric grid.[15] An ongoing project will refine the model, providing greater granularity necessary for use by utilities and the CPUC.
    - CEC staff participated in the CPUC's climate adaptation rulemaking to summarize information available on Cal-Adapt to parties and decision makers engaged in the proceeding. The CPUC directed the IOUs to use Cal-Adapt as a source of data in climate adaptation efforts for California's electricity system. For example, Cal-Adapt includes projections for timing, frequency, and magnitude of the potential impact of extreme heat for locations in California.
- EPIC research on inverters informs CPUC requirements for equipment that interconnects to and exports electricity to California's distribution grid (Rule 21). Ongoing energy storage research is anticipated to inform future CPUC use cases. Through December 2019, the CEC received requests for more than 40 model numbers with Phase 2 data. Manufacturers are required to comply with the new advanced inverter functionalities by March 22, 2020.

**Table 3: Selected Policies, Proceedings, Codes, Standards, or Protocols Advanced by Project Results**

| Investment Topic | Policies, Proceedings, Codes, Standards or Protocols Advanced by Project Results |
|---|---|
| Entrepreneurial Ecosystem | • With a small EPIC California Sustainable Energy Entrepreneur Development grant, CodeCycle is demonstrating a software platform to streamline building inspection and expedite compliance with California's Building Energy Standards. |

15 Dale, Larry, Michael Carnall, Gary Fitts, Sarah Lewis McDonald, and Max Wei. (Lawrence Berkeley National Laboratory). 2018. Assessing the Impact of Wildfires on the California Electricity Grid. California's Fourth Climate Change Assessment, California Energy Commission. Publication Number: CCCA4-CEC-2018-002. https://www.energy.ca.gov/sites/default/files/2019-07/Energy_CCCA4-CEC-2018-002.pdf.

| Investment Topic | Policies, Proceedings, Codes, Standards or Protocols Advanced by Project Results |
|---|---|
| Resilience and Safety | • The CPUC directed the IOUs to use Cal-Adapt as a source of data in climate adaptation efforts to improve resilience and safety for California's electricity system.<br>• As a result of an EPIC-funded demonstration project, the CPUC decided to allow DC-coupled energy storage systems with firmware modification to become eligible for net energy metering. The CEC-funded Fremont fire station microgrids project demonstrated this approach could meet non-import and non-export requirements for battery storage systems at a lower cost than hardware-based protective relays. |
| Building Decarbonization | • LBNL project on "cool walls" (cool walls reflect solar energy to reduce heat gain and, thus, reduce space conditioning costs) is informing updates to applicable ASHRAE standards.<br>• Workforce Instruction for Standards and Efficiency helped the building industry transition to high-performance attics and walls required in 2016 Title 24 Energy Code.<br>• Taylor Engineering developed new HVAC control sequences as part of a demonstration project in response to a new mandatory requirement under Title 24 2019 (Occupant Sensor Ventilation Requirement). This project developed a major innovation for HVAC controls by integrating management of lighting controls, fault detection and diagnostics, and measurement and verification. In the past, many of these elements were standalone, one-at-a-time units. The approach developed by Taylor Engineering enables buildings to comply with the Title 24 2019 occupant sensor ventilation requirement, which is expected to lead to first year electricity savings of 5 gigawatt-hours (GWh) for new construction in California (according to the related Title 24 2019 Codes and Standards Enhancement report). This new sequence fills a gap as there were no other published sequences that addressed the new Title 24 requirement. The project results informed an addendum to ASHRAE Guideline 36-2018 on advanced sequences of operation for common HVAC systems.<br>• OhmConnect worked with California ISO to guide development of policy that allows collective participation by small customers in the California ISO wholesale markets, including methods to measure, document, and communicate load reductions. |

| Investment Topic | Policies, Proceedings, Codes, Standards or Protocols Advanced by Project Results |
|---|---|
| Industrial and Agricultural Innovation | • PowWow Energy Inc. achieved a major breakthrough by demonstrating the use of energy data from irrigation pumps for certified water measurement. This provides automated daily water records to help farmers reduce energy and water use. As a result of this project, this software is used by the California Department of Food and Agriculture to measure energy savings from the State Water Efficiency and Enhancement Program. |
| Grid Decarbonization and Decentralization | • SunSpec Alliance developed a test framework and open-source software tools to enable rapid product development and safety testing. Knowledge gained from the project reduces the time necessary for manufacturers to document compliance with CPUC-required equipment communication capabilities. In 2019, SunSpec Alliance reported four vendors have incorporated the open source software developed under EPIC into products, and others are looking into doing so. The software can be integrated into inverters, aggregator control systems, and other products. |
| Transportation Electrification | • EPIC funding has supported numerous research projects that demonstrate different electric vehicle charging standards and collectively build toward greater standardization and interoperability. For example, Electric Power Research Institute (EPRI) led two EPIC projects (EPC-14-086 and EPC-16-054) that informed updates to SAE J-series standards to align more closely with CPUC requirements for interconnection of distributed energy resources (DERs). |

Source: California Energy Commission staff

# CHAPTER 2:
# Budget

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

The CEC awards EPIC funds through a competitive process to projects that will accelerate achievement of California's clean energy policies, selecting projects designed to be impactful in the following areas:

- Advancing California's entrepreneurial ecosystem
- Building a safe and resilient energy system
- Advancing energy equity
- Enabling decarbonization of buildings, industry, agriculture, water treatment, energy, and transportation

## Authorized Budget

In 2018, the CPUC approved an EPIC budget for the third triennial investment cycle (2018-2020) in Decisions 18-01-008 and 18-10-052. Table 4 through Table 6 show the CEC funding for investment plans 2012-2014, 2015-2017, and 2018-2020, as approved by the CPUC.

**Table 4: California Public Utilities Commission Approved Energy Commission Electric Program Investment Charge Funding for 2012-2014**

| Funding Element/Program Area | Total |
|---|---|
| Applied Research and Development | $158,700,000 |
| Technology Demonstration and Deployment | $129,800,000 |
| Market Facilitation | $43,300,000 |
| **Subtotal** | $331,800,000 |
| Program Administration | $36,900,000 |
| **Total** | $368,700,000 |

Source: California Energy Commission staff

**Table 5: California Public Utilities Commission Approved, Escalated Energy Commission Electric Program Investment Charge Funding for 2015-2017**

| Funding Element/Program Area | Total |
|---|---|
| Applied Research and Development | $158,166,500 |
| Technology Demonstration and Deployment | $151,271,600 |
| Market Facilitation | $55,566,400 |
| **Subtotal** | $365,004,500 |
| Program Administration | $40,782,600 |
| **Total** | $405,787,100 |

Source: California Energy Commission staff

**Table 6: California Public Utilities Commission Approved, Escalated Energy Commission Electric Program Investment Charge Funding for 2018-2020**

| Funding Element/Program Area | Total |
|---|---|
| Applied Research and Development | $158,912,222 |
| Technology Demonstration and Deployment | $172,237,778 |
| Market Facilitation | $66,230,000 |
| **Subtotal** | $397,380,000 |
| Program Administration | $44,400,000 |
| **Total** | $441,780,000 |

Source: California Energy Commission staff

## Funding Commitments and Encumbrances

To clarify the difference between commitments and encumbrances for the EPIC program, 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 particular 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."[16]

Table 7 summarizes the committed project funds and encumbered project funds for each three-year EPIC investment plan. The data in this table are current as of December 31, 2019.

**Table 7: Committed and Encumbered Project Funding by EPIC Investment Plan (as of December 31, 2019)**

| Investment Plan | Approved Plan Project Funds | Committed Project Funds | Encumbered Project Funds |
|---|---|---|---|
| 2012-2014 | $331,800,000 | $331,800,000 | $328,246,114 |
| 2015-2017 | $365,004,500 | $365,004,500 | $354,008,897 |
| 2018-2020 | $397,380,000 | $397,380,000 | $37,946,992 |

Source: California Energy Commission staff

## Approved Awards in 2019

In 2019, the CEC approved 29 new projects totaling nearly $74.0 million (Table 8).

**Table 8: CEC Approved EPIC Awards in 2019 by Solicitation**

| Solicitation Number and Title | Number of Awards | Award Amount for Solicitation |
|---|---|---|
| GFO-15-312 The EPIC Challenge: Accelerating the Deployment of Advanced Energy Communities (Phase II) | 2 | $9,999,060 |
| GFO-17-308 Assessing Long-duration Energy Storage Deployment Scenarios to Meet California's Energy Goals | 8 | $18,255,827 |
| GFO-18-301 Wildfire: Assessing and Preparing for Risks under Climate Change | 1 | $5,000,000 |
| GFO-18-302 Production Scale-Up for Clean Energy Technologies | 10 | $22,392,201 |
| GFO-18-303 Cost Reductions, Advanced Technology for Solar Modules (CREATE Solar) | 3 | $2,593,260 |

16 CPUC Decision 13-11-025, Ordering paragraphs 44 and 45.

| Solicitation Number and Title | Number of Awards | Award Amount for Solicitation |
|---|---|---|
| GFO-18-304 Bringing Rapid Innovation Development to Green Energy (BRIDGE) - Energy Storage | 4 | $11,954,172 |
| RFP-18-802 Technology Transfer for EPIC Research Projects | 1 | $3,788,265 |
| **Grand Total** | **29** | **$73,982,785** |

Source: California Energy Commission staff

## Dollars Spent on Program Administration

The CPUC EPIC budget requirements cap administrative costs at 10 percent, excluding program evaluation costs. Expenditures for CEC administrative costs totaled about $14.8 million in calendar year 2019.

The CEC EPIC program administrative costs for calendar years 2012 through 2019 are nearly $87.3 million out of the $122.1 million from CPUC approved program administration budgets for the three EPIC Investment Plans. Therefore, the CEC's administrative costs are within the approved budgeted amount.

AB 523 requires the CEC to provide a brief description of the "impact on program administration from the allocations required to be made" by AB 523. The required allocations are as follows: 25 percent of EPIC funds for technology demonstration and deployment at sites in and benefiting disadvantaged communities; and an additional 10 percent of EPIC funds for technology demonstration and deployment at sites in and benefitting low-income communities.

In 2019, the CEC increased stakeholder engagement and outreach staff resources by about 1 person year to implement AB 523. As discussed in "Energy and Equity: AB 523 Implementation" in Chapter 1, the CEC exceeds the allocation required by AB 523. Through December 2019, technology demonstration and deployment projects funded by the CEC's EPIC program invested 29 percent of funds to projects in disadvantaged communities[17] and an additional 36 percent to projects in communities that are low income but not disadvantaged as defined by AB 523 using CalEnviroScreen.

17 As defined in section 39711 of the California Health and Safety Code and the California Environmental Protection Agency based on census tracts with the top 25 percent scores from CalEnviroScreen. The CalEnviroScreen score is based on pollution indicators and socio-economic factors. For more information on the use of CalEnviroScreen for designation of disadvantaged communities, see https://oehha.ca.gov/calenviroscreen/sb535.

EPIC Program Administration activities related to AB 523 include the following.

- CEC staff participated in public workshops and outreach to disadvantaged communities and low-income communities.
- Applicable EPIC solicitations set aside funding for projects in and benefitting disadvantaged communities and low-income communities.
- CEC staff developed new scoring criteria for projects that benefit disadvantaged and low-income communities. The new scoring criteria were developed with public input. Competitive solicitations began using the new scoring criteria in 2019.

## Funding Shifts

EPIC administrators must obtain CPUC approval to shift more than 5 percent of budgeted funds for each funding category or program area or to new categories of funding within an approved EPIC triennial investment plan.[18] In 2019, the CEC did not shift or apply to shift funds between or to new funding categories or program areas.

## Uncommitted/Unencumbered Funds and Interest Accrual

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

- The funds are committed, but have not been encumbered.
- After funds were encumbered, the funds were disencumbered from projects that were completed without using the full budget by project term end, projects that were terminated, or projects that were canceled.

As of December 31, 2019,

- There are no uncommitted funds from the first, second, or third EPIC Investment Plan.
- Unencumbered funds were $3.6 million from the *2012-2014 EPIC Investment Plan*. After funds were encumbered, this amount was disencumbered from projects that were completed without using the full budget by project term end, projects that were terminated, or projects that were canceled.
- Unencumbered funds were $11.0 million from the *2015-2017 EPIC Investment Plan*. After funds were encumbered, this amount was disencumbered from projects that were completed without using the full budget by project term end, projects that were terminated, or projects that were canceled.
- Unencumbered funds were $359.4 million from the *2018-2020 EPIC Investment Plan*. All funds are committed from this *EPIC Investment Plan.* The CEC plans to encumber the balance by June 30, 2022.

18 CPUC Decision 13-11-025, Ordering Paragraph 36.

In calendar year 2019, the CEC accumulated about $8.9 million in interest from all funds in the EPIC account. Due to administrative limitations, instead of returning accumulated interest, CEC subtracts the amount of accrued interest from future invoices it submits to the IOUs.[19]

19 See CPUC Decision 13-11-025, page 105.

# CHAPTER 3:
# Projects

Through the EPIC program, the CEC funds innovation to advance safety, reliability, and affordability in California's electricity system. The CEC awards EPIC funds through a competitive process to projects that will accelerate achievement of California's transformative clean energy policies to reduce greenhouse gas emissions and adapt to climate change.

CEC staff applies dedicated expertise to fund a strategic portfolio of EPIC research projects in the public interest. This portfolio of projects will make California's transition to 100 percent clean energy faster, lower cost, and more inclusive by supporting entrepreneurship, funding advanced energy communities, and providing public access to data and lessons learned.

The CEC EPIC program advances innovations for resilience and safety, energy equity, and decarbonization of California's building, industry, agriculture, water treatment, electricity, and transportation sectors. Since the beginning of the EPIC program, the CEC has funded 332 project awards, encumbering about $720.2 million.

## Summary of Project Awards

Table 9, Table 10, and Table 11 list the number of projects and total funding awarded since 2012 under each strategic objective of the *2012-2014 EPIC Investment Plan*, the *2015-2017 EPIC Investment Plan*, and the *2018-2020 EPIC Investment Plan*, respectively. These tables also indicate the investment area of each strategic objective: applied research and development (ARD), technology demonstration and deployment (TDD), and market facilitation (MF). The data in these tables are current as of December 31, 2019. There are a few instances where a single cross-cutting project is funded from two strategic objectives. As noted in the following tables, this occurs for one strategic objective in the *2015-2017 EPIC Investment Plan* and two strategic objectives in the *2018-2020 EPIC Investment Plan*. In each instance, the project is counted only once.

**Table 9: Summary of Projects Awarded Under the CEC 2012-2014 EPIC Investment Plan by Strategic Objective**

| Area | Strategic Objective | Number of Projects | Total Funding |
|---|---|---|---|
| ARD | S1: Develop Next-Generation End-Use Energy Efficiency Technologies and Strategies for the Building Sector. | 21 | $38,815,729 |
| ARD | S2: Develop New Technologies and Applications That Enable Cost-Beneficial Customer-Side-of-the-Meter Energy Choices. | 10 | $30,144,179 |
| ARD | S3: Develop Innovative Technologies, Tools, and Strategies to Make Distributed Generation More Affordable. | 12 | $18,408,700 |
| ARD | S4: Develop Emerging Utility-Scale Renewable Energy Generation Technologies and Strategies to Improve Power Plant Performance, Reduce Costs, and Expand the Resource Base. | 8 | $11,095,832 |
| ARD | S5: Reduce the Environmental and Public Health Impacts of Electricity Generation and Make the Electricity System Less Vulnerable to Climate Impacts. | 34 | $18,252,181 |
| ARD | S6: Develop Technologies, Tools, and Strategies to Enable the Smart Grid of 2020. | 5 | $5,401,868 |
| ARD | S7: Develop Operational Tools, Models, and Simulations to Improve Grid Resource Planning. | 2 | $1,690,055 |
| ARD | S8: Integrate Grid-Level Energy Storage Technologies and Determine Best Applications That Provide Locational Benefits. | 5 | $8,673,198 |

| Area | Strategic Objective | Number of Projects | Total Funding |
|---|---|---|---|
| ARD | S9: Advance Technologies and Strategies That Optimize the Benefits of Plug-In Electric Vehicles to the Electricity System. | 5 | $6,681,669 |
| ARD | S10: Leverage California's Regional Innovation Clusters to Accelerate the Deployment of Early Stage Clean Energy Technologies and Companies. | 6** | $19,435,655 |
| TDD | S12: Demonstrate and Evaluate the Technical and Economic Performance of Emerging Energy Efficiency and Demand-Side Management Technologies and Strategies. | 20 | $52,189,861 |
| TDD | S13: Demonstrate and Evaluate Emerging Clean Energy Generation Technologies and Deployment Strategies. | 13** | $37,983,642 |
| TDD | S14: Demonstrate the Reliable Integration of Energy-Efficient Demand-Side Resources, Distributed Clean Energy Generation, and Smart Grid Components to Enable Energy-Smart Community Development. | 11** | $37,668,883 |
| MF | S16: Collaborate With Local Jurisdictions and Stakeholder Groups in IOU Territories to Establish Strategies for Enhancing Current Regulatory Assistance and Permit Streamlining Efforts That Facilitate Coordinated Investments and Widespread Deployment of Clean Energy Infrastructure. | 11 | $15,942,016 |

| Area | Strategic Objective | Number of Projects | Total Funding |
|---|---|---|---|
| MF | S17: Strengthen the Clean Energy Workforce by Creating Tools and Resources That Connect the Clean Energy Industry to the Labor Market. | 2 | $8,908,107 |
| MF | S18: Guide EPIC Investments Through Effective Market Assessment, Program Evaluation, and Stakeholder Outreach. | 7** | $16,954,539 |
| **All** | **2012-2014 EPIC Plan Subtotal** | **172** | **$328,246,114** |

****Six projects used funds from both the *2012-2014 and 2015-2017 EPIC Investment Plans*. These projects are indicated under the first plan (2012-2014) only. The amounts in the "Number of Projects" column and the "Total Funding" column include all projects, even those that are funded under both plans or more than one strategic objective.**

**This table does not include five projects from the 2012-2014 EPIC Plan that were approved at a CEC business meeting and later canceled or terminated by the recipient as of December 31, 2019. No work was done on these projects, and no EPIC funds were spent.**

**The amounts in the "Total Funding" column represent the project funding that was approved at a CEC business meeting and any adjustments made thereafter—adjustments made thereafter are also included in Appendix C EPIC Project Status Report of this report.**

Source California Energy Commission staff

**Table 10: Summary of Projects Awarded Under the CEC 2015-2017 EPIC Investment Plan by Strategic Objective**

| Area | Strategic Objective | Number of Projects | Total Funding |
|---|---|---|---|
| ARD | S1: Improve Energy Efficiency Technologies and Strategies in California's Building, Industrial, Agriculture, and Water Sectors. | 34 | $65,427,940 |
| ARD | S3: Develop Innovative Solutions to Increase the Market Penetration of Distributed Renewable and Advanced Generation. | 19 | $26,398,707 |

| Area | Strategic Objective | Number of Projects | Total Funding |
|---|---|---|---|
| ARD | S4: Improve Power Plant Performance, Reduce Cost, and Accelerate Market Acceptance of Existing and Emerging Utility-Scale Renewable Energy Generation Systems. | 7 | $7,105,218 |
| ARD | S5: Reduce the Environmental and Public Health Impacts of Electricity Generation and Make the Electricity System Less Vulnerable to Climate Impacts. | 13 | $8,891,007 |
| ARD | S6: Advance the Use of Smart Inverters as a Tool to Manage Areas with High Penetrations of PV | 1 | $2,935,822 |
| ARD | S7: Develop Advanced Distribution Modeling Tools for the Future Smart Grid. | 6** | $14,189,656 |
| ARD | S9: Advance Electric Vehicle Infrastructure to Provide Electricity System Benefits. | 4 | $5,326,250 |
| ARD | S10: Advance the Early Development of Breakthrough Energy Concepts. | Project counted in S10 2012-2014 Investment Plan | $20,211,957 |
| ARD | S11: Provide Federal Cost Share for Applied Research Awards. | 7 | $4,950,000 |
| TDD | S12: Overcome Barriers to Emerging Energy Efficiency and Demand-Side Management Solutions through Demonstrations in New and Existing Buildings. | 16** | $56,433,389 |

| Area | Strategic Objective | Number of Projects | Total Funding |
|---|---|---|---|
| TDD | S13: Demonstrate and Evaluate Biomass-to-Energy Conversion Systems, Enabling Tools, and Deployment Strategies. | 5 | $19,739,817 |
| TDD | S14: Take Microgrids to the Next Level: Maximize the Value to Customers. | 9 | $44,978,120 |
| TDD | S15: Demonstrate Advanced Energy Storage Interconnection Systems to Lower Costs, Facilitate Market, and Improve Grid Reliability. | 4** | $7,087,640 |
| TDD | S16: Expand Smart Charging and Vehicle-to-Grid Power Transfer for Electric Vehicles. | 4 | $11,767,152 |
| TDD | S17: Provide Federal Cost Share for Technology Demonstration and Deployment Awards. | 2 | $2,999,822 |
| MF | S18: Foster the Development of the Most Promising Energy Technologies into Successful Businesses. | 5** | $31,110,790 |
| MF | S19: Facilitate Inclusion of Emerging Clean Energy Technologies into Large-Scale Procurement Processes. | 4 | $16,983,471 |
| MF | S20: Accelerate the Deployment of Energy Technologies in IOU Territories Through Innovative Local Planning and Permitting Approaches. | 2 | $2,487,609 |
| MF | S21: Inform Investments and Decision-Making Through Market and Technical Analysis. | 4 | $4,984,530 |

| Area | Strategic Objective | Number of Projects | Total Funding |
|---|---|---|---|
| **All** | **2015-2017 EPIC Plan Subtotal** | **146** | **$354,008,897** |

**** Four projects used funds from 2015-2017 EPIC Investment Plan, but addressed more than one strategic objective within the plan. These projects are indicated under the first strategic objective only. The amounts in the "Number of Projects" column and the "Total Funding" column include all projects, even those that are funded under both plans or more than one strategic objective.**

**This table does not include two projects from the 2015-2017 EPIC Plan that were approved at a CEC business meeting and later terminated by the recipient as of December 31, 2018. No work was done on these projects, and no EPIC funds were spent.**

**The amounts in the "Total Funding" column represent the project funding that was approved at a CEC business meeting and any adjustments made thereafter—adjustments made thereafter are also included in Appendix C EPIC Project Status Report of this report.**

Source: California Energy Commission staff

**Table 11: Summary of Projects Awarded Under the CEC 2018-2020 EPIC Investment Plan by Strategic Objective**

| Area | Strategic Objective | Number of Projects | Total Funding |
|---|---|---|---|
| ARD | 4.1 Advance Emerging Thin-Film PV Technologies for High Value Applications | 3 | $2,593,260 |
| ARD | 7.2 Increase the Resiliency of the Electricity System to Climate Change and Extreme Weather Events | Project counted under S7.1, 2012-2014 Investment Plan | $978,584 |
| TDD | 2.3 Define and Improve the Customer's Business Proposition of Integrated Distributed Storage | 2 | $8,693,989 |

| Area | Strategic Objective | Number of Projects | Total Funding |
|---|---|---|---|
| TDD | 2.4 Incentivize DER Adoption through Innovative Strategies at the Local Levels | Projects counted under S12 2012-2014 Investment Plan | $2,520,579 |
| TDD | 4.4 Improve the Value Proposition of Bioenergy | 1 | $4,999,830 |
| MF | 5.2 Accelerate the Most Promising Energy Technologies from Prototype to Market Entry | 8 | $18,160,750 |
| **All** | **2018-2020 EPIC Plan Subtotal** | **14** | **$37,946,992** |

**The amounts in the "Total Funding" column represent the project funding that was approved at a CEC business meeting and any adjustments made thereafter—adjustments made thereafter are also included in Appendix C EPIC Project Status Report of this report.**

Source: California Energy Commission staff

## Electric Program Investment Plan Project Status Report

Appendix C of this report includes a project status report for each project awarded EPIC funds and includes specific information in an electronic spreadsheet format using the template provided in Attachment 6 of CPUC Decision 13-11-025. Information included for each project is as follows:

- Investment program period
- Program administrator
- Project name
- Project type
- Brief description of project
- Date of award
- Was this project awarded in the immediately prior calendar year?
- Assignment to value chain
- Encumbered funding amount ($)
- Committed funding amount ($)

- Funds expended to date: contract/grant amount ($)
- Funds expended to date: in-house expenditures ($)
- Funds expended to date: total spent to date ($)
- Administrative and overhead costs to be incurred for each project
- Leveraged funds
- Partners
- Match funding
- Match funding split
- Funding mechanism
- Intellectual property
- Identification of method used to grant awards
- If competitively selected, provide the number of bidders passing the initial pass/fail screening for project
- If competitively selected, provide the name of selected bidder
- If competitively selected, provide the rank of the selected bidder in the selection process
- If competitively selected, explain why the bidder was not the highest scoring bidder, explain why a lower scoring bidder was selected
- If interagency or sole source agreement, specify date of notification to the Joint Legislative Budget Committee (JLBC) was notified and date of JLBC authorization
- Does the recipient for this award identify as a California-based entity, small business, or businesses owned by women, minorities, or disabled veterans?
- How the project leads to technological advancement or breakthroughs to overcome barriers to achieving the state's statutory energy goals
- Applicable metrics
- Project update

## Completed Projects

In 2019, 83 EPIC projects were completed (See Appendix B for more information.). A final project report by the award recipient (available upon request) has been or will be submitted to the CEC.

CEC staff are working to ensure EPIC final reports meet the 2019 formatting requirements specified in California Government Code Sections 7405 and 11135 and the Web Content Accessibility Guidelines. Once approved, finalized, and formatted to be digitally accessible, each final project report will be posted on the Energy Commission website and available at the Research and Development Reports and Publications page at https://www.energy.ca.gov/energy-rd-reports-n-publications. Table 12 provides information on the final project reports currently available online.

**Table 12: CEC EPIC-Funded Projects Completed in 2019**

| Agree-ment # | Company | Project Name | Invest-ment Program Period | Total EPIC Funds | Final Report Link |
|---|---|---|---|---|---|
| EPC-14-008 | The Regents of the University of California, San Diego | High-Fidelity Solar Power Forecasting Systems for the 392 MW Ivanpah Solar Plant (CSP) and the 250 MW California Valley Solar Ranch (PV) | 2012-2014 EPIC Investment Plan | $999,898 | https://www.energy.ca.gov/2020publications/CEC-500-2020-010/CEC-500-2020-010.pdf |
| EPC-14-035 | Lawrence Berkeley National Laboratory | Demonstration of integrated photovoltaic systems and smart inverter functionality utilizing advanced distribution sensors | 2012-2014 EPIC Investment Plan | $1,000,000 | https://www.energy.ca.gov/2020publications/CEC-500-2020-019/CEC-500-2020-019.pdf |
| EPC-14-038 | Indicia Consulting | Fieldwork to Document Technology Adoption and Behavior Change Across Diverse Geographies and Populations to Inform Energy Efficiency Program Design | 2012-2014 EPIC Investment Plan | $574,545 | https://www.energy.ca.gov/2020publications/CEC-500-2020-017/CEC-500-2020-017.pdf |

| Agree-ment # | Company | Project Name | Invest-ment Program Period | Total EPIC Funds | Final Report Link |
|---|---|---|---|---|---|
| EPC-14-040 | Glint Photonics, Inc. | Self-Tracking Concentrator Photovoltaics for Distributed Generation | 2012-2014 EPIC Investment Plan | $999,940 | https://www.energy.ca.gov/2020publications/CEC-500-2020-021/CEC-500-2020-021.pdf |
| EPC-14-044 | Lawrence Berkeley National Laboratory | Enabling Anaerobic Digestion Deployment for Municipal Solid Waste-to-Energy | 2012-2014 EPIC Investment Plan | $4,300,000 | https://www.energy.ca.gov/2020publications/CEC-500-2020-011/CEC-500-2020-011.pdf |
| EPC-14-050 | Gridscape Solutions, Inc. | City of Fremont Fire Stations Microgrid Project | 2012-2014 EPIC Investment Plan | $1,817,925 | https://www.energy.ca.gov/2019publications/CEC-500-2019-054/CEC-500-2019-054.pdf |
| EPC-14-055 | Chabot-Las Positas Community College District | Las Positas College Microgrid | 2012-2014 EPIC Investment Plan | $1,522,591 | https://www.energy.ca.gov/publications/displayOneReport_cms.php?pubNum=CEC-500-2019-052 |
| EPC-14-059 | Trane U.S., Inc. | Laguna Wastewater Treatment Plant Microgrid | 2012-2014 EPIC Investment Plan | $4,999,804 | https://www.energy.ca.gov/2019publications/CEC-500-2019-063/CEC-500-2019-063.pdf. |

| Agree-ment # | Company | Project Name | Invest-ment Program Period | Total EPIC Funds | Final Report Link |
|---|---|---|---|---|---|
| EPC-14-061 | U.S. Geological Survey | Learning from Real-World Experience to Understand Renewable Energy Impacts to Wildlife | 2012-2014 EPIC Investment Plan | $1,000,000 | https://www.energy.ca.gov/2020publications/CEC-500-2020-012/CEC-500-2020-012.pdf |
| EPC-14-062 | University of California, Riverside | Bringing Energy Efficiency Solutions to California's Water Sector With the Use of Customized Energy Management System and Supervisory Control and Data Acquisition System | 2012-2014 EPIC Investment Plan | $3,017,034 | https://www.energy.ca.gov/2020publications/CEC-500-2020-003/CEC-500-2020-003.pdf |
| EPC-14-066 | Lawrence Berkeley National Laboratory | High-Performance Integrated Window and Facade Solutions for California Buildings | 2012-2014 EPIC Investment Plan | $3,000,000 | https://www.energy.ca.gov/2020publications/CEC-500-2020-001/CEC-500-2020-001.pdf |
| EPC-14-067 | The Regents of the University of California, Berkeley | Improving Hydro-logical Snowpack Forecasting for Hydropower Generation Using Intelligent Inform-ation Systems | 2012-2014 EPIC Investment Plan | $1,100,000 | https://www.energy.ca.gov/sites/default/files/2019-07/Energy_CCCA4-CEC-2018-001.pdf |

| Agree-ment # | Company | Project Name | Invest-ment Program Period | Total EPIC Funds | Final Report Link |
|---|---|---|---|---|---|
| EPC-14-070 | Wexus Technologies, Incorporated | Wexus Energy and Water Management Mobile Software for the Agricultural Industry | 2012-2014 EPIC Investment Plan | $4,000,000 | https://www.energy.ca.gov/2020publications/CEC-500-2020-002/CEC-500-2020-002.pdf |
| EPC-14-071 | Frontier Wind | Rotor-Mounted Bat Impact Deterrence System Design and Testing | 2012-2014 EPIC Investment Plan | $862,875 | https://www.energy.ca.gov/2020publications/CEC-500-2020-008/CEC-500-2020-008.pdf |
| EPC-14-075 | The Regents of the University of California, Berkeley | Unlocking Industrial Energy Efficiency Through Optimized Energy Management Systems | 2012-2014 EPIC Investment Plan | $4,981,729 | https://www.energy.ca.gov/publications/displayOneReport_cms.php?pubNum=CEC-500-2019-060 |
| EPC-14-076 | Kennedy/ Jenks Consultants | Raw Wastewater Filtration to Increase Organic Removal Efficiency and Achieve Significant Electrical Savings | 2012-2014 EPIC Investment Plan | $3,476,085 | https://www.energy.ca.gov/2020publications/CEC-500-2020-026/CEC-500-2020-026.pdf |
| EPC-15-008 | The Regents of the University of California, Berkeley | Visualizing Climate-Related Risks to the Electricity System using Cal-Adapt | 2012-2014 EPIC Investment Plan | $400,000 | https://www.energy.ca.gov/2020publications/CEC-500-2020-013/CEC-500-2020-013.pdf |

| Agree-ment # | Company | Project Name | Invest-ment Program Period | Total EPIC Funds | Final Report Link |
|---|---|---|---|---|---|
| EPC-15-013 | The Regents of the University of California, Berkeley | Open Source Platform for Plug-in Electric Vehicle Smart Charging in California | 2012-2014 EPIC Investment Plan | $1,500,000 | https://www.energy.ca.gov/2020publications/CEC-500-2020-005/CEC-500-2020-005.pdf |
| EPC-15-025 | Home Energy Analytics | Plug Load Reduction App:RYPL | 2012-2014 EPIC Investment Plan | $884,100 | https://www.energy.ca.gov/2020publications/CEC-500-2020-007/CEC-500-2020-007.pdf |
| EPC-15-028 | Electric Power Research Institute, Inc. | Real World Electrification Options of Energy Services and Environmental Justice (EJ) Considerations | 2012-2014 EPIC Investment Plan | $799,444 | https://www.energy.ca.gov/publications/displayOneReport_cms.php?pubNum=CEC-500-2019-049 |
| EPC-15-044 | Electric Power Research Institute, Inc. | Certified Open-Source Software to Support the Inter-connection Compli-ance of Distributed Energy Resources | 2012-2014 EPIC Investment Plan | $816,539 | https://www.energy.ca.gov/2020publications/CEC-500-2020-025/CEC-500-2020-025.pdf |
| EPC-15-046 | Siemens Corporation, Corporate Technology | Developing a Distribution Substation Management System | 2012-2014 EPIC Investment Plan | $500,000 | https://www.energy.ca.gov/publications/displayOneReport_cms.php?pubNum=CEC-500-2019-059 |

| Agree-ment # | Company | Project Name | Invest-ment Program Period | Total EPIC Funds | Final Report Link |
|---|---|---|---|---|---|
| EPC-15-059 | Onset, Inc. | UniGen Smart System for Renewable Integration | 2012-2014 EPIC Investment Plan | $638,993 | https://www.energy.ca.gov/2019publications/CEC-500-2019-063/CEC-500-2019-063.pdf |
| EPC-15-086 | Advanced Power and Energy Program - University of California, Irvine | Substation Automation and Optimization of Distribution Circuit Operations | 2012-2014 EPIC Investment Plan | $932,718 | https://www.energy.ca.gov/2020publications/CEC-500-2020-022/CEC-500-2020-022.pdf |
| EPC-16-011 | Kennedy/ Jenks Consultants | Novel Membrane Technology to Improve Energy Efficiency and Water Savings in Wastewater Treatment Operations | 2015-2017 EPIC Investment Plan | $882,430 | https://www.energy.ca.gov/2020publications/CEC-500-2020-027/CEC-500-2020-027.pdf |
| EPC-16-020 | SRI International | Recovery of Lithium from Geothermal Brines | 2015-2017 EPIC Investment Plan | $873,387 | https://www.energy.ca.gov/2020publications/CEC-500-2020-020/CEC-500-2020-020.pdf |
| EPC-16-029 | Antelope Valley Water Storage, LLC | Water/Energy Bank Proof-of-Concept | 2015-2017 EPIC Investment Plan | $1,000,000 | https://www.energy.ca.gov/2020publications/CEC-500-2020-006/CEC-500-2020-006.pdf |

Source: California Energy Commission staff

# Description of Projects

Appendix B provides project write-ups for all active, approved, completed, and terminated (if EPIC funds were spent) projects in 2019, following the EPIC annual report outline from CPUC Decision 13-11-025, Attachment 5 (Item 4c of the outline).

The following sections highlight projects nearing completion or achieving important milestones in 2019. Examples address the following high priority energy investment topics:

- Entrepreneurial ecosystem
- Resilience and safety
- Energy equity
- Decarbonization

## Advancing California's Entrepreneurial Ecosystem

In 2016, the CEC launched the first phase of the EPIC-funded entrepreneurial ecosystem. The first phase had five parts: a small grant program called CalSEED, which provides proof-of-concept funding for new technology ideas, and four regional innovation clusters that collectively provide entrepreneurial support services—such as laboratory equipment and buildings, business plan development, and connections to investors—throughout the state.

Support continued in 2018 with the establishment of the BRIDGE program, which provided follow-on funding for the most promising technologies that had previously received funding for early-stage development from an eligible federal agency or one of the CEC's research programs.

The year 2019 continued this trend by establishing new EPIC-funded programs that sought to fill additional gaps in the journey from innovation to commercialization. These new programs include:

- CalTestBed, which held the public launch in November 2019. This program will provide start-up companies with access to one of nearly 30 testing centers throughout California, allowing clean energy entrepreneurs access to facilities, infrastructure, and resources to validate their technology with third-party testing and data. Applications are expected to open in the first quarter of 2020.
- The Realizing Accelerated Manufacturing and Production (RAMP) program issued the first set of awards in 2019. This program provides technical and financial assistance to help clean energy entrepreneurs successfully advance their emerging best-of-class innovative technologies to the low-rate initial production stage. In 2019, the program approved 10 awards for $22 million.
- The Empower Innovation Network held the public launch in October 2019. Empower Innovation is a new online platform that provides easy access to funding opportunities, curated resources, and connections to people and

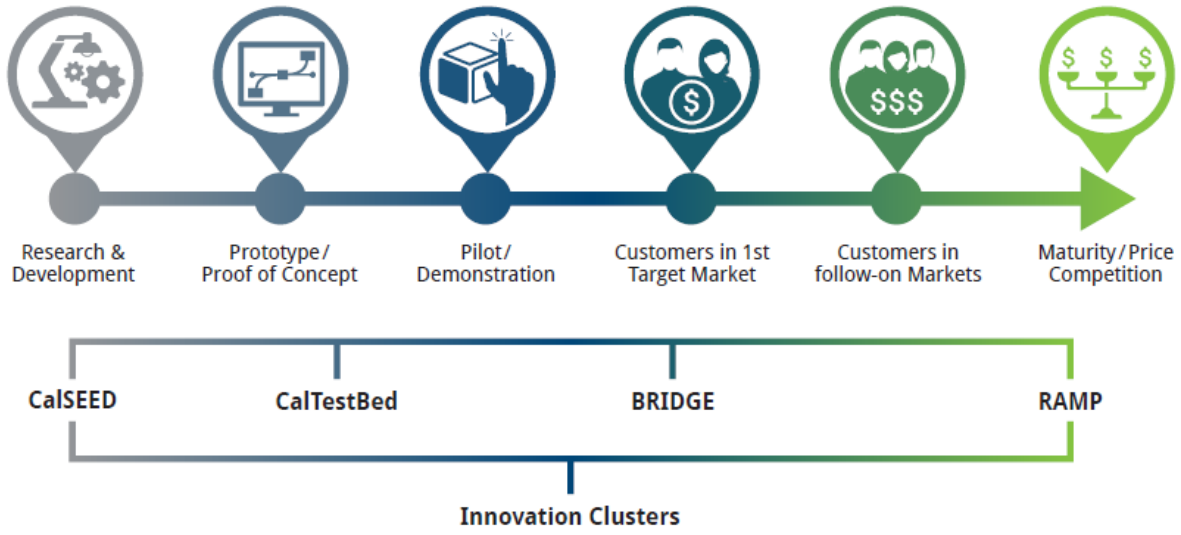
organizations working towards a clean economy for all. More information at www.empowerinnovation.net.

In addition to these new elements, the foundational five programs of the CEC EPIC entrepreneurial ecosystem continued to foster clean energy entrepreneurship in 2019:

- Start-up companies accepted into CalSEED or one of the innovation clusters have attracted more than $100 million in private and more than $50 million in public follow-on funding

Figure 9 illustrates the five components of the EPIC-funded entrepreneurial ecosystem, including technology research and development (CalSEED), prototype (CalTestBed), pilot, customers in first target market (BRIDGE), and maturity/price competition (RAMP), with innovation cluster support for the full range of activities. Table 13 summarizes innovations of five of the participating companies.

**Figure 9: California's EPIC-Funded Entrepreneurial Ecosystem**




Source: California Energy Commission staff

**Table 13: Example Companies Participating in the CEC EPIC Entrepreneurial Ecosystem**

| Company and Entrepreneurial Ecosystem Cohort | Innovation |
|---|---|
| Treau (RAMP—2019) | Treau has developed an innovative polymer heat exchanger that can enable high efficiency and low cost building heating and cooling systems. Combined with an innovative design that does not require professional installation, Treau's room HVAC system offers users better performance at lower cost than currently available room HVAC systems. |
| Nativus (CalSEED—2016) | Nativus innovative design combines a rotary heat exchanger with a centrifugal fan to achieve higher efficiency with significantly lower operating costs than traditional ductless air-conditioning units. This technology will result in an air conditioner that consumes half the power while being quieter, lighter, and more aesthetically pleasing. |
| Nuvve (Southern California Regional Energy Innovation Network—2016) | Nuvve is developing high-powered bi-directional electric vehicle charging stations that are integrated with a cloud-based aggregation network. This allows for intelligent electric vehicle charging that can optimize electric vehicle owners' needs with dynamic grid conditions. |
| Fervo Energy (Cyclotron Road—2018) | Fervo Energy has developed advancements in horizontal drilling and real-time flow control using distributed fiber optic sensing. The application of these techniques will increase the potential for economic geothermal power by orders of magnitude. The inclusion of geothermal—a dispatchable, zero-GHG resource—adds a valuable resource to the clean energy mix. |
| ReJoule (LACI - 2018) | ReJoule is developing battery management systems that provides real-time and more accurate monitoring of battery health than is currently available. Combined with an analytics platform to sort all the data, Rejoule's battery management system helps protect, and enhance the performance of large-format lithium batteries. |

Source: California Energy Commission staff

## Building a Safe and Resilient Energy System

California is strengthening resilience for power emergencies today and planning for changing conditions on the horizon. In 2019, California experienced several power safety shut-off events during periods of high winds and dry conditions. These outages aimed to reduce the risk that electric utility infrastructure could start wildfires, but the duration and frequency of the events posed challenges in themselves.

Microgrids combine distributed energy resources with a controller to manage energy use. Microgrids combine distributed energy resources with a controller to manage energy use. A key feature of many microgrids is the ability to continue operating even if the surrounding electricity grid experiences an outage, referred to as "islanding." Microgrids using local or on-site renewable generation can offer one approach to maintain power for critical loads in electrically islanded locations. In addition, projected climate change scenarios and impacts provide essential input to utility and community planning and resilience.

### Solar Emergency Microgrids at Fremont Fire Stations

Managers of critical facilities, such as fire stations and hospitals, are especially concerned about interrupted power as these facilities would not be able to deliver vital services or protection to the community during an outage. These concerns have led to the pursuit of alternative solutions to help recover quickly from an energy outage.

The CEC is investing in microgrid technology to demonstrate low-carbon-based microgrids, produce technical and economic data, and understand pathways to increasing microgrid adoption. Gridscape Solutions (Gridscape), in partnership with the City of Fremont and funded by the CEC with $1.8 million grant funding, installed solar emergency microgrid systems at three fire stations in Fremont (Alameda County). The project demonstrated integration of distributed clean energy generation and microgrid components for critical facilities.

These microgrids generated 205,000 kilowatt-hours of clean energy during the demonstration period and are expected to produce more than 175 megawatt-hours (MWh) per year totaling 1,750 MWh of clean power over the 10-year useful life of the project. The project has saved more than $20,000 collectively in energy costs over the 12-month demonstration period for the three fire stations, 25 percent better than expected. The fire stations successfully executed four islanding tests (ability to operate without power from the surrounding electricity system) during the demonstration. Each test lasted more than three hours with the last test lasting more than 13 hours. The project has also met the greenhouse gas emissions reduction goal of 80,000 lbs/year during the demonstration period and helped the City of Fremont meet its climate action plan objectives. The project team achieved a technology cost reduction of more than 30 percent from the first microgrid at Fire Station 11 to the remaining two at Fire Stations 6 and 7 by adopting value-engineering and cost-optimization measures such as splitting controller functionalities into local and cloud, developing design and interconnection

templates, reducing onsite configuration, and choosing cost competitive components for standard designs. Gridscape is developing other microgrids at critical facilities and with various commercial and industrial customers, using lessons learned from this project.

### Renewable-Powered Microgrid for a Medical Center

The CEC provided EPIC funds in 2015 to Charge Bliss, Inc. to develop a high-performance, renewable-powered microgrid for the Kaiser Permanente Medical Center in Richmond (Figure 10). The project was completed in December 2018. The hospital is the only general hospital serving western Contra Costa County providing essential services to the surrounding community affected by high levels of environmental pollution and the consequent health effects. In 2019, CEC staff held a workshop to share the lessons learned and best practices from this project and other microgrid projects awarded EPIC funding in 2015.

As the first installation of its kind for a hospital in California, this project demonstrated the safety, feasibility, and resiliency of renewable energy microgrids for health-care centers. The project developed a novel microgrid controller that can island the hospital's life safety emergency power branch, including emergency lighting and exit signs, and provide power services during emergencies. Relying entirely on on-site renewable energy sources, the microgrid is capable of islanding the hospital's life safety branch for more than three hours. During nonemergency periods, the controller enabled the microgrid to achieve performance goals such as reducing utility energy consumption, site peak load, and utility costs.

**Figure 10: A Renewable Energy Microgrid for Kaiser Richmond Medical Center**


Source: Kaiser Permanente and Charge Bliss

The lessons learned from this project have informed the California Public Utilities Commission and the Office of Statewide Health Planning and Development (OSHPD) on the safety and efficacy of renewable energy microgrids. This project engaged OSHPD to identify relevant regulatory requirements for the build-out of the microgrid and methods to comply with them, defined approaches to permitting and approvals, demonstrated interconnection with the investor-owned utility, and illustrated the feasibility and value of renewable energy microgrids to healthcare stakeholders. Kaiser Permanente's microgrid has reduced the peak power demand of the facility by 100-150 kW and saved the hospital nearly 20 percent of its baseline utility costs. Annual solar energy production of 360,000 kilowatt-hour (kWh), over a projected project life span of 30 years, will save as much as 6,400 metric tons of carbon dioxide. The project is exploring a future in participating in markets for automated demand response (a service to reliably and quickly ramp energy load up or down in response to price signals) and grid services (frequency control, operating reserves or other ancillary services to maintain electric grid stability).

**Las Positas College Microgrid**

The CEC provided EPIC funding to Las Positas Community College in Livermore (Alameda County) to design a microgrid system around an existing solar generation and energy management system. The control for this microgrid was split into two components: the demand charge controller (coordinates the battery discharge in response to predicted energy use that may lead to demand charges) and the master controller (coordinates the local dispatch of signals and protection devices, and integrates communication and data). Furthermore, this microgrid deployment used an alternative battery chemistry, vanadium redox flow battery (leverages electrolyte, membrane, and electrodes to store and discharge energy), developed by UniEnergy Technologies. The controls helped the campus coordinate the various DERs onsite (such as PV and energy storage) and optimize the operation of the microgrid to benefit the campus, the grid, and the surrounding communities.

The Las Positas microgrid project provided valuable information to stakeholders in deployment lessons, economic analysis, and future considerations. Microgrids provide a medium for high DER penetration because localized controllers help coordinate onsite energy resources and respond to grid conditions. Through islanding, this microgrid allows the college to provide a gathering place and shelter with essential electrical services during natural disasters and public safety power shutoffs. In normal operations, the microgrid helps reduce costs for the college. Reductions in demand charges alone from this project would save at least $60,000 annually with a monthly demand reduction of 200 kW. As California shifts to a more resilient and carbon-neutral economy by 2045, microgrids have emerged as an important technology solution. In addition, $40,000 to $90,000 of cost savings annually can be achieved through thermal storage programming and demand response.

## Cal-Adapt: Making Climate Projection Data Available to Support Risk Management

The Cal-Adapt Web platform[20] supports risk management and planning by providing access to the wealth of climate projections data and interactive visualizations that help utilities, local leaders, and state officials analyze energy sector vulnerabilities to climate change in California and take strategic actions to strengthen resilience.

EPIC funds together with Public Interest Energy Research Natural Gas program funds have supported the development of Cal-Adapt 2.0 (an expanded web platform with updated climate change projections and data visualization tools), with project implementation led by UC Berkeley's Geospatial Innovation Facility. The original version of Cal-Adapt, released in 2011, presented a prior generation of climate projections that were more limited in capturing extreme events and offered more basic user interactive features. Cal-Adapt 2.0 presents climate projections that support California and national assessments, with updates and enhancements to the interactive, web-based platform for investigating climate-related risks. EPIC funds were used to increase the ease of use of Cal-Adapt, provide powerful visualization tools, and make projection data developed for *California's Fourth Climate Change Assessment* (a group of more than 50 technical, regional, and statewide reports including climate projections and analyses of expected climate change impacts in California) accessible to the public.

Design of Cal-Adapt 2.0 was informed by feedback from a variety of sources to present interactive visualizations of high-resolution downscaled data. Engagement of IOUs throughout the design enabled development of tools and visualizations with the needs of IOUs in mind. For example, user-defined thresholds for extreme heat and a sea-level rise tool were incorporated based on IOU feedback. In addition to offering data download in many formats to support a variety of users, Cal-Adapt offers an open application programming interface that enables other organizations to build planning tools.

Cal-Adapt has bolstered adaptation practice and policy in California by providing data and visualization tools in an easy-to-use, freely available manner that serves as a resource for many climate resilience applications. In 2019, Cal-Adapt had more than 23,000 users and more than 126,000 page views. Cal-Adapt has been used by California IOUs for a range of applications that leverage data and visualizations from the web platform, including to inform:

- The climate dimensions of electrical grid hardening (changes to improve performance under extreme conditions) projects (SDG&E).
- Design of an electrical substation project (SCE).

[20] The Cal-Adapt Web platform is available online at https://cal-adapt.org/.

- Siting of transmission towers in the San Francisco Bay Area using hourly sea level rise data (PG&E).

Recognizing the robustness of these data, on November 1, 2019, the CPUC released a decision in its adaptation rulemaking (R.18-04-019) directing IOUs to use Cal-Adapt as a primary source of acceptable data for use in adaptation planning.

## Advancing Energy Equity

California is working to advance clean energy equity in disadvantaged and low-income communities, tribes, and rural communities. According to CARB, millions of Californians live in communities with unhealthful levels of ozone and particulate matter. The final report for an EPIC-funded study, *Air Quality Implications of an Energy Scenario for California Using High Levels of Electrification,* published in 2019, indicates electrifying energy services in California, such as transportation and space heating, can provide public health benefits valued at more than $100 billion per year in 2050.

EPIC technology demonstration and deployment projects can advance knowledge sharing and address barriers to access to clean energy technologies. For example, EPIC projects expanded availability of energy efficient retrofits in low-income multifamily housing and low-income communities.

### Real-World Electrification Options of Energy Services and Environmental Justice Considerations

The CEC contracted with EPRI to study the air quality and public health implications of electrifying energy services, such as transportation and space heating. The research team used, as a starting point, E3's prior EPIC study on *Deep Decarbonization in a High Renewables Future*. In addition to this work, the team collected information on how disadvantaged communities could be engaged to increase the availability of electrification in these communities and ensure the benefits of electrification were shared equitably. This effort included interviews with stakeholders in the environmental justice advocacy community and a meeting to discuss the results.

The project showed that electrification would significantly reduce emissions, improve air quality and reduce mortality rates from pollution. The monetized health benefits for combined changes in the amount of fine particulate matter with a diameter less than 2.5 micrometers (PM2.5) and ozone were estimated at $108 billion per year in 2050 for California, including $56 billion in benefits for the South Coast Basin. Particulate matter is unburned fuel particles that form smoke or soot and stick to lung tissue when inhaled. It is a chief component of exhaust emissions from heavy-duty diesel engines.

The analysis indicated air quality benefits can provide a relatively rapid "payback" for energy electrification investments. Project results indicate benefits were slightly higher in disadvantaged communities. The study includes recommendations to ensure disadvantaged communities directly benefit from electrification through higher in-community adoption. EPRI has presented the results of this study at electrification

conferences; at Technical Advisory Committee meetings that included stakeholders from utilities, air quality management districts, and academia; and EPRI will present results in an upcoming trade journal publication.

### Customercentric Approach to Demand-Side Management Retrofits

The CEC provided EPIC funds in 2016 to EPRI to develop and demonstrate an approach to scale energy efficiency retrofits of multifamily housing that focus on customercentric solutions. The project was active in 2019. The customercentric approach develops retrofit solutions that match technologies to occupant and building owner preference and behavior, while being minimally intrusive. EPRI demonstrated this approach in two disadvantaged California communities: one is a senior living community in Ontario (San Bernardino County); the other is a disadvantaged and low-income community in Fresno.

In Ontario, EPRI installed high-efficiency heat-pump HVAC, "smart" thermostats, appliance upgrades, window upgrades, wall-attic insulation, LED lighting, low-flow water fixtures, reflective wall paints, and tankless water heaters. Each unit was also equipped with monitoring equipment to validate energy savings. These installed technologies, along with customer feedback, provided residents and building owners with more technical knowledge on energy efficiency retrofits.

Preliminary results in Ontario showed a reduction in tenant energy use, reduction in property owner energy bills, and a substantial carbon emissions reduction. EPRI also conducted indoor environment quality monitoring to ensure that the occupants were not affected by the retrofit. Surveys show tenant satisfaction with their living conditions increased from 88 percent pre-retrofit to 97 percent post-retrofit. More than 65 percent of the respondents reported lower energy bills post-retrofit.

For Fresno, EPRI is looking to demonstrate a complete decarbonized, all-electric retrofit approach. The research team plans to install 110 volt terminal heat pump HVAC that can be installed without additional electrical upgrades. EPRI will also install a community water heating system. The goal is to address occupant and building owner needs while reducing energy bills and eliminating greenhouse gas emissions with an all-electric retrofit solution. The estimated energy savings from this retrofit package is 30 percent to 40 percent.

At the conclusion of this project, EPRI will provide lessons learned on the pathway to scaling retrofits. EPRI will provide the approach to technology solutions and funding mechanisms to help replicate similar retrofits in other disadvantaged and low-income communities. The scalability can happen through various avenues, such as IOU incentive programs and the low-income weatherization program, as well as mortgage refinancing and owner-paid property improvements. This project will provide a "how-to" guide for stakeholders as they enter into deep retrofits with electrification.

## Smart Ceiling Fans and Thermostats for Energy-Efficient Comfort

In 2015, a report from California's Legislative Analyst's Office stated low-income households in California spend 67 percent of their income on housing. In a 2014 paper for the American Council for an Energy-Efficient Economy, Serj Berelson of Opower reported: compared to average households, low-income households are 25 percent more likely to have energy-intensive space heaters and 50 percent more likely to rely on window air conditioning units. In PG&E territory in Northern California, beginning in 2020, the residential customers will move to time-of-use rates where they will experience rates of 36 cents per kWh from 3 pm to 8 pm June-September—exactly coinciding with the hottest temperatures of the day.

With EPIC funding awarded by the CEC in 2016, UC Berkeley developed an optimal system configuration for smart comfort-controlled ceiling fans integrated with learning thermostats. This project was active in 2019.

- Optimal system configuration. The integration of two technologies (smart ceiling fans and communicating thermostats) has the potential to automate energy savings, provides improved comfort, and lower energy cost.
- Smart comfort control ceiling fan. Communicating with thermostats, smart ceiling fans provide the first stage of cooling by turning on when the air starts to warm, then using air conditioning to provide cooling after the room has warmed to a higher temperature. They can also turn off when no one is detected in the room.
- Thermostat learns patterns. The "smart" thermostat observes behavior patterns and desired temperatures for certain days and times during the week and incorporates the observed patterns into subsequent thermostat settings.

This system was tested and evaluated for energy performance and occupant acceptance in low-income multi-family homes and small commercial buildings in disadvantaged communities in California.

This project installed 99 smart ceiling fans in offices, community rooms, and homes in low-income housing developments at four sites in California's Central Valley. The fans act as the first stage of cooling, providing comfort and instant control to the occupants. As temperatures rise indoors, the fans gradually speed up. The air-conditioning system starts running only when the indoor temperature is substantially higher (for example, 78°F or 80°F) than usual thermostat settings (such as 70°F -75°F). This strategy saves energy and utility costs compared to using air conditioning alone while providing equal or more comfortable conditions.

The research team installed ceiling fans and increased the thermostat settings. At one of the sites, these actions reduced the amount of energy consumed for air conditioning by 60 percent, cutting the electricity bill by nearly $1,200/month.

In one of the installations, the air-conditioning system actually failed. Even when temperatures reached 80°F and higher indoors, 89 percent of the people were still comfortable with ceiling fans alone. These devices show great promise for saving

energy and costs while maintaining comfort. Also, these devices provide a measure of resilience when air-conditioning equipment fails.

To support expanded use of these technologies, the UC Berkeley research team will:

- Identify and address market barriers to wider acceptance and adoption, such as:
    - Cost of smart ceiling fans and thermostats.
    - Lack of knowledge. Most occupants do not know that recent changes to ceiling fan design allows some to operate at only 3 to 10 watts, less power than air conditioning.
    - Occupant perception. Some occupants may not think of ceiling fans cooling people rather than spaces, so fans may run when no one is present or may not be placed where people perceive the most benefits or both.
    - Occupant use of the interfaces. The user interfaces to smart fans/ thermostats are still too complicated for the average user, much less in low-income communities where language and cultural understanding of icons may be different than what is on the thermostat.
    - The design and installation of ceiling fans.
- Provide guidance to manufacturers, designers, and engineers as they implement these new energy-saving technologies.
- Develop standard rating methods, a design guide, and energy code language.

**Richmond Advanced Energy Community**

Despite increases in zero-net-energy construction in recent years, infill zero-net-energy developments, particularly in low-income communities, have remained largely unattainable due to design, financing, and scale-up challenges. Under the EPIC Challenge Phase I, the Zero Net Energy Alliance of Davis worked with the City of Richmond to design and adopt a comprehensive integrated policy and financing framework needed to scale advanced clean energy technologies at the community level. Phase I CEC investment enabled the project to develop and integrate ZNE design strategies with the Social Impact Bond Housing Renovation Program and design the DER community aggregation.

Focused on the particular challenges presented in disadvantaged communities and in-fill projects, these strategies were piloted as part of a redevelopment effort to convert 20 abandoned houses into affordable zero-net-carbon-ready (ZNCR) homes. A social impact bond (return on investment depends on achievement of specified social goals) developed in partnership with the Richmond Community Foundation is funding the acquisition and basic rehabilitation of the homes. The CEC Phase I award and match funds from the City of Richmond are enabling implementation of advanced all-electric design features, including heat pump water heaters and space conditioning, advanced building controls, grid-integrated electric vehicle chargers, solar and energy storage,

super-efficient walls and insulation, and other advanced elements. Upon rehabilitation, new ZNC-ready homes will be available for purchase by members of a local first-time home buyers' program.

This project received an EPIC Challenge Phase II award in 2019, which enables the implementation and scale-up of both the ZNC-ready homes and DER community aggregation (management of local energy resources and load to reduce use of grid electricity during the evening ramp period). In addition, a climate finance toolkit will be developed in partnership with the Local Government Commission to enable other California communities to adopt and deploy the innovations piloted in Richmond.

The Phase II project will strive to reduce costs, improve resiliency and deliver additional benefits by helping a diverse set of industrial, commercial, and low-income residential customers in Richmond (including single and multi-family housing) to adopt, integrate, and operate smart appliances, solar, energy storage, and electric vehicles. This community will be scaled to include 10 commercial and industrial facilities, 20 small-to-medium businesses, and 120 residential participants, including the 20 ZNCR home project initiated under the EPIC Challenge Phase I.

## Decarbonization: Improving Energy Efficiency in Buildings

As described in the *2019 Integrated Energy Policy Report*, reducing the amount and shifting the time of electricity use in commercial and residential buildings are important components of achieving California's greenhouse gas emission reduction goals. Significant energy savings opportunities exist for restaurants, which often operate on a slim profit margin. Reducing energy-related operating costs can help maintain employment opportunities, while advancing state energy goals.

In addition, load flexibility can shift load to a time of day when renewable energy generation is higher than the amount of energy needed at that time. When renewable generation exceeds demand, the renewable energy supply is often reduced (curtailed). For example, the California ISO reports the amount of wind and solar curtailment per month reached 225,000 MWh in May 2019.

### Food Service Plug Load Replacement Can Save up to 65 Percent of Electricity Costs

The CEC's EPIC program funded Frontier Energy, a consulting firm specializing in energy efficiency, to conduct a comprehensive commercial kitchen plug load equipment study coupled with actual on-site testing of advanced energy efficient commercial plug load foodservice equipment. More than 92 pieces of equipment were evaluated spanning 22 appliance types from 29 site locations. The study compared "business as usual" energy profiles of kitchen equipment to advanced energy models to determine the cost effectiveness and energy savings. This project demonstrated the cost-effectiveness, energy savings, and behavioral changes needed to maximize the effectiveness of the newly installed technologies. For example:

- Conveyor toasters, with a payback of six months to two years depending on voltage, yielded an estimated average savings of more than $220/year.
- Hot plates showed a payback period of less than two years and savings of more than $280 per year where older resistance hot plates were replaced with efficient induction technology.
- Espresso machines, with a payback of about seven years, showed more than 60 percent energy savings, equivalent to more than $460 per year. Education initiatives are required to help owners learn about implementing an automatic timer shutoff for nonbusiness hours and switching to a unit with an insulated boiler.
- Holding cabinets, with a payback of about 10 years, showed energy savings greater than 40 percent and annual energy savings estimated at more than $280 per year. However, the cost for an insulated holding cabinet is around $4,000 compared to $1,000 for uninsulated clear-door cabinets.

Assuming a modest 20 percent energy savings per replacement and 10 percent technology adoption rate, food service operators could reduce energy use by 46 MWh/year. For comparison, the annual plug-load energy consumption for this industry is 2.3 terawatt-hours (TWh), or 2,300,000 MWh.

In addition to energy and cost savings, another important finding from the study is that none of the sites where replacements were performed provided negative feedback. From an operator's perspective, the changes in day-to-day operations associated with the efficient technologies were minimal, making these technologies low risk for replacement.

By demonstrating the benefits of replacing appliances with innovative energy-efficient models and sharing the information through training sessions offered by electric utilities, such as at the Food Service Technology Center in San Ramon, the demand and adoption of energy-efficient appliances could be accelerated. The robust data set also provides substantiation for possible utility rebate incentives. For ratepayers, this means improved availability, awareness and lower prices for energy-efficient equipment.

As of December 2019, the "smart" toaster has been adopted by a multi-unit restaurant chain as its standard specification. Similarly, several multi-unit restaurant chains have started adopting induction soup warmers and holding units.

### Increasing Comfort in Office Buildings While Reducing HVAC Energy Use

Many HVAC systems are not optimized for energy efficiency because of inaccurate measurement of airflow rates both in rooms and in air ducts. Accurate air flow measurements will help the HVAC systems reduce fan speeds when the ventilation requirements have been met, resulting in energy savings, and improved human comfort.

The CEC provided EPIC funds in 2015 to the Regents of the University of California Berkeley/Center for the Built Environment to create two prototypes of a low-cost ultrasonic sensor (anemometer) to measure airflow in rooms and air ducts. This project was completed in 2019. The developed measurement system includes miniature ultrasonic sensors, a thermometer, a compass, and a built-in radio for wireless communication. The system uses arrangements of high-frequency, ultrasonic sensors that measure sound pulses, air temperatures, and other environmental factors. Algorithms calculate the differences in the transit time of each pulse to determine the air velocity.

With EPIC funding, the team successfully created and demonstrated 50 sensors in the field. The devices were low-cost, calibration-free, and low-power. At volume, the sensors are projected to cost less than $200 compared to other sensors at $1,000 currently on the market. The sensors can be battery-powered by a 3.6 volt lithium battery and expected to last six months to more than a year or the device can be hardwired with the building electrical system. The accuracy is within 0.05 meters per second (m/s), or about 10 feet per minute.

Based on industry feedback, the most promising application is to incorporate the sensors into HVAC systems. Assuming 15 percent final market penetration for new applications, and 10 percent penetration for retrofits, the estimated total statewide savings could be 265 GWh and 38 million therms per year. These savings could result in an estimated annual energy and maintenance savings of $90 million per year based on an estimated level of market penetration of 10 years. At least one major HVAC control manufacturer will conduct additional testing. A provisional patent was filed by UC Berkeley for room and duct anemometers. Low-cost airflow sensors offer the potential to expand affordability and use of load-flexibility opportunities.

### Developing a Load Flexibility Solution for the Underserved, Small Commercial Customer Market

Small commercial buildings, such as retail spaces and offices smaller than 50,000 square feet, make up almost 94 percent of commercial buildings in the United States and account for 44 percent of total electricity use. However, small commercial customers (consuming less than 100 kilowatts [kW]) typically do not have the sophisticated building management systems found in most large commercial buildings and, thus, cannot easily manage energy consumption or participate in utility programs designed to reduce demand at critical times.

The CEC provided EPIC funds in 2016 to the California Institute for Energy and Environment (CIEE) at UC Berkeley to develop a standards-compliant open-source software platform that functions as a virtual energy management system. The software platform is called the eXtensible Building Operating System—Demand Response (XBOS-DR). This project was active in 2019.

The research team developed the platform to provide a virtual building management system for small commercial buildings by networking multiple devices such as thermostats, plug-load controllers, electric vehicle (EV) chargers, and digital meters. The research team performed pilot testing in 20 small commercial buildings.

The platform itself successfully communicated price signals, provided data (weather, setpoints and temperature from multiple thermostats, whole-building energy data) and allowed different control algorithms to act upon the systems. Installing the networked thermostats alone reduced energy consumption by up to 29 percent. Adjusting temperature setpoints during price event days (days when energy conservation is encouraged through price signals) reduced demand by 5-25 percent and reduced associated costs. The open architecture of XBOS-DR is designed to foster technical innovation by third-party vendors and HVAC, lighting, and other device manufacturers.

The near-term target market for this project is research groups who need access to data for analytics or for testing control. The mid-term target market is utility program designers, startup companies, and other early adopters who see value in securing access to building and systems data. The long-term target market is control companies who would use the platform to advance small and large commercial building control. The technology could also be adapted to the residential sector at low cost, requiring relatively simple software drivers to be developed to interface with the different types of hardware. The platform will continue to be used in additional research projects funded by the CEC (see the UC Berkeley XBOS-V project highlight described below.), the New York State Energy Research and Development Authority (NYSERDA), and the U.S. Department of Energy (DOE).

## Decarbonization: Innovation and Energy Efficiency for Industrial, Agricultural, and Water Sectors

Annual electricity used to supply water to farms is estimated to be 10 TWh per year, or about 4 percent of California's total electricity usage. This usage increases significantly in drought years because of the need to pump water from increasingly deeper wells. California Senate Bill 1168 (Pavley, Chapter 346, Statutes of 2014) requires growers to monitor groundwater extraction. Reduced irrigation techniques have not been adopted by growers because of perceived risks associated with lower crop yield and quality, and lack of equipment and labor to measure water consumption.

When sent to landfills, organic food waste produces methane—a potent greenhouse gas—and many nutrients that constitute the organic waste go unused. Using organic food waste in an anaerobic digester to generate electricity provides a renewable source of energy and reduces methane emissions.

### Irrigation Optimization and Well Pump Monitoring to Reduce Energy and Water Consumption

The CEC EPIC program funded PowWow Energy, Inc., a technology company with energy-saving software solutions for the agriculture and food sector, to demonstrate a

new "software-as-a-service" platform that enhances irrigation scheduling. The platform was demonstrated at six commercial farming sites in the Sacramento and San Joaquin Valleys. The platform uses "smart meter" data to measure water volumes from pumps without installing hardware devices on site. The software also communicates with the farmer and irrigator to optimize crop yields and water applications. A major breakthrough in this project was the demonstration of certified water measurement from energy data. This provides automated daily water records to help farmers with irrigation water management. This project demonstrated 13 percent energy savings and 9 percent water savings.

In 2018 when this EPIC project was completed, the PowWow Energy, Inc., irrigation software platform was used on 1,000 acres. In 2019, the PowWow Energy, Inc. irrigation software platform was used on about 700 electric meters and 105,000 acres, including about 600 electric meters and 90,000 acres in the San Joaquin Valley. The software is also used by the California Department of Food and Agriculture to measure energy savings from the State Water Efficiency and Enhancement Program.

### Demonstration of an Innovative, Community-Scale Organic Waste-to-Energy Facility

In 2017, the CEC provided EPIC funds to HZIU Kompogas SLO Inc. to construct a state-of-the-art high-solids anaerobic digestion plant designed to meet the organics diversion goals of San Luis Obispo County (Figure 11). This project was active in 2019. At this plant the organic solid waste can be processed at a thermophilic temperature of 131° F using combined heat and power to produce the heating for the digester. This temperature is considerably higher than the lower mesophilic temperature range of most of the state's other anaerobic digestion plants. The higher processing temperature ensures that spores and bacteria are eliminated, completely sanitizing the organic matter during processing, to allow production of fertilizer as a co-product. In addition, the higher temperature permits the biogas potential to be fully exploited by the time the material comes out of the digester, thus, a higher volume of carbon-neutral biogas is extracted compared with other anaerobic digestion plants.

The site accepts 700 tons of organic waste per week, and electricity generation at the facility is ramping up, with current generating capacity at 465 kW. This power is sold to PG&E. The compost produced at the plant is sold to local agricultural businesses and distributed to the local community at no cost. As a part of its open door program, the project team is educating the community about the technology and importance of keeping their organic wastes "clean" – free from plastics, gravel, and so forth. The return on investment is less than 15 years.

**Figure 11: Kompogas San Luis Obispo Facility**

Source: Kompogas SLO

The project is the first-of-its-kind anaerobic digestion plant in the United States, bringing with it distinct challenges and yielding lessons learned. The project addressed scale-up challenges to make this plant as well as future facilities more economical. For example,

- Construction costs associated with the project are higher compared to existing same-sized projects in Europe.
- Seasonal farming activities lead to variances in feedstock throughout the year and can influence plant output.
- Marketing of final compost products requires time and customer engagement and education.

Continued process parameter optimization and plant modifications helped to resolve encountered issues. The project team is preparing a "lessons learned" program, which will be brought into future projects in the United States and elsewhere. These lessons will make follow-up projects more economical and successful.

## Decarbonization: Enabling a More Decarbonized and Decentralized Electric Grid

Solar energy provides a growing proportion of California's renewable energy, increasing the flexibility required from other electricity resources. For example, in April 2019, according to the California ISO, solar energy served more than half of the monthly maximum percentage of load. In March 2019, the California ISO maximum three-hour net-load (load not served by solar or wind) ramp was more than 15,000 MW, requiring a large increase in electricity generation from other resources in a short amount of time. Flexible low-carbon resources along with more sophisticated tools and

technologies can ease integration of the large and growing amount of variable renewable generation serving California's electricity load.

### Development of a Novel Solar PV Tracker for Sloped Terrain

In 2017, the CEC provided EPIC cost share funds to Nevados Engineering (Nevados), located in San Francisco, to improve the design and decrease the manufacturing costs of a novel single-axis solar PV tracking system that was initially developed with funding from the DOE. A solar PV tracking system changes the angle of the PV panels to follow the sun during the day. Leveraging federal funding supports efficient use of funding—a guiding principle of the EPIC program. This project was active in 2019.

Developing and testing multiple generations of the Nevados tracker (second through fourth generations) at the Photovoltaics for Utility Scale Applications (PVUSA) demonstration site near Davis (Figure 12) resulted in reducing costs associated with manufacturing by nearly 50 percent, from $0.25/W down to $0.128/W. Moreover, the design is easier to install, with a 10 percent reduction in construction time and increased foundation installation tolerances. The fourth generation version of the technology has obtained UL2703 (safety standard for PV rack mounting systems) and UL3703 (safety standards for solar trackers) certification listings. These listings certify the technology meets applicable safety standards.

Through the course of this EPIC award, the project team developed, manufactured, and operated a commercially ready technology. The version of the product that was ready at the end of the project includes a single-axis tracker that can fit to flat, sloped, and rolling terrain. The tracker technology can be installed on slopes of up to 37 percent grade with changes in slope along the length of the row of up to 17 percent grade at each bearing assembly. Compared to conventional PV trackers, Nevados estimates its tracker triples the amount of land in California with technical potential for PV.

Nevados also advanced its business-related activities, reducing the cost of the tracker technology to a competitive price by building a strong supply chain. With its PV tracker now commercially ready for manufacturing and deployment, Nevados sold and installed the new tracker system at two customer sites, and closed another sale on August 1, 2019 for a third installation. More sales are imminent. The customer with the most recent sale bought the equipment as a pilot install and expects to buy gigawatts of additional equipment over the coming four years if the pilot is successful.

**Figure 12: Second Generation of the Nevados Tracker Technology**

**PVUSA test facility in Davis with the second generation of the Nevados tracker technology, including control system and optimization software**

Source: Nevados

## Improving Forecasting Accuracy for Solar Energy

To address forecast uncertainty, the CEC provided EPIC funds in 2017 to Clean Power Research to develop and test solar forecast economic valuation methods to quantify forecasting-related costs and the cost savings that result from improved forecasts. Under this project, the University of California at San Diego and the State University of New York also developed methods to improve forecast accuracy. This project was active in 2019.

During this project, the research team addressed forecast improvements for the coastal marine fog layer and other low cloud and fog events by applying innovative methods in identifying low-cloud layers. A portion of this research built on a prior CEC EPIC project, "Improving Short-Term Load Forecasts by Incorporating Solar PV Generation (CEC-EPC-14-001)."

This project advanced the state of PV forecasting in California by improving the accuracy of solar irradiance and PV production forecasts, particularly for rooftop solar, which was not previously well-understood. This project provided the California ISO with an improved day ahead PV production forecast to increase electric power system reliability across California. The researchers developed methods for the day-ahead forecast of the morning/evening, afternoon, and dawn hours that are expected to have accuracy gains of 10 percent, 3 percent, and 8 percent, respectively. As a result, increasing the forecast accuracy narrows the error distribution and, therefore, decreases the reserve requirement, with environmental and cost-reduction benefits. Clean Power Research estimates that the forecasting methods developed in this project will save California $176 million over the next 30 years.

## Decarbonization: Transportation Electrification

As discussed in the *2019 Integrated Energy Policy Report*, the cost of electric vehicles and trucks continues to decline—potentially reaching parity with fossil-fueled vehicles by the mid-2020s for battery-electric vehicles—and the number of California vehicles and charging stations is growing quickly in part because of ambitious statewide goals, incentives, and regulations. EPIC-funded research advanced technologies to integrate the growing electricity load related to transportation, including: 1) a project to accelerate procurement of electric vehicles for fleets; and 2) a project to ease management of building loads, on-site renewable energy, and electric vehicle charging.

### Accelerating the Adoption of Electric Vehicles as DERs Through Fleet Procurement

In 2018, the CEC provided EPIC funds to Lawrence Berkeley National Laboratory (LBNL) to develop and launch a fleet procurement analytics system, MyFleetBuy. MyFleetBuy leverages streamlined data collection on fleet operating profiles by collecting data on fleet vehicle driving distances, traffic, terrain, and driving style. These vehicle data are fed through vehicle physics models to allow fleet managers to compare fuel costs in any current fleet vehicle against those in any conventional, hybrid, or EV being considered for their fleet. The cost savings of electric vehicles and electric vehicle charging are highlighted within MyFleetBuy through a Web portal that allows fleet managers to think through the implications of any vehicle being used within their fleet.

MyFleetBuy builds on LBNL's consumer facing MyGreenCar application, a system of vehicle physics models and analytics that LBNL worked closely with the U.S. Environmental Protection Agency (EPA) to validate. The sophisticated vehicle physics models developed by LBNL represent a significant technological advancement over current EPA static fuel economy labels, allowing fleet managers to make more informed procurement decisions.

For this agreement, LBNL is using telematics data (telematics data record vehicle location using onboard diagnostics and the Global Positioning System) from pilot partner fleets from the California Department of Transportation (CalTrans), Alameda County and the City of Oakland to produce a fleet procurement analysis solution that can be rapidly scaled up. Through 2019, MyFleetBuy has processed data on 10,000 vehicles, which will lead to $1.1 million in reduced fueling costs and 15,000 tons of avoided carbon dioxide emissions for the three pilot partner fleets by increasing the rate of electric vehicle adoption.

Progress has been so encouraging that the MyFleetBuy technology has since been transitioned to the subcontractor for the agreement, Green Light LabsGLL. Green Light Labs has received subsequent funding from the National Science Foundation's Small Business Innovation Research program and was accepted into the EPIC-funded Los Angeles Cleantech Incubator's (LACI) Innovators Program, which provides

entrepreneurial support for start-ups. The City of Fremont also entered into a contract with Green Light Labs to use MyFleetBuy for municipal fleet electrification.

*Enabling Smart Charging Solutions for Plug-in Electric Vehicles*

The CEC awarded the University of California, Berkeley (UCB) an EPIC grant in 2015 to develop the eXtensible Building Operation System—Vehicles (XBOS-V) platform to control plug-in electric vehicle charging in conjunction with building loads in residential and small commercial settings. The platform uses a novel and flexible open-source, open-architecture charge communication and control platform that any developer can modify. This project was active in 2019.

UCB successfully developed, tested, and documented a set of open-source software drivers to control the operation of the plug-in electric vehicle chargers and other building loads. The XBOS-V platform used a dynamic plug-in electric vehicle charging rate control to keep total site power under a certain limit—either physical limits because of transformer or electrical panel capacity constraints, or economic limits to manage facility demand charges. Through usage of simulated grid signals, the platform was also used to respond to scheduled or more dynamic 15-minute-ahead calls for demand response or power acceptance. Platforms such as XBOS-V can be readily scaled to medium and large fleets with the appropriate communication infrastructure.

Project analysis shows that managed plug-in electric vehicle charging has the potential to address renewable electricity generation curtailment by up to 500 GWh in 2024 and about 2,000 GWh in 2030, helping bring more low-cost and low-carbon resources onto California's utility grid. This mitigated power curtailment amounts to about $5 million to $15 million per year in avoided electricity costs in 2024, and $20 million to $60 million per year in 2030 (at avoided generation costs of $10 to $30 per MWh), as well as about 72,500 tons (2024) and 290,000 tons (2030) of avoided greenhouse gas emissions.

# CHAPTER 4: Conclusion

## Key Results for 2019 for the Energy Commission's EPIC Program

The following examples provide a small sample of the accomplishments EPIC research has achieved through 2019:

- From a sample of 22 startup companies seeking private investment, estimates indicate total private investment nearly tripled after firms received an EPIC award, from about $260 million to more than $740 million.
- EPIC funding for the entrepreneurial ecosystem helped early-stage California entrepreneurs attract $50 million in government (non-EPIC) funding. In addition, later stage EPIC recipients leveraged EPIC awards to attract nearly $180 million in federal and state (non-EPIC) funding.[21]
- During a public safety power shutoff in October 2019, the EPIC-funded microgrid at the Blue Lake Rancheria in Humboldt County provide an island of electricity (a place with electricity when surrounding areas did not have electricity). As a result, Blue Lake Rancheria facilities served about 10,000 people during the outage, including people who rely on medical devices that need electricity to operate.[22]
- Through December 2019, 29 percent of the CEC EPIC Technology Development and Deployment funds has been invested in projects in disadvantaged communities and an additional 36 percent has been invested in projects in communities that are low-income but not disadvantaged.
- Improved day ahead forecasting methods developed and tested with EPIC funding and being used by California ISO are projected to save California $176 million over the next 30 years.
- EPIC funded Nevados to develop and test a PV tracker for sloped terrain. Compared to conventional PV trackers, Nevados estimates its tracker triples the amount of land in California with technical potential for PV.
- More than 9,000 users viewed EPIC projects online more than 120,000 times.

21 This amount includes $25 million of leveraged federal funds for an EPIC cost-share project expected to be considered for approval at a CEC business meeting in 2020.

22 Peter Maloney, "Life Won Thanks to Blue Lake Rancheria Microgrid," 2019, https://microgridknowledge.com/blue-lake-rancheria-microgrid-outages/ (Accessed November 12, 2019).

To share program results and solicit feedback on research priorities, CEC staff discussed the EPIC program in more than 50 public workshops and webinars in 2019. Many of these events provided information on EPIC-funded projects in disadvantaged communities and low-income communities. For example,

- The 2019 EPIC Symposium included panels on scaling-up energy solutions for low-income customers.
- A preapplication workshop was held on a grant funding opportunity for longer-duration storage. This competitive solicitation included funding to support demonstrations in low-income and disadvantaged communities.
- A preapplication workshop was held on a grant funding opportunity with $3 million available to support one or two low-carbon water heating technology demonstrations in low-income and disadvantaged communities.

**Table 14: CEC EPIC Public Workshops and Webinars in 2019**

| Type of Workshop or Webinar | Number of CEC EPIC Public Workshops and Webinars in 2019 |
|---|---|
| Knowledge sharing | 13 |
| Networking | 3 |
| Outreach and community engagement | 10 |
| EPIC Administrator coordination | 6 |
| Coordination with state and federal agencies | 4 |
| Scoping of research roadmaps or draft solicitations | 9 |
| Preapplication workshops | 6 |
| **Total** | 51 |

Source: California Energy Commission staff

# Next Steps for the Electric Program Investment Charge Investment Plan

This section lists next steps scheduled for 2020 organized by investment topic. In addition to the topics listed below, the CEC has scheduled the following cross-cutting public forums:

- The 2020 EPIC Forum: Powering Resilient Communities, February 25, 2020, at the Long Beach Convention Center.
- 2020 EPIC Symposium, April 1-2, 2020, at California State University, Sacramento.

## Entrepreneurial Ecosystem

- First voucher applications expected in 2020 for CalTestBed. This program will provide start-up companies with access to one of nearly 30 testing centers throughout California, allowing clean energy entrepreneurs access to facilities, infrastructure, and resources to validate their technology with third-party testing and data.

## Resilience and Safety

- Long-term climate scenarios developed in EPC-18-026 will support California's Fifth Climate Change Assessment.
- CEC staff plans to release a competitive solicitation to provide next-generation climate projections that capture important parameters for electricity sector resilience, such as wind, cloudiness, and subdaily temperature. These projections are intended for use in California's Fifth Climate Change Assessment, as well as IOU adaptation efforts.

## Advancing Energy Equity

- CEC staff plans to hold three networking events in 2020 to bring community organizations and other stakeholders representing low-income and disadvantaged communities onto the Empower Innovation platform.
- CEC staff plans to hold two workshops in February 2020 (one in San Diego and one in Los Angeles) to discuss a proposed EPIC solicitation titled "The Next EPIC Challenge: Reimagining Affordable Mixed-Use Development in a Carbon-Constrained Future."

## Decarbonization: Improving Energy Efficiency in Buildings

- Proposals will be due in early 2020 for the following two solicitations:
    - GFO-19-301 Advancing Next-Generation Heating, Cooling and Water Heating Systems

    - GFO-19-307 Advancing Envelope Technologies for Single Family Residential Buildings, Low-Rise Multifamily Buildings, and Mobile Homes.
- Technology assessments for plug loads will be completed in 2020 and large commercial buildings will be completed in 2021. These assessments identify potential research needs for these sectors.
- Flexible Load Research and Deployment Hub solicitation planned for release in early 2020.

## Decarbonization: Innovation and Energy Efficiency in Industrial, Agricultural, and Water Sectors

- Proposals will be due in early 2020 for the following solicitation:
    - GFO-19-304 Advanced Refrigeration and Heat Pumps for the Industrial Sector.

## Decarbonization: Enabling a More Decarbonized and Decentralized Grid

- In the first half of 2020, the CEC plans to issue project awards for the Next Wind grant solicitation and launch the associated projects.
- Proposals for the geothermal solicitation were due to the CEC on January 30, 2020; project selections will be completed and awards are anticipated to be brought to CEC Commissioners for approval in May and June 2020, with anticipated project kickoffs soon thereafter.
- The utility-scale renewable energy generation technology roadmap developed by staff and Energetics is intended to identify, describe, and prioritize technology RD&D opportunities and provide CEC with recommended initiatives that address research gaps in the near, mid, and long term. The CEC plans to release the roadmap in early 2020.
- The Distributed Energy Resource Research Roadmap developed by Navigant and CEC staff will provide the CEC with recommended and prioritized research topics for the near, medium, and long term. Release of the roadmap is anticipated in early 2020.

## Decarbonization: Transportation Electrification

- In 2020, the state's roadmap to integrate electric vehicle charging needs with the needs of the electrical grid will be completed and will reflect advancements in technology and include actions the state can take to advance vehicle-grid integration efforts.
- A solicitation to develop the Research Hub for Electric Technologies in Truck Applications will be released in mid-2020 to promote and accelerate the transformative electrification and scale-up of California’s heavy-duty vehicle market.

- In 2020, a competitive solicitation will be released to support vehicle-to-grid demonstration of heavy-duty vehicles. Efforts will focus on reducing the marginal cost of bi-directional power-flow functionality and assess the value and benefits of providing grid services.

## Issues

The EPIC annual report is required to include a discussion of issues "that may have major impact on progress in projects, if any."

Renewal of the EPIC program beyond 2020 is under consideration at the CPUC in Rulemaking 19-10-005. The CEC looks forward to supporting the proceeding to renew the EPIC program and build on the ability of the program to shape California's clean energy market and enable the state to more effectively and efficiently meet its energy mandates and aspirations.

No projects were terminated in 2019.

# GLOSSARY

| Term | Definition |
|---|---|
| AB | Assembly Bill |
| ARD | 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 |
| ASHRAE Guideline 36-2018 | Voluntary American Society of Heating, Refrigerating, and Air-Conditioning Engineers guideline for High-Performance Sequences of Operation for HVAC Systems. |
| California ISO | California Independent System Operator |
| $CO_2$ | Carbon dioxide |
| CPUC | California Public Utilities Commission |
| CPUC Rule 21 | Electric Rule 21 describes requirements for interconnection, operating, and metering facilities connected a utility's distribution system in the service territory of PG&E, SCE, or SDG&E. |
| Disadvantaged community | A community that scores at or above 75 percent in the version of CalEnviroScreen that was available at the time of project application. |
| EPIC | Electric Program Investment Charge |
| HVAC | Heating, ventilation, and air conditioning |
| IEPR | Integrated Energy Policy Report |
| IOU | Investor-owned utility |
| NOPA | Notice of proposed awards |
| PG&E | Pacific Gas and Electric Company |
| RD&D | Research, development, demonstration, and deployment |

| Term | Definition |
|---|---|
| SAE J3072 | The SAE standard specifying Interconnection Requirements for Onboard, Utility-Interactive Inverter Systems for plug-in electric vehicles. This standard specifies requirements for onboard plug-in electric vehicle inverters to discharge to the electricity grid through electric vehicle supply equipment. The standard includes communication requirements between the vehicle and the electric vehicle supply equipment. |
| SB | Senate Bill |
| SCE | Southern California Edison Company |
| SDG&E | San Diego Gas & Electric Company |
| Smart grid | A smart grid is the thoughtful integration of intelligent technologies and innovative services that produce a more efficient, sustainable, economic, and secure electrical supply for California communities. |
| Smart inverter | An inverter with communications capability to send and receive messages that can ensure proper operation of the electric grid |
| Title 24 Energy Code | California Code of Regulations, Title 24, Parts 6 and 11 |
| TDD | Technology deployment and demonstration |
| U.S. DOE | United States Department of Energy |
| ZNCR | Zero-net-carbon ready |

# APPENDICES

Appendix A: CEC EPIC Reporting Requirements for 2019

Appendix B: CEC EPIC Project Write-Ups for 2019 Active, Completed, or Terminated Projects

Appendix C: CEC EPIC Project Status Report

These appendices are available as a separate volume, Publication Number CEC-500-2020-009-AP-CMF.