DOCKETED	
Docket Number:	20-EPIC-01
Project Title:	Development of the California Energy Commission Electric Program Investment Charge Investment Plans 2021-2025
TN #:	236882
Document Title:	Motion of the California Energy Commission for Approval of the Electric Program Investment Charge Interim Investment Plan 2021
Description:	CEC's Motion to the CPUC containing the proposed EPIC Interim Investment Plan and appendices
Filer:	Misa Werner
Organization:	California Energy Commission
Submitter Role:	Commission Staff
Submission Date:	2/23/2021 10:07:40 AM
Docketed Date:	2/23/2021

BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF CALIFORNIA

Order Instituting Rulemaking on the Commission's Own Motion to Consider Renewal of the Electric Program Investment Charge Program.	Rulemaking 19-10-005

MOTION OF THE CALIFORNIA ENERGY COMMISSION FOR APPROVAL OF THE ELECTRIC PROGRAM INVESTMENT CHARGE INTERIM INVESTMENT PLAN 2021

I. INTRODUCTION

In accordance with Rule 11.1 of the California Public Utilities Commission ("Commission") Rules of Practice and Procedure, the California Energy Commission ("CEC") submits this Motion for Approval of the Electric Program Investment Charge ("EPIC") Interim Investment Plan ("Motion"). The CEC files this Motion in response to the Commission's *Decision Renewing the Electric Program Investment Charge* ("Phase 1 Decision") in Rulemaking 19-10-005.

The CEC appreciates the opportunity to file this Motion to enable the CEC to continue fostering important technology research to support the state's clean energy goals and priorities while the first five-year investment plan for the renewed EPIC Program is developed in 2021. The CEC looks forward to continuing its work with the Commission and stakeholders to implement the renewed EPIC Program, build on the program's success in shaping California's clean energy system, and enable the state to more effectively and efficiently meet its energy policy goals and mandates.

II. DISCUSSION

In the Commission's Phase 1 Decision, the Commission renewed the EPIC Program for an additional ten years (January 1, 2021 through December 31, 2030). The Phase 1 Decision approved the CEC to continue as an EPIC program administrator, approved the CEC's budget at $147.26 million per year for the first five years, and ordered the investor-owned utilities to collect funds for the renewed program starting January 1, 2021. The Commission required the

CEC to file an investment plan to the Commission by October 1, 2021 to cover the funding-collection period of January 1, 2021 through December 31, 2025 (also referred to as the "EPIC 4 Investment Plan" or "EPIC 4").

In the Phase 1 Decision, the Commission also recognized that to maintain continuity of the program, the CEC may need funding to begin work on new EPIC projects before a full EPIC 4 Investment Plan is developed with public and stakeholder input and approved by the Commission. Since EPIC 4 is due on October 1, 2021, and the Commission will need time to consider the plan, approval is not expected until early 2022. An Interim Investment Plan, as allowed by the Commission in the Phase 1 Decision, will enable the CEC to continue to fund projects critical to maintaining research momentum needed to achieve the state's clean energy goals faster. This will also provide benefits to ratepayers and support economic recovery.

This Motion provides the Commission with an EPIC 4 Interim Investment Plan ("Interim Investment Plan" or "Interim Plan") for approval. The CEC developed the Interim Investment Plan (Appendix A) as a bridge between the CEC's third triennial investment plan ("EPIC 3 Investment Plan" or "EPIC 3") (funding-collection period 2018-2020) and a full five-year EPIC 4 Investment Plan (2021-2025).[1] As such, the scope of the research initiatives in the Interim Investment Plan is restricted in scope compared to a typical 3- or 5-year investment plan. The CEC anticipates that this Interim Investment Plan would only cover the period during which a full EPIC 4 Investment Plan is being developed and approved, which is approximately one year after the completion of Phase 2 of this proceeding.

To develop the Interim Investment Plan, CEC staff consulted regularly with the Commission's Energy Division staff on the scope of the draft research initiatives. In addition, the CEC presented draft research initiatives to the EPIC Subcommittee of the Disadvantaged Communities Advisory Group (DACAG) on December 7, 2020 and incorporated their input (Appendix B). The CEC also edited the draft initiatives to address multiple sets of comments from the Commission's Energy Division staff (Appendix C). The CEC held a public workshop on January 6, 2021 to review the approach for developing the draft Interim Investment Plan and the preliminary set of research themes and initiatives. The CEC considered both public comments received at the workshop as well as written comments submitted to CEC Docket 20-

[1] Implementation of the research planned in these collection periods typically occurs beyond the collection period and could span several CEC fiscal years.

EPIC-01 (Appendix D). Public comments on the Motion received by the Commission will also be considered.

The CEC applied the following guiding principles to focus the scope of the Interim Investment Plan:

- The CEC uses the original EPIC mandatory and complementary guiding principles to shape the research initiatives in the Interim Investment Plan. All initiatives are designed to provide ratepayer benefits, including greater reliability, lower costs, and increased safety. Additionally, the initiatives in the Interim Investment Plan support the complementary guiding principles of societal benefits, greenhouse gas (GHG) emissions mitigation and adaptation, low-emission vehicles/transportation, loading order, and economic development.
- Equity is an important consideration in the Interim Investment Plan. Certain initiatives are specifically designed to benefit under-resourced communities and address their priorities such as sustainable, affordable housing and community resilience.
- Increasing the resilience and reliability of California's electric system and the critical services it provides to customers is an important theme, driven by recent increases in heat waves and wildfires.
- Decarbonization is a strong theme in the plan because of the need to dramatically reduce GHG emissions and reduce reliance on fossil fuels within a relatively short time window and meet state energy and environmental goals.
- The CEC proposes to continue supporting the California clean energy entrepreneurial ecosystem ("Entrepreneurial Ecosystem") to ensure clean energy technology startups are able to access needed funding especially given these challenging economic times.
- Lastly, the CEC is focusing on research initiatives that naturally follow from lessons learned and results from EPIC 3 research and earlier investment plans. Table 1, below, provides an example of the learnings from a broad portfolio of active and completed EPIC projects.

Table 1. EPIC Research Portfolio Summary

Investment Topic	EPIC Investment Through December 2020 ($million)	Count of Projects	Example Projects
Entrepreneurial Ecosystem	$ 143	34	NeoCharge is developing a technology to reduce the installation cost of electric vehicle chargers.
Resiliency and Safety	$ 151	67	Caban Systems received an EPIC grant to further develop its grid-independent energy storage system, which provides a clean source of back-up power to critical telecommunications infrastructure.
Building Decarbonization and Affordability	$ 194	84	Working with LINC Housing on a multifamily apartment complex in a disadvantaged community in Fresno, EPRI installed a Sanden heat pump water heater that supplies multiple residential units.
Grid Decarbonization and Decentralization	$ 207	124	SRI International developed an innovative new sorbent material and regeneration process to capture lithium from geothermal brine and directly produce lithium carbonate. The technology was licensed to ExSorbtion Inc. to pursue commercialization.
Industrial and Agricultural Innovation	$ 119	59	Terzo Energy Systems has developed a hydraulic pump unit that replaces valves with a permanent magnet, increasing efficiency by 80 percent over state-of-the-art hydraulic pumps.

Low-Carbon Transportation	$ 32	17	Nuvve developed and demonstrated vehicle-grid integration technologies for managing aggregated plug-in electric vehicle charging and discharging within the University of California (UC) San Diego microgrid.
Total	**$ 846**	**385**	

Source: CEC staff

While the CEC recognizes that there are many emerging technology solutions that may be beneficial to the state, the CEC believes that additional planning and stakeholder engagement is necessary to scope such research initiatives fully. The CEC will consider a broader spectrum of emerging research initiatives as part of the full EPIC 4 Investment Plan development, which will include more opportunities for stakeholder input.

The Interim Investment Plan is attached as Appendix A to this Motion for the Commission's review and consideration. It proposes a program-level budget of $41.2 million (M) for applied research and development, $75M for technology demonstration and deployment, $16.3M for market facilitation, and $14.7M for administration. CEC requests a continuation of the Commission practice of allowing up to five percent reallocation within these three research categories. If the Commission approves the Interim Investment Plan, the CEC will follow all current CEC procedures for developing research grant funding opportunities (GFOs), such as budgeting components of research initiatives, holding public workshops to shape specific topics, and announcing the research GFOs and events via notices on the CEC's EPIC website and listserves.

III. CONCLUSION

The CEC appreciates the opportunity to submit an Interim Investment Plan that will allow the CEC to continue funding EPIC projects in the interim until the full EPIC 4 Investment Plan is approved. The CEC respectfully requests that the Commission approve this Interim Investment Plan by no later than April 15, 2021, to ensure that the state can continue to build on the success of prior EPIC research in helping achieve the state's clean energy goals while

providing much-needed support to the Entrepreneurial Ecosystem and supporting economic recovery in the state.

Dated this 16th day of February 2021.

Respectfully submitted,

CALIFORNIA ENERGY COMMISSION

/S/ Linda Barrera

Linda Barrera

Assistant Chief Counsel
Chief Counsel's Office
CALIFORNIA ENERGY COMMISSION
1516 9th Street, MS 14
Sacramento, CA 95814-5512
Telephone: (916) 628-2122
Facsimile: (916) 654-3843
Email: linda.barrera@energy.ca.gov

APPENDIX A: California Energy Commission Proposed EPIC Interim Investment Plan 2021

Introduction

The Electric Program Investment Charge (EPIC) Program was established by the California Public Utilities Commission (Commission, CPUC) in 2011 to fund research leading to technological advancement and scientific breakthroughs supporting California's clean energy goals, with a focus on providing ratepayer benefits, including reliability, lower costs, and safety. The program has provided substantial benefits to the state, including the following examples:[1]

- Sixty-five percent of technology demonstration and deployment (TD&D) project funding to research in and benefiting low-income or disadvantaged communities.
- Commercialization of more than 34 technologies and related service companies.
- Contribution to the ability of companies funded by EPIC research to collectively receive over $2.2 billion in private investment and follow-on funding.
- Research that has improved the effectiveness of energy-related codes and standards. Five such research projects could lead to over $1 billion in annual energy cost savings if adopted into regulatory codes.

Funding for the EPIC Program was initially authorized until December 31, 2020. In 2019, the Commission initiated a proceeding to renew EPIC Program funding. In the first phase of the proceeding, completed on September 2, 2020, the Commission renewed the EPIC Program for an additional 10 years, which will consist of two, five-year investment cycles. The Commission approved the California Energy Commission (CEC) as a continued program administrator and authorized a budget of $147.26 million per year for the first investment cycle of January 1, 2021

[1] CEC, April 17, 2020, Opening Brief of the California Energy Commission to the Phase 1 Issues Identified in the Assigned Commissioner's Scoping Memo and Ruling, Rulemaking 19-10-005, https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M335/K836/335836752.PDF. Note: The amount reported here for private investment and follow-on funding was updated by CEC staff and reported at the EPIC Virtual Symposium in October 2020.

through December 31, 2025 (referred to as EPIC 4). In the second phase of the proceeding, the Commission is evaluating administrative changes to the EPIC Program.

The Commission recognized that the CEC may need funding to begin work on new EPIC projects until a full EPIC 4 Investment Plan can be developed with public and stakeholder input and approved by the Commission. The EPIC 4 Investment Plan is due in October 1, 2021, and approval is not expected until early 2022. An Interim Investment Plan, as allowed by the Commission in the Phase 1 Decision, would enable the CEC to continue to fund projects critical to maintaining research momentum and helping achieve the state's clean energy goals faster, providing benefits to ratepayers, and providing economic stimulus to support economic recovery.

This appendix is the CEC's Interim Investment Plan (Interim Plan). The Motion contains a proposed program-level budget for Interim Plan research. Appendices B, C, and D summarize comments on the interim research initiatives and staff's responses. The Interim Plan includes a set of research initiatives that build on the previous EPIC 3 Investment Plan[2] and are focused on a limited set of specific, near-term needs that can feasibly be pursued through EPIC-funded projects for the first year of EPIC 4. The full EPIC 4 Investment Plan will include a more diverse set of research initiatives shaped by the additional stakeholder outreach afforded by the full plan development cycle (for example, multiple public workshops).

Timing for the implementation of the Interim Plan's research depends upon the timing of plan approval by the Commission that authorizes the CEC to proceed. Staff estimates that the earliest approval possible could occur at the Commission's mid-April business meeting. Staff would then begin the solicitation development process for the research initiatives, with solicitations released in CEC fiscal year 2021-2022 (July 1, 2021 – June 30, 2022). Once a solicitation is released, the process takes approximately nine months before the research may start (see the Administration Section for steps in the solicitation timeline). Research project timeframes range depending on the type of research and other factors such as COVID-19-related time extensions. However, in general, research projects can take on average about 3 to 4 years to complete depending on the nature of the research. For instance, a "paper study" lacking field sites may only require a couple of years to complete whereas research projects involving equipment testing and demonstration at

[2] https://efiling.energy.ca.gov/getdocument.aspx?tn=217117

multiple sites may require much longer timeframes due to the pre- and post-project monitoring and verification needed.

Research Themes and Policy Priorities

Because this plan involves the first funding-collection year of EPIC 4[3] and had a much shorter development window, the scope and extent of the research initiatives proposed here are more limited than those in a full investment plan. The Interim Plan's research themes of *decarbonization*, *resilience and reliability*, and *entrepreneurship* are described in this section and aligned to key state policy priorities as illustrated in Table 1. In addition, *equity* is an overarching theme across the plan. Therefore, equity considerations are discussed within the proposed initiatives and the approach to advancing equity is described later in this section and in the Administration Section.

Table 1: Interim Investment Plan Research Themes Align to State Policy Priorities and CPUC Proceedings

Research Theme	Key State Policies[4]	CPUC Proceedings[5]
Decarbonization	Senate Bill (SB) 350 (Statutes of [Stats.] 2015, Chapter [Ch.] 547)	Rulemaking R.17-07-007
	Assembly Bill (AB) 758 (Stats. 2009, Ch. 470)	R.19-01-011
	SB 100 (Stats. 2018, Ch. 312)	R.13-11-005
	AB 2137 (Stats. 2014, Ch. 290)	R.15-03-010
	SB 1477 (Stats. 2018, Ch. 378)	R.13-09-011
	AB 3232 (Stats. 2018, Ch. 373)	R.18-12-006
	SB 676 (Stats. 2019, Ch. 484)	R.13-02-008

[3] January 1, 2021 through December 31, 2021. Implementation of the research planned in the funding-collection periods covered by an EPIC Investment Plan typically occurs beyond the collection period and could span several CEC fiscal years (July 1 through June 30).
[4] See https://leginfo.legislature.ca.gov for more information.
[5] See https://apps.cpuc.ca.gov/apex/f?p=401:1:0 for more information.

Research Theme	Key State Policies[4]	CPUC Proceedings[5]
	AB 2127 (Stats. 2018, Ch. 365) SB 32 (Stats. 2016, Ch. 249) SB 1383 (Stats. 2016, Ch. 395) SB 1369 (Stats. 2018, Ch. 567)	R.18-07-003 R.20-08-022 R.20-08-20
Resilience and Reliability	AB 1482 (Stats. 2015, Ch. 603) AB 2514 (Stats. 2010, Ch. 469) AB 2868 (Stats. 2016, Ch. 681) SB 100 (Stats. 2018, Ch. 312) SB 1339 (Stats. 2018, Ch. 556) SB 1369 (Stats. 2018, Ch. 567) SB 246 (Stats. 2015, Ch. 606) SB 350 (Stats. 2015, Ch. 547) SB 379 (Stats. 2015, Ch. 608) SB 901 (Stats. 2018, Ch. 626)	R.14-08-013 R.14-10-003 R.20-05-003 R.17-07-007 R.17-09-020 R.18-07-003 R.18-07-033 R.19-01-011 R.20-08-020 R.20-01-007
Entrepreneurship	SB 100 (Stats. 2018, Ch. 312) SB 96 (Stats. 2013, Ch. 356) AB 327 (Stats. 2013, Ch. 611) SB 350 (Stats. 2015, Ch. 547) SB 32 (Stats. 2016, Ch. 249) AB 2514 (Stats. 2010, Ch. 469)	

Source: CEC Staff

Decarbonization

Achieving California's climate goals will require phasing out the combustion of fossil fuels, or decarbonization. For the building, industrial, agriculture, water, and transportation sectors, this requires incorporation of high levels of energy efficiency and use of zero-carbon fuels. Meeting the state's climate goals in the next 30 years requires scaling up and using market-ready technologies, as well as advancing performance and reducing cost of promising technologies that have not been commercially proven.[6] At the same time, California must build a foundation for science-based policy to foster a strategic, climate-resilient, and equitable transition from fossil fuels. Decarbonization must occur in an informed manner, both ensuring benefits to under-resourced communities and avoiding impacts to vulnerable populations.

Staff worked with the CEC Public Advisor's Office to develop a broad term, "under-resourced communities," to encompass both legislatively defined categories and underrepresented groups. In this plan, under-resourced communities include disadvantaged and low-income communities as defined AB 523 (Stats. 2017, Ch. 551), Native American tribes, and other underrepresented groups. Disadvantaged communities are those designated pursuant to Health and Safety Code section 39711 as representing the 25 percent highest-scoring census tracts in the California Communities Environmental Health Screening (CalEnviroScreen) Tool 3.0.[7] Low-income communities are those within census tracts with median household incomes at or below 80 percent of the statewide median income or the applicable low-income threshold listed in the state income limits[8] updated by the California Department of Housing and Community Development. California Native American Tribes are those on the contact list maintained by the Native American Heritage Commission for the purposes of Chapter 905 of the Statutes of 2004.[9]

Low-income households spend a larger portion of their income on energy bills and need affordable housing options that are comfortable, healthy, and energy efficient. California

---

[6] Mahone, Amber, Zachary Subin, Jenya Kahn-Lang, Douglas Allen, Vivian Li, Gerrit De Moor, Nancy Ryan, Snuller Price. 2018. Deep Decarbonization in a High Renewables Future: Updated Results from the California PATHWAYS Model. California Energy Commission. Publication Number: CEC-500-2018-012.

[7] https://calepa.ca.gov/envjustice/ghginvest/

[8] https://www.hcd.ca.gov/grants-funding/income-limits/state-and-federal-income-limits.shtml

[9] Public Resources Code, § 21073

residents' average annual energy costs (electricity and natural gas) are more than $1,700/year,[10] and costs are typically higher for those using wood pellets or propane for heating. In addition to this, housing in California remains some of the most expensive in the country with the average median purchase price of a home at more than $700,000 as of November 2020. In 2017, the median rent in California was at $1,358/month.[11] To help achieve California's greenhouse gas (GHG) reduction goals and reduce electricity bills, the CEC plans to invest EPIC funds to increase the efficiency, affordability, and resiliency of electric homes and include on- or near-site solar photovoltaic (PV) systems and energy storage.

On an annual basis, California's industrial sector consumes over 25 percent of the state's electricity and 35 percent of its natural gas and is responsible for more than 20 percent of the state's GHG emissions.[12,13] The industrial sector is heavily dependent on natural gas for processing raw materials to finished products. However, with technology advancements there is the potential that some industries can convert some processes from gas to electric or to gas and hydrogen blends, improve the energy efficiency of their processes, and avail themselves of load-reduction strategies to provide flexibility to the grid. As most industrial facilities are located in under-resourced areas, decarbonizing these facilities can result in jobs being maintained while minimizing environmental impact. To help reduce GHG emissions in this sector, the CEC plans to target cold-storage facilities. Many cold-storage facilities are located in under-resourced communities and are associated with food processing and distribution or commercial/retail facilities. These facilities have the potential for increasing efficiency of their cooling systems while also providing demand response (DR) and grid flexibility. A 2015 Lawrence Berkeley National Laboratory (LBNL) study indicated that refrigeration warehouses are well-suited for DR because of their high-power demand, thermal mass of the stored products, and insensitivity to short-term power reductions. Research innovations in cold-storage facilities can help reduce

[10] https://freopp.org/the-high-cost-of-california-electricity-is-increasing-poverty-d7bc4021b705
[11] State of California Draft 2020-2024 Federal Consolidated Plan; California Department of Housing and Community Development. https://www.hcd.ca.gov/policy-research/plans-reports/docs/2020-2024_cp.pdf
[12] California Energy Consumption Database – Staff estimate from 2016 dataset.
[13] "Optionality, flexibility & innovation pathways for deep decarbonization in California". Energy Futures Initiative. 2019. https://energyfuturesinitiative.org/s/EFI_CA_Decarbonization_Full-b3at.pdf.

electricity bills in this economically vital sector and help California achieve its clean energy and decarbonization goals at the same time.

As stated in the 2019 Integrated Energy Policy Report (IEPR), eliminating emissions from the transportation sector is critical to the state's clean air goals.[14] Emissions from transportation and associated production and refining of fossil fuels account for more than half of California's GHG emissions.[15] Transportation contributes the majority of smog-forming emissions of nitrogen oxides (NOx) and is a significant contributor of other toxic air contaminants that negatively impact the health of all Californians.[16] In 2020, Governor Newsom accelerated work to reduce pollution from the transportation sector by setting a bold new target: "by 2035, all new cars and passenger trucks sold in California will be zero-emission vehicles."[17] EPIC focuses on transportation electrification that facilitates electric vehicle (EV) growth, while maintaining or improving grid stability. Also, advancing EV charging and vehicle-to-building/vehicle-to-grid technologies to realize the potential for millions of new EVs may allow for enhanced load flexibility for California's grid.

Resilience and Reliability

There are conflicting definitions of resilience and how it relates to, and differs from, reliability, as discussed in the CPUC Microgrid Proceedings and associated staff white papers.[18] Although some ambiguity and overlap remain, CEC staff used the following conceptual definitions for discussing EPIC interim research initiatives:

- *Resilience* investments advance technologies, knowledge, and strategies to plan for, manage through, and recover from *large-area* or *long-duration outages.*

[14] Final 2019 IEPR Chapter 3 "Advancing Zero-Emission Vehicles." https://efiling.energy.ca.gov/getdocument.aspx?tn=232922.
[15] California Air Resources Board (CARB) GHG Inventory 2020 Edition. https://ww2.arb.ca.gov/ghg-inventory-data.
[16] California Air Resources Board (CARB) 2020 Draft Mobile Source Strategy. https://ww2.arb.ca.gov/sites/default/files/2020-11/Draft_2020_Mobile_Source_Strategy.pdf.
[17] Executive Order (EO) N-79-20, https://www.gov.ca.gov/wp-content/uploads/2020/09/9.23.20-EO-N-79-20-text.pdf.
[18] (R.19-09-009) https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M344/K038/344038386.PDF.

- *Reliability* investments advance technologies, knowledge, and operational strategies that reduce the frequency or impact of *small-scale* or *short-duration disruptions* in electric service.

Some technologies supported by EPIC can contribute both to increased resilience and reliability. For example, continued advancements are needed for application and commercialization of microgrids that provide both reliability and resilience support to high-priority critical facilities and community emergency centers when protection at the local level is more appropriate and cost effective than larger grid upgrades.

Increasing the resilience and reliability of California's electric system and the critical services it provides customers remains a theme of EPIC research investments, the importance of which was reinforced by recent events. In August 2020, a historic heat wave in the Western United States challenged the ability of imported and in-state generation resources to meet net peak demand in California, contributing to the state's first rolling blackouts in more than a decade.[19] Through November 2020, wildfires burned more than 4.7 million acres across California—more than double the total area burned in 2018—and eleven of the top-20 largest wildfires have occurred in recent years.[20] Climate change is bringing more frequent and severe extreme heat waves, wildfires, and associated public power safety shutoffs (PSPS) that pose growing threats to resilient and reliable electricity in California.[21]

Research, development, and demonstration (RD&D) efforts focused on projecting future climate and anticipating catastrophic and large-scale events, such as wildfires and sea-level rise, strengthen California's electric system and customer resilience. For example, advancements in climate science and near- and long-term forecasting of wildfire-related risks to electric infrastructure will be critical for informing planning and hardening investments in changing

[19] Final Root Cause Analysis Report, January 12, 2021, http://www.caiso.com/Documents/Final-Root-Cause-Analysis-Mid-August-2020-Extreme-Heat-Wave.pdf
[20] CalFire. Stats and Events. https://www.fire.ca.gov/stats-events/. Accessed December 2, 2020.
[21] Bedsworth, Louise, Dan Cayan, Guido Franco, Leah Fisher, Sonya Ziaja. (California Governor's Office of Planning and Research, Scripps Institution of Oceanography, California Energy Commission, California Public Utilities Commission). 2018. Statewide Summary Report. California's Fourth Climate Change Assessment. Publication number: SUMCCCA4-2018-013. https://www.energy.ca.gov/sites/default/files/2019-11/Statewide_Reports-SUM-CCCA4-2018-013_Statewide_Summary_Report_ADA.pdf.

conditions. Technology advancements in distributed energy resources that can provide zero-emission back-up power to homes and public buildings during grid outages can support critical services and limit the damage caused by outages.

Similar advancements are required to develop technologies and strategies that increase electric system reliability at low cost while achieving SB 100 (Stats. 2018, Ch. 312) targets for 100-percent zero-carbon retail electricity sales. Preliminary modeling suggests California may require approximate 50 gigawatts (GW) of storage capacity by 2045 to provide the flexibility necessary to maintain reliability.[22] Increasing deployment and participation of flexible load in residential, commercial, and industrial sectors can be one of the lowest cost strategies for increasing reliability, although in the long-term new technologies will be needed. For example, offshore wind energy (OSW) development is a promising resource available for California that can support increased reliability due to its complementary generation profile. Similarly, innovations in green electrolytic hydrogen and other forms of long-duration energy storage capable of discharging electricity for 10 to 100 hours will be critical for maintaining reliability. Special attention is given in this plan to initiative investments in under-resourced communities that are particularly vulnerable to service disruptions.

Entrepreneurship

Clean energy innovation has emerged as an important economic sector in California. For example, California is home to 107 of the 318 energy-storage technology companies in the United States and attracts more than 51 percent of all venture capital in the United States for clean energy innovation. Because of the economic impacts of COVID-19, private-sector investors are expected to continue the significant reduction in new investments for even the most promising clean energy start-up companies. This will leave a funding shortfall that will likely put many of these companies out of business and slow further progress of clean energy innovation previously advanced by the state's significant investment.

In addition, the loss of these clean energy start-up companies could set California's clean energy policy goals back several years. Large energy corporations have mostly forgone in-house

[22] SB 100 Preliminary Results. https://efiling.energy.ca.gov/getdocument.aspx?tn=234549.

research and development (R&D) activities,[23] making the energy sector reliant on the start-up sector to introduce new technology solutions to the market. Instead of conducting their own R&D, large energy companies have found it more cost effective and opportunistic to strategically partner with or acquire start-up companies with new technology solutions than to develop their own. For example, Enel X and EDF Renewables, subsidiaries of two large global energy corporations, acquired EPIC-funded startups eMotorWerks and PowerFlex, respectively, to include new smart EV-charging products and services in their business offerings. Boeing HorizonX Ventures, the venture-investment arm of Boeing, led a strategic investment in EPIC-funded Cuberg, Inc., a Bay Area start-up company developing an advanced lithium-metal battery cell that greatly increases both energy density and safety compared to the best lithium-ion batteries currently used in EVs and energy-storage systems.

Without a prospering portfolio of clean energy start-up companies to partner with, large energy corporations would have to develop and scale up their own internal R&D activities as well as build up their internal capacity and expertise to deploy these new technology products. That timeline that can take several years or more and at a risk profile most large companies are not willing to accept or likely to pursue. As a result, California's energy sector would be unable to introduce new technology solutions needed to continue transforming the electricity sector to be more resilient, affordable, and emissions-free in the necessary timeline.

Equity

The CEC's overall approach to advancing equity in the development of the plan was to build on what we have learned through engagement to date through meetings, workshops,[24] past research projects, and input from project technical advisory committees, as well as input from recent equity-related reports. These include meetings with the EPIC Working Group of the Disadvantaged Communities Advisory Committee (DACAG);[25] Policy + Innovation

[23] International Energy Agency (IEA) (2020), Clean Energy Innovation, IEA, Paris. https://www.iea.org/reports/clean-energy-innovation.

[24] CEC held an Environmental Social Justice Roundtable with community leaders and advocates on Dec 10, 2019 and received input on EPIC, specifically on the Entrepreneurial Ecosystem.

[25] Staff met with the DACAG EPIC Working Group on December 7, 2020; presented draft initiatives and received feedback on the ones that were of highest interest and suggestions to improve relevance; and incorporated their input into the initiatives. See Appendix B for meeting summary.

Coordinating Group (PICG) [26] Equity Workstream meetings; and recommendations from sources such as the California Environmental Justice Alliance *Environmental Justice Agency Assessment* and the Greenlining Institute's *Making Racial Equity Real in Research*.

Several proposed initiatives are outgrowths of current projects and have been articulated as under-resourced community priorities such as sustainable/affordable housing and community resilience. These initiatives include dedicated funding (25 percent minimum up to 100 percent) to under-resourced communities. Also, solicitations developed from this plan could provide additional targets – such as particular geographical areas in California – or focus on one particular type of under-resourced community like tribal lands.

Other initiatives have statewide applicability but will require inclusion of benefits for under-resourced communities (e.g., the value of resilience initiative). To amplify the benefits of research projects intended to increase equitable access to new and emerging clean energy technologies, the CEC has heard several messages that inform our program implementation. Communities do not want to be an afterthought in projects and should be meaningfully engaged throughout project implementation. Often there is information overload and information provided is not always relevant to their interests so information should be curated and targeted. Priority should be given to cultivating relationships and partnerships that help communities to more actively participate in research projects. Finally, communities expressed a need for additional training on EPIC.

The CEC has implemented a four-pronged equity strategy:

1. Increase awareness of EPIC and the opportunities it provides under-resourced communities;
2. Encourage technology/project developers to seek out projects in under-resourced communities;
3. Scope many solicitations around specific issues facing ratepayers in under-resourced communities; and
4. Embed equity in clean energy entrepreneurship.

[26] Information on the PICG is posted on the CPUC website https://epicpartnership.org/.

One mechanism that will empower active community-based organization[27] (CBO) engagement is the inclusion of scoring criteria[28] in TD&D solicitations that require the project team to have active, substantive input and partnerships with CBOs. Projects need to do more than simply be located in an under-resourced area. Applications must consider the localized health impacts and project benefits. Importantly, solicitations require inclusion of CBOs as paid project partners who expand community engagement through traditional and digital methods.

The CEC is planning to escalate equity engagement for the full EPIC 4 Investment Plan. We welcome input on how to best reach and incorporate input from interested communities and organizations. As an initial launch, we have an energy equity outreach proposal that is still under development. Before finalizing the proposal, part of our development process is to engage the DACAG EPIC Working Group to gather input before finalizing a formal outreach plan. Outreach will include Empower Innovation Events[29] proposed as using a networking "getting-to-know-you" session format with a moderator facilitating small-group discussions and opportunities to meet virtually one-on-one. The goal is to enable communities to communicate their clean technology priorities, connect with technology developers as potential project partners, and profile host sites within their communities for clean energy technology projects. The outcome will be a directory of community-desired research projects that can feed into the Empower Innovation Platform[30] to facilitate project match-making and accelerate funding for some of these projects.

Proposed Research Initiatives

This section describes the nine proposed research initiatives in this interim investment plan. Table 2 below provides an overview of research initiative topics and the themes addressed by

[27] A CBO is a public or private non-profit organization of demonstrated effectiveness that: a) has an office in the region (e.g., air basin or county) and meets the demographic profile of the communities they serve; b) has deployed projects and/or outreach efforts within the region of the proposed disadvantaged or low-income community; c) has an official mission and vision statements that expressly identifies serving disadvantaged and/or low-income communities; d) currently employs staff member(s) who specialized in and are dedicated to – diversity, or equity, or inclusion, or is a 501(c)(3) non-profit.
[28] See Table 3 in the Administration Section.
[29] For a recent example, visit https://www.energy.ca.gov/event/webinar/2021-01/developing-sustainable-affordable-housing-californias-communities.
[30] https://www.empowerinnovation.net/

each. Subsequent sections are dedicated to describing the background and details of each initiative.

Table 2: Proposed Research Initiatives and Themes*

Research Initiative	Decarbonization	Resilience and Reliability	Entrepreneurship
1. Advanced Prefabricated Zero-Carbon Homes	X	X	
2. Energy Efficiency and Demand Response in Industrial and Commercial Cold Storage	X	X	
3. Energy Efficiency and Load Shifting in Indoor Farms	X	X	
4. Optimizing Long-Duration Energy Storage to Improve Grid Resiliency and Reliability in Under-resourced Communities	X	X	
5. The Role of Green Hydrogen in a Decarbonized California—A Roadmap and Strategic Plan	X	X	
6. Valuation of Investments in Electricity Sector Resilience		X	
7. Vehicle-to-Building for Resilient Back-up Power	X	X	
8. Offshore Wind Energy Technologies	X	X	
9. Entrepreneurial Ecosystem	X	X	X

Source: CEC Staff

* Equity is a cross-cutting theme for the plan and discussed under each initiative. Research conducted under the Entrepreneurial Ecosystem addresses the other themes as well.

1. Advanced Prefabricated Zero-Carbon Homes

Description

This initiative aims to develop zero-carbon or near-zero-carbon (collectively "ZC"), cost-effective, modular and manufactured homes (collectively "prefabricated homes") that can be readily deployed, particularly in under-resourced communities (e.g., disadvantaged communities, low-income communities, and Native American tribes). Requirements would be identified to determine the most advanced and cost-effective ZC prefabricated homes. Potential requirements include: 1) meet or exceed California's 2022 Title 24 Building Energy Efficiency Standards;[31] 2) be all-electric; 3) be fire-resistant; 4) use on-site, or near-site solar PV; 5) have on-site or near-site stationary energy storage; 6) provide back-up power to critical loads during grid outages; and 7) have a price point below the median construction price point per square foot for comparable buildings in the county where the homes are to be located.

Selected prefabricated home builders would design and construct prefabricated ZC residential units. Eligible building categories include single-family units, accessory dwelling units, and migrant or agricultural worker housing. The built homes will be sited in under-resourced communities. Fire-prone communities are eligible to participate.

Anticipated Impact

Projects under this initiative could develop a model for other prefabricated home builders for homes that are ZC, fire-resilient, and energy-resilient at a price point that would be affordable to low-income residents in the community. The research results could inform the CPUC's Building Decarbonization Proceeding (R.19-01-011) by creating a new building decarbonization solution. Additionally, the results could assist the Wildfire and Natural

[31] Manufactured homes must meet the U.S. Housing Urban Development efficiency standards, which are less efficient than California's Building Energy Efficiency Standards. This initiative will require that manufactured homes meet or exceed California's standards. Modular homes are required to meet California's Building Energy Efficiency Standards. This initiative will require that these homes exceed the minimum California standards.

Disaster Resiliency Rebuild Program by offering a template for all-electric, energy-resilient, and fire-resilient homes.

The initiative would have persistent benefits. Recommendations resulting from the research would be pursued through appropriate codes and standards organizations and through voluntary participation by builders to adopt methods of construction that produce more efficient, high-performance, and cost-effective buildings. These improved methods could serve as targets for utility incentive programs to further encourage diffusion into the manufactured building industry or other programs/organizations such as the California Advanced Homes Program, California's Building Energy Efficiency Standards, and other standard-setting organizations. Additionally, to inform communities of the benefits and costs of ZC-home ownership, project recipients will sponsor workshops/webinars to highlight project results.

The electricity grid would benefit from the enhanced potential for these homes to shift load to off-peak periods; reduce net load due to efficient design, on-site solar PV, and energy storage; and provide ancillary services. If the research is successful, the end result would be ZC homes with renewable energy and energy storage that are affordable from an ownership and operation perspective, can provide resilience in the event of a power outage, and achieve low energy costs and higher comfort for residents compared to standard construction.

Primary Users and Beneficiaries

Residential building developers and designers, prefabricated home industry, residents in fire-prone communities, under-resourced communities, electric and natural gas ratepayers, utilities, and state and local governments

Metrics and Performance Indicators

- Number of prefabricated home builders that adopt methods of construction that produce more cost-effective, high-performance, and energy-resilient ZC homes
- Number of ZC prefabricated home models available in the California market as well as other states[32]

[32] California has 17 prefabricated manufacturing plants in California. Some of these plants ship homes outside of California.

• Number of high-performance prefabricated homes that are below the median construction price point per square foot for comparable buildings in the county where the homes placed in under-resourced communities are to be located • Number of ZC prefabricated home models available in California that include fire-resilient design features	
Value Chain[33] Demand-side management Generation	**Program Area(s)** Technology demonstration & deployment

Background

This initiative focuses on prefabricated homes, which are homes built in a factory setting, including manufactured and modular homes. The aim is to increase the efficiency, affordability, and resiliency of these homes by efficient design and technologies; and adding on-site, or near-site solar PV and storage. The focus is to demonstrate projects located in under-resourced communities. Potential home elements include the following:

- Decarbonization: Inclusion of advancements in energy-efficient, all-electric construction, including use of high-efficiency, low global-warming potential (low-GWP) refrigerant heat pumps; and building envelopes, including air tightness, that meet or exceed current building energy efficiency codes and minimize GHG emissions.
- Fire Resiliency: The need for fire-resilient homes is growing as intense and longer wildfire seasons become the norm in California. This research considers new construction practices, techniques, and materials that can be implemented in buildings located in fire-prone communities to withstand massive, wind-driven flames and embers—including ignition-resistant roofs and exteriors, tempered windows, unvented attics and soffits, and back-draft dampers.

[33] Per the CPUC's 2/10/2012 EPIC Staff Proposal "In general, staff suggests the activities should be able to be mapped to the different elements of the electricity system "value chain" which we characterize as consisting of: Grid Operations/Market Design, Generation, Transmission, Distribution, Demand Side Management. … this mapping ensures that there is a clear relationship between the activities funded by EPIC and the electricity ratepayers who are ultimately paying for this program." (https://docs.cpuc.ca.gov/EFILE/rulc/159429.pdf)

- Energy Resiliency: PSPS can leave communities and essential facilities without power, which poses risks to vulnerable communities and individuals. Integrating solar and energy-storage technologies with prefabricated home units would provide back-up power during grid outages.
- Affordability: "Affordable housing cost" for lower-income households is defined in state law as not more than 30 percent of gross household income with variations (Health and Safety Code Section 50052.5). Less than a third of Californians can afford a median-priced home.[34] This research initiative challenges prefabricated home manufacturers to build homes that are affordable to own and operate for those living in under-resourced communities.
- Reliability: Uncontrolled electric space conditioning and water heating contribute to peak demand. Incorporating load-flexibility controls and advanced envelope design features into prefabricated homes will allow for daily load shifting from peak to off-peak periods and allow homes to be pre-cooled during extreme heat events.

The two types of prefabricated homes this research initiative focuses on include manufactured homes and modular homes.

- **Manufactured homes**: These homes are built on steel chassis and transported to the site. The destination of these homes are mobile home parks and private lots. These homes are built quickly and more affordably in a factory setting compared to standard construction. However, these manufactured homes only need to meet the U.S. Housing Urban Development's efficiency standards, which are less energy efficient than the California 2019 Title 24 Building Efficiency Standards.[35] As a result, ratepayers in this sector, who are often in under-resourced communities, pay twice as much in energy costs (per square foot) than those who live in homes that are built to Title 24 Standards.[36]

[34] https://www.car.org/marketdata/data/haitraditional.
[35] EIA 2008. Residential Energy Consumption Survey. http://www.eia.doe.gov/emeu/recs/contents.html. Washington, D.C. US Department of Energy.
[36] EIA 2008. Residential Energy Consumption Survey. http://www.eia.doe.gov/emeu/recs/contents.html. Washington, D.C. U.S. Department of Energy.

- **Modular homes**: These homes are created in sections and then transported to the home site for construction and installation. These are typically installed and treated like a standard house for financing, appraisal, and construction purposes. Although the sections of the house are prefabricated, the sections or modules, are put together at the construction site. These homes are required to meet California's Title 24 Building Efficiency Standards. Modular construction enables home customization to include standardized energy-efficiency measures; therefore, it can serve as a path to increased ZC-home penetration. Modular construction can be used to create a tight building envelope, well-insulated and air-sealed, to downsize the heating, ventilation, and air-conditioning (HVAC) systems and reduce overall building energy consumption and construction costs compared to standard construction. An affordable ZC home can potentially be achieved if this is combined with high-efficiency appliances and renewable generation.

Research Themes and Policy Priorities Addressed

This initiative falls under the themes of **decarbonization** and **resilience and reliability**. Key policy priorities that may be addressed by the proposed research are discussed below.

Building Decarbonization. Current 2019 Title 24 Standards do not achieve the ZC statewide goal set by Executive Orders B-55-18 and B-30-10.[37] This initiative aspires to assist in reaching this goal by developing affordable ZC home designs and buildings that can concurrently fulfill the CEC's Residential New Construction Zero Net Energy Action Plan and low-income and disadvantaged community resource requirements.[38] In January 2019, the CPUC instituted a new rulemaking on building decarbonization (R.19-01-011). The proposed scope of the rulemaking includes: 1) implementing SB 1477; 2) launching potential pilot programs to address new construction in areas damaged by wildfires; 3) coordinating CPUC policies with California's

[37] Executive Order (EO) B-55-18 (Establishing a new statewide goal to achieve carbon neutrality as soon as possible, no later than 2045, and achieve and maintain negative emissions thereafter); EO B-30-15 (Establishing a new interim statewide GHG emission reduction target to reduce emissions to 40 percent below 1990 levels by 2030, to ensure California meets its target of reducing emissions to 80 percent below 1990 levels by 2050).

[38] Residential New Construction Zero Net Energy Action Plan (It supports the California Energy Efficiency Strategic Plan's goal to have 100 percent of new homes achieve zero net energy beginning in 2020 and provides a foundation for the development of a self-sustaining zero net energy market for new homes.). California Energy Efficiency Strategic Plan, 2008, adopted by the CPUC in its decision D. 08-09-040 and the 2011 update, adopted in D. 10-09-047. https://www.cpuc.ca.gov/general.aspx?id=4125.

Building Energy Efficiency Standards and Title 20 Appliance Efficiency Standards developed at the CEC; and 4) establishing a building decarbonization policy framework. This initiative would help inform this rulemaking through building and demonstrating ZC homes that are all-electric, energy-efficient and resilient, and that can be installed in areas damaged by wildfires.

GHG emissions from buildings represent a significant portion (25 percent) of statewide emissions.[39] By reducing the amount of energy needed in buildings through energy-efficient design, replacing on-site combustion appliances with high-efficiency heat pumps, and reducing the carbon content of energy resources (e.g., solar PV), this research initiative aspires to achieve the following:

- Reduce GHG emissions;
- Improve both indoor and outdoor air quality; and
- Reduce health risks from buildings.

Resilience and Reliability. These homes would include solar PV, storage, and potentially DR controls to provide energy resilience. The solar PV and energy-storage system will be designed to provide power to essential building loads in the event of a power outage. DR controls can also be used to provide regular reliability support under normal grid conditions and to reduce electrical loads during periods when the grid is stressed, thus increasing grid reliability.

Previous Research

This initiative builds on previous research as discussed below.

- In 2017, the CEC completed a research project focused on pilot-testing advanced envelope designs for the manufactured housing industry and how to provide high-performance, cost-effective alternative envelope designs to factory homebuilders.[40] This project demonstrated advanced building envelope technologies are cost-effective, commercially-viable, and offer new manufactured home buyers a compelling value proposition: to pay a little more upfront but enjoy lower monthly energy bills and other benefits. The focus was

[39] https://ww2.arb.ca.gov/our-work/programs/building-decarbonization.
[40] Agreement number PIR-12-028: Advanced Envelope Systems for Factory Built Homes.

manufactured homes, and the advanced envelope designs were offered as an option to potential homebuyers by participating manufactured housing industry representatives.[41]

- Following the results from the 2017 study, in 2020, the CEC awarded two EPIC grants focused on advanced building envelopes for all-electric manufactured homes. The CEC received more applications and passing proposals than available resources could fund. This research initiative would build on this solicitation by including other energy-efficiency advancements along with solar PV and energy storage to contribute to fire resilience, energy resilience, and affordability, and would include prefabricated modular homes. Like the 2020 solicitation, continuing elements would include fire resiliency, building envelope energy efficiency, and GHG reductions.[42]
- The CEC's Bringing Rapid Innovation Development to Green Energy (BRIDGE) and California Sustainable Energy Entrepreneur Development (CalSEED) programs discussed near the end of this Research Initiatives Section could provide advanced technologies that can be incorporated into manufactured homes. These technologies can be evaluated; and if ready for larger-scale deployment, the technologies can be included in the home design. Example technologies could include advanced heat pumps and windows with PV.
- The U.S. Department of Energy (DOE) has targeted research toward highly efficient and productive construction practices for new buildings and retrofits. This includes development of new building materials, new methods of fabrication (such as use of 3D printing), robotics, and digitization and off-site manufacturing. The construction practices include those for standard and modular construction and manufactured housing. The projects focus on manufactured housing and evaluating the cost-effectiveness of various technologies through improved techniques. For instance, DOE's Building Technologies Office's 2019 Advanced Building Construction Initiative invested $33.5 million in new technologies that included innovations in construction technology, improving quality and affordability, increasing competitiveness among buildings, and developing a skilled

[41] Advanced Envelope Systems for Factory Built Homes, Publication Number CEC-500-2019-007, California Energy Commission Publication Database.
[42] EPC-19-035: Advancing Energy Efficiency in Manufactured Homes Through High Performance Envelope; and EPC-19-043: Advanced Energy-efficient and Fire-resistive Envelope Systems Utilizing Vacuum Insulation for Manufactured Homes.

building and retrofit workforce. The goals are high building performance, quick deployment with minimal on-site construction time, and buildings that are affordable and appealing to owners, investors, and occupants. The focus of many of these projects was to achieve deep energy savings and greater lifecycle affordability and included manufactured homes, such as modular and mobile homes. The CEC would leverage DOE's research and focus on innovative construction technologies.

Key Technical and Market Challenges

Market Penetration Challenges. The most common prefabricated homes in California are manufactured homes. To date, highly efficient and zero-net-carbon manufactured homes have failed to gain market traction due in part to the need to minimize upfront capital costs to homeowners. As most manufactured home purchasers have limited incomes, any increase in home cost could limit their ability to secure financing.[43] Most construction companies and factory homebuilders are not incentivized to develop manufactured homes with energy-efficient designs that meet or exceed state or federal requirements or provide on-site energy generation. Energy-efficient features are typically treated as options. With increased investment in these homes, economies of scale may be achieved, lowering the cost and perceived risk to stakeholders.

Developing Business and Technical Case for Zero-Net-Carbon or Low-Carbon Manufactured Homes. The typical ownership and tenant relationship in mobile home parks presents difficult design issues to achieving ZC mobile homes. Generally, manufactured homes are owned by their occupants, who lease (pay rent on) land that is owned by another entity where their homes are located. These homes generally cannot accommodate rooftop solar PV due to their size, weight, and structural requirements. Innovation in manufactured home or mobile home park design is needed to incorporate solar PV and energy storage and address existing electrical infrastructure. There is a need for scalable and replicable business and technical cases addressing the challenges facing many manufactured home occupants and mobile home park owners. Once performance is validated, these solutions can be available as options to purchasers of manufactured homes and

[43] Agreement number PIR-12-028: Advanced Envelope Systems for Factory Built Homes.

mobile home park developers, if permitted by the Department of Housing and Community Development.

Equity Considerations

To ensure equity in the EPIC Program's investments, this initiative will occur exclusively in under-resourced communities, including an option for fire-prone areas. Highly efficient prefabricated homes can result in more comfortable and energy-efficient single-family homes that are also more cost-effective to own and operate and faster to build.

2. Energy Efficiency and Demand Response in Industrial, Agricultural, and Commercial Cold Storage

Description

This funding initiative aims to develop and deploy innovative energy-efficiency technologies for cost-effective decarbonization and DR participation of cold-storage facilities. The advancements would increase DR participation, while allowing food industries, agricultural businesses, and emerging online grocers opportunities to utilize more cost-effective and reliable cold storage. Example technologies and strategies include:

- Advanced refrigeration systems
- Artificial intelligence-based software and controls
- Advanced coatings to reduce defrost cycle times
- Use of low-GWP refrigerants
- Innovative moisture control methods to reduce cooling load (such as desiccant dryers, evaporators, or other energy-efficient means)
- Thermal energy storage and controls to enable grid flexibility and participation in DR programs
- Deployment of smart control systems and software to optimize system performance to increase energy efficiency, reduce operation and maintenance costs, reduce GHG emissions, and identify system refrigerant leaks and other equipment performance issues that impact equipment lifespan

- Cost-effective retrofits of existing, old facilities

Thermal storage technologies can act as a capacitor for maintaining the temperature of large, refrigerated spaces for long periods. With the recent advancements in phase-changing materials and controllers, cold-storage facilities can potentially increase their thermal storage and further enhance their ability to participate in shifting and fine-tuning their cooling loads. Advanced surface coatings have the capability to increase the life of condensers by keeping moisture off the fins and preventing ice buildup. Ice buildup increases the system run time as well as the energy required to run defrost cycles. System performance may also be improved by adding dryers to air intakes, which decrease the air's humidity through chemical processes; thus, this enhancement can further reduce the cooling load and increase the life of components in moist environments. There will be funding set-aside for projects located in under-resourced communities.

Anticipated Impact

Assuming an annual electricity use of 1 terawatt-hour (TWh), or an average continuous load of 114 megawatts (MW), projects in refrigerated warehouses are expected to increase efficiency by at least 10 percent. With a 30-percent market penetration, it is estimated that cold-storage facilities would save 30 gigawatt-hours (GWh) annually.[44] For DR projects, with an estimated 20-percent peak-load shift, there is potential to shift over 20 MW.[45]

[44] Estimated adoption rate

[45] Estimated 20 percent load shift potential:
Firestone, Ryan, Refrigerated Warehouse Demand Response, Regional Technical Forum, June 2019, https://nwcouncil.app.box.com/v/20190618FridgeWarehouseDRPres BNL and the Electric Power Research Institute Lawrence Berkeley National Laboratory, Demand Response Strategy Guide, November 2015, https://eta-publications.lbl.gov/sites/default/files/refrigerated_warehouse_demand_reponse.pdf and EPRI proposal in response to GFO-16-305 for proposal entitled Develop and Pilot Test Flexible Demand Response Control Strategies for Water Pumping and Industrial Refrigeration Plants (EPC-16-026)

Primary Users and Beneficiaries

This research on cold storage would provide the food, beverage, and other industries and customer-facing commercial cold-storage facilities (such as grocery stores) with the potential to improve energy efficiency, reduce GHG, and provide grid flexibility.

Metrics and Performance Indicators

- Electrical energy savings (percent)
- Avoided/reduced maintenance costs ($)
- Increased system efficiency (Coefficient of Performance)
- Load-shift potential (kilowatt [kW]/time)
- Increases in cooling capacity (British thermal units)
- Savings for the delivered end product ($)
- GHG savings (metric tons of carbon dioxide equivalent)
- Decrease in defrost intervals (time)

Value Chain	Program Area(s)
Demand-side management	Technology demonstration & deployment

Background

On an annual basis, California's industrial sector consumes over 25 percent of the state's electricity and 35 percent of its natural gas; and is responsible for more than 20 percent of the state's GHG emissions.[46,47] This sector is vital to California's economy, accounting for 10 percent of its GDP[48] in 2019, and it depends on affordable, reliable, and sustainable energy supplies.

Decarbonization of industrial systems and services can create several benefits for Californians, including improved air quality, reduced GHG emissions, and significant cost savings. Decarbonization is often performed through the substitution of natural gas with electricity as well as increasing the energy efficiency of production processes to reduce electricity or natural gas use. Furthermore, the widespread adoption of energy management system software can help

[46] California Energy Consumption Database – Staff estimate from 2016 dataset.
[47] "Optionality, flexibility & innovation pathways for deep decarbonization in California". Energy Futures Initiative. 2019. https://energyfuturesinitiative.org/s/EFI_CA_Decarbonization_Full-b3at.pdf.
[48] Bureau of Economic Analysis – U.S. Department of Commerce 2019 Third Quarter Dataset.

ensure that equipment is operated efficiently to reduce GHG emissions without sacrificing equipment performance or product quality.

Refrigeration accounts for an estimated one-third of the total energy usage for food-processing facilities, while additional energy is used for intermediate cold storage at warehouses and at commercial retail locations. The CEC estimates that refrigerated warehouses and grocers used more than 5 TWh of electricity for refrigeration annually, with refrigerated warehouses accounting for 1 TWh of the total.[49] The state currently has nearly 400 million cubic feet of cold-storage space and demand for additional cold-storage facilities is increasing due to online grocery sales.[50] Grocers are investing more heavily in their supply chains and e-commerce capabilities to reduce transit and delivery times. That is fueling the development of more cold-storage facilities, especially in densely populated areas where more people are demanding faster deliveries of fresh food. Jones Lang LaSalle IP, Inc. said the average U.S. cold-storage warehouse is more than 40 years old. Companies who rent cold-storage space prefer newer buildings with more energy-efficient cooling systems and higher ceilings that can pack bigger volumes,[51] reducing operational costs. Newer cooling systems have the capability to keep product temperatures between a smaller temperature range, increasing shelf life and thus profits.

Hydrofluorocarbons (HFCs) can be up to 1,430 times more damaging to the environment than carbon dioxide (CO_2) and can remain in the atmosphere for 15 years or more. In the U.S., there has been a 269-percent increase in HFCs since 1990. Commercial and industrial refrigeration applications including air conditioning are responsible for 48 percent of HFC emissions in California.[52] Shifting commercial refrigeration equipment to high energy efficiency and low-GWP refrigerants will achieve maximum GHG reductions.[53]

---

[49] California Energy Commission demand forecast intermediate data, 2013
[50] Borland, K.M. California is the Top Market for Cold Storage, June 2019, https://www.globest.com/2019/06/17/california-is-the-top-market-for-cold-storage/?slreturn=20201003214341
[51] Fung, Ester, "The Hot New Real-Estate Investment is in Keeping Food Chilled", Wall Street Journal, October 6, 2020.
[52] California Air Resources Board, "Appendix C: California SLCP Emissions", November 2016, https://ww2.arb.ca.gov/sites/default/files/2020-07/SLCP_Appendix_C.pdf.
[53] Lawrence Berkeley National Laboratory, Benefits of Energy Efficient and Low Global Warming Potential Refrigerant Cooling Equipment, August 2019, https://eta-publications.lbl.gov/sites/default/files/lbnl-2001229_final_0.pdf

Today, distributed demand-side resources play a growing role in distribution and transmission grid management. DR can help smooth a renewables-heavy grid by shifting load away from the high-ramp periods, raising the belly of the "duck curve"[54] to limit renewable curtailment, and balancing variable generation with the help of smart communicating technologies both behind the meter and on the grid. With round-the-clock operations of energy-intensive processes, the industrial and commercial refrigeration sectors can further help California decarbonize by incorporating DR into processes and facilities capable of providing flexibility.

The DR potential for cold-storage facilities has been documented by LBNL and the Regional Technical Forum for the Pacific Northwest.[55] In their 2015 study, LBNL estimated that the statewide DR potential for the refrigerated warehouse sector to be over 22.1 MW.[56] They found that refrigeration warehouses are well-suited to shift or shed electrical loads in response to utility financial incentives and were selected as one of the foci of LBNL's energy efficiency and DR research because:

- They have significant power demand, especially during utility peak periods.
- Refrigeration loads account for a significant portion of the facilities' total energy usage.
- Most refrigeration loads are not sensitive to short-term (two to four hours) power reductions, so DR activities are often not disruptive to facility operations.
- The thermal mass of the stored product in the insulated spaces can often tolerate reduced cooling capacity for a few hours when needed.
- Past experience with some DR strategies that were successful in commercial buildings may apply to refrigerated warehouses.[57]

Additionally, load shifting can turn cold-storage facilities into a "virtual battery of coldness" with the potential to reduce load when the grid is stressed. These facilities can pre-cool in advance of a potential grid-stress event, and not draw any electricity from the grid while

[54] http://www.caiso.com/Documents/Flexibleresourceshelprenewables_FastFacts.pdf
[55] Firestone, Ryan, Refrigerated Warehouse Demand Response, Regional Technical Forum, June 2019, https://nwcouncil.app.box.com/v/20190618FridgeWarehouseDRPres
[56] Lawrence Berkeley National Laboratory, Demand Response Strategy Guide, November 2015, https://eta-publications.lbl.gov/sites/default/files/refrigerated_warehouse_demand_reponse.pdf
[57] Aghajanzadeh, Arian, "2006-2015 Research Summary of Demand Response Potential in California Industry, Agriculture, and Water Sectors", CEC, 2015.

maintaining safe temperatures for food for 6-8 hours, until the event has passed. As an example, one large cold-storage facility was able to reduce its grid electric load by 2-3 MW.[58] The ability to drop load could result in these facilities being counted on to meet future grid emergencies.

Research Themes and Policy Priorities Addressed

Energy efficiency, advanced controls, and energy management systems in the industrial and commercial refrigeration sectors would help those sectors with **decarbonization** by reducing electricity consumption and increasing use of low-GWP refrigerants. DR in refrigeration addresses **resilience and reliability** by aiding grid reliability and stability. Also, DR helps California transition from fossil fuels to intermittent renewables as the state decarbonizes.

Previous Research

Several past and current EPIC R&D efforts have focused on advanced technologies to increase efficiency in the refrigeration sector. Projects range from demonstrating systems that utilize low-charge ammonia, reduce potential leakage of refrigerants, and increase efficiencies, such as developing an advanced booster ejector system, which recovers waste heat and enhances overall heat pump efficiencies. For DR, EPIC has funded systems capable of shifting their electrical load by a minimum of 20 percent and anticipated to achieve up 30 percent. The control strategies enabled by projects such as these have also increased system operability and allowed plant managers an easier way to manage and control their equipment.

In recent years, EPIC R&D has focused on improving the efficiency of industrial energy-related systems, such as compressed-air systems, by demonstrating software programs that benchmark and compare existing operations with industry standards and then identify opportunities for reducing energy use. Project results for cloud-based energy management of compressed-air systems for 102 demonstration sites showed total energy savings of 20,406,000 kWh/year and 5,775 tons/year in avoided GHG emissions. Forty percent of the sites were in the food and beverage manufacturing industry; however, no refrigerated warehousing and storage sites participated. More research is needed to understand energy savings and benefits across more

[58] AT&T 10x Case Study, Energy Efficient Frozen Food, https://www.itcanwait.com/ecms/dam/csr/2019/reducing-emissions/Lineage%2010X%20Case%20Study.pdf

diverse industries and to develop data sets to generate industry baselines for cold-storage industries.

Key Technical and Market Challenges

Despite the advancements described above, the adoption of previously funded general research and small-scale demonstrations remains an obstacle for several reasons. Before adopting an energy-efficient improvement, a facility must be convinced the improvement will maintain or improve product quality. California's food and beverage manufacturers have historically operated on small profit margins; equipment capital costs are high and need high levels of justification; and installation must not significantly disrupt manufacturing or jeopardize profit margins. As a result, to facilitate adoption, dissemination of successful research results will be key to showcase the technology's technical and economic performance, benefits, and any impacts on product quality.

In more recent years, online food retailers are growing at a massive rate and are transitioning to warehouse storage for quicker, more economical solutions to delivering food. The influx of new businesses will create new challenges for the refrigeration sectors, requiring innovative solutions to match the demand and maintain current systems while meeting California's electric grid challenges and climate and decarbonization goals.

Major equipment replacements are costly and disruptive. The industrial and agricultural sectors are very much attuned to economics and cost. Equipment replacements typically happen infrequently, and any downtime results in production decreases and revenue losses. Returns on investments must be below three years to justify high equipment costs and require strong examples of technology fully implemented in a similar application to minimize risk.

The industrial and agricultural sectors are risk averse. Demonstrations are needed to show that energy savings and benefits are achievable and sustainable while maintaining or improving product quality.

Equity Considerations

One of the target areas of this initiative would focus on projects in under-resourced communities, where many cold-storage facilities are located. Energy use of these facilities is quite high per square foot. Creating additional positive cash flow through energy efficiency and DR

opportunities helps these businesses maintain a positive cash flow and ability to pay its workforce. There is an economic benefit to keeping businesses viable in under-resourced communities. It is important to retain jobs and avoid job cuts due to cost-cutting measures to control higher energy costs. Additionally, job training and hiring from under-resourced communities for the retrofit work would be encouraged. Thus, this initiative has the potential to reduce operation and maintenance costs, which will help cold-storage facilities remain competitive, keep jobs in California, help the bottom line, and provide opportunities for job training and hiring.

3. Energy Efficiency and Load Shifting in Indoor Farms

Description

The purpose of this initiative is to demonstrate advancements in energy efficiency and load shifting in indoor farms. Indoor farms include conversion of existing buildings into indoor farms and retrofits of existing greenhouses that can achieve the following:

- Improve electrical efficiency, reduce water use, and increase yield;
- Reduce GHG emissions;
- Develop potential to shift load of operations;
- Expand potential for growing high-value crops (such as berries and other fruits, mushrooms, herbs, leafy greens, etc.) in an urban setting; or
- Expand potential for growing food closer to the point of processing or consumption to further reduce energy usage associated with transport.

This initiative focuses on demonstrating pre-commercial technologies, hardware systems, control systems, and operational procedures of a digitized indoor farm that would increase energy efficiency and develop the potential to shift load. Potential pre-commercial technologies or strategies may include (but are not limited to) the following:

- Optimized layout, type, and operation of farm to reduce energy use per unit of product
- Data acquisition and energy management system
- Combination of natural and advanced artificial lighting, high-efficiency HVAC, and dehumidification systems and controls to reduce overall electrical energy use

- Hardware and software to enable DR and load flexibility
- Modular farm concepts that could be easily deployed with a limited urban footprint to reduce energy use and GHG emissions associated with crop production and transportation of the crops to the end user

There will be funding set aside for projects located in under-resourced communities.

Anticipated Impact

Intensive vertical farms can consume 8,700 to 70,000 megawatt-hours per year (MWh/year) of electricity, while a shipping-container farm might consume 45 MWh/year. The energy load varies depending on the size and type of indoor farm but is estimated between 500 kW and 15 MW.[59] Projects are expected to increase efficiency by at least 10 percent, providing savings up to 700 MWh/year for large facilities, and provide DR capability to shift daily electrical load by at least 20 percent.

Primary Users and Beneficiaries

Energy-efficiency projects would help the indoor farm's bottom line and provide farmers with the potential to improve energy efficiency, reduce GHG, and provide grid flexibility. Customers in under-resourced communities could benefit from wider availability of fresh produce.

Metrics and/or Performance Indicators:

- Electrical energy usage and savings (kWh/square feet)
- Water usage and savings (gallons [gal] water/square feet)
- Product yield per area (lbs/square feet)
- Product yield per energy use (lbs/kWh)
- Product yield per water use (lbs/gal)
- DR or load-shift capabilities of facility (kW shifted)
- Net cost of product produced ($/lbs)

Value Chain	Program Area(s)
Demand-side management	Technology demonstration & deployment

[59] Golden, Sarah, Microgrids-indoor agriculture go together like peas and carrots, https://www.greenbiz.com/article/microgrids-indoor-agriculture-go-together-peas-and-carrots

Background

California is home to a vibrant and diverse agricultural sector where the value of the 2019 crop year was over $50 billion, making it the top agricultural producing state in the United States. To produce California's vegetable, fruit, and nut crops, over 11 TWh is used annually for irrigation. Indoor farming has potential to reduce water use by over 70 percent, providing a potential for substantial electricity reduction for water pumping, although this reduction is partially offset by the energy requirements for lighting and environmental control.

Indoor farms currently represent a small segment of the agricultural market, but it is growing market, especially in urban areas where food production closer to consumers is desired. Allied Market Research projects that the global market for vertical indoor farms will grow nearly 25 percent annually between 2019 and 2026 based on 2018 data.[60]

Indoor farms producing high-value crops typically are heated, cooled, and lighted 24 hours a day, seven days a week. Through the optimization of indoor-farm operations, development and deployment of advanced, energy-efficient technologies, and optimization of crop yield versus energy usage, there is opportunity for electricity savings, especially in the areas of lighting technologies, space conditioning, and smart controls. Though recent advances in LED lighting reduced indoor farming's energy use by about 80 percent, there is still potential for further reductions. Much of the energy is used during times when renewable energy is unavailable, such as at night and during the evening ramp. In an indoor farm, satisfactory plant growth is not dependent upon lights coming on at a specific time of day or night, and this provides an opportunity for shifting electric load to times when renewable energy is available. However, load shifting for indoor farming requires understanding impacts of underwatering, reduced lighting, and changes in climate control on plant health and potential yields throughout the lifecycle. Changes to when "night" comes do not adversely affect plants; thus, operators have the opportunity to respond to utility price signals.

---

[60] Electric Power Research Institute, Can Indoor Agriculture Help Feed a Growing World? February 2021, https://publicdownload.epri.com/PublicAttachmentDownload.svc/AttachmentId=70746?utm_campaign=Efficient%20Electrification&utm_medium=email&_hsmi=109174283&_hsenc=p2ANqtz-_f7CMfUqGBeWlnAdTKtITGQ7ijnLNMdTkhsoMgKjnLSasxi4xIaBficGEEqFdDpbzfvtRiIjRcNxrxSoboK_Qkf9jugZKhZIuQj8ohUImBj0a8TX0&utm_content=109174283&utm_source=hs_email#page=9

Indoor farming has the potential to reduce transportation and energy use associated with distribution if indoor farms are located near the point of processing or consumption. Currently, in the United States, most of the fresh produce is shipped extensive distances (in some cases between 1,500 and 2,500 miles) from the field to the consumer. Billions of dollars are spent annually delivering and distributing crops from where they are grown to where they are sold, consumed, or processed. Studies have shown that long-distance transport can result in fresh vegetables and fruits losing a portion of their nutrition and freshness. Unless preservatives are used, long-distance shipment reduces the shelf life of the produce once it reaches the warehouse or store. Reduced shelf life leads to additional spoilage and waste. It was reported in 2008 that approximately $47 billion worth of food in the U.S. (which includes meat, dairy, produce, and other products) did not make it into consumers' shopping carts due to waste.[61]

Despite the benefits of indoor farms, their energy consumption is high. The growth in indoor farms could result in new industrial-scale loads that are large enough to impact grid operations and planning since these farms require much electricity to power their systems.[62] The main users of electricity are lighting (65 percent), air conditioning (20 percent), and dehumidifiers (10 percent), and these account for 95 percent of electricity usage.[63] The energy load varies greatly depending on the size and type of operations, but it could be between 500 kW and 15 MW — more than a retail box store and less than a data center.[64] Another report estimates that the typical indoor container farm annually consumes about 45 MWh with more intensive vertical farms consuming from 8,700 to 70,000 MWh annually.[65]

---

[61] Buzby, Jean C. and Jeffrey Hyman. "Total and Per Capita Value of Food Loss in the United States." Food Policy, 37(2012):561–570

[62] Electric Power Research Institute, Can Indoor Agriculture Help Feed a Growing World? February 2021, https://publicdownload.epri.com/PublicAttachmentDownload.svc/AttachmentId=70746?utm_campaign=Efficient%20Electrification&utm_medium=email&_hsmi=109174283&_hsenc=p2ANqtz-_f7CMfUqGBeWlnAdTKtITGQ7ijnLNMdTkhsoMgKjnLSasxi4xIaBficGEEqFdDpbzfvtRiIjRcNxrxSoboK_Qkf9jugZKhZIuQj8ohUImBj0a8TX0&utm_content=109174283&utm_source=hs_email#page=9.

[63] iFarm, How Much Electricity Does a Vertical Farm Use, 2020, https://ifarm.fi/blog/2020/12/how-much-electricity-does-a-vertical-farm-consume

[64] Golden, Sarah. "Microgrids, Indoor Agriculture Go Together Like Peas and Carrots." March 2020, https://www.greenbiz.com/article/microgrids-indoor-agriculture-go-together-peas-and-carrots

[65] American Council for an Energy Efficient Economy. "Controlled Environment Agriculture." https://www.aceee.org/sites/default/files/pdfs/eo-indoor-ag.pdf

Research Themes and Policy Priorities Addressed

Decarbonization. Energy efficiency, advanced controls, and energy management systems in indoor agriculture would help the sector decarbonize by reducing electricity consumption.

Resilience and reliability. Electric load shifting in indoor farms can reduce consumption during grid stress and reduce outages.

Previous Research

Past and current EPIC research objectives in agriculture focused on precision irrigation and use of software controls to: increase the efficiency of irrigation and participation in DR programs; and assess whether these approaches could optimize water use and energy management while providing grid flexibility. One project developed a data analytics software platform that monitors irrigation pumps, energy rates, and other parameters to send alerts to growers on how and when to irrigate. The project demonstrated the ability to reduce water and energy usage by 9 percent and 15 percent, respectively, without affecting crop yield or quality. Similar approaches could be used to optimize the lighting, environmental controls, and water use in indoor farms to reduce energy usage based on plant growth and development lifecycles.

Key Technical and Market Challenges

Despite the advancements described above, the adoption of previously funded research and small-scale demonstrations remains an obstacle for several reasons. Before adopting an energy-efficient improvement, a facility must be convinced the improvement will maintain or improve product quality. California's farmers have historically operated on small profit margins; equipment capital costs are high, and they need confidence that changes will not jeopardize their profit margins.

The COVID-19 pandemic has sparked demand for urban agriculture due to farmers struggling to supply food to markets as a result of labor shortages and sharp shifts in demand that have forced them to dump crops.[66] Avoiding such logistical problems is one of the chief advantages to growing food closer to population centers with indoor farms.

[66] Despommier, Dickson, "Vertical Farms fill a Tall Order", Wall Street Journal, July 25, 2020.

Major equipment replacements can be costly and disruptive. Returns on investments typically should be below three years to justify equipment costs and potential down time in an industry that operates in an emerging market with typically slim profit margins. Investors may be hesitant to spend money on advanced technologies with long payback periods in the current market.

Indoor farms are exempt from energy codes and other efficiency policies covering buildings and industry. Large energy end uses like HVAC and lighting are classified as "process loads" in cultivation facilities. As a result, they fall outside the scope of those energy loads regulated by code.[67]

Equity Considerations

This initiative targets demonstrating indoor farms in under-resourced communities. In addition to the demonstrations, this initiative would include requirements for job training and education to residents in these communities. Such training and education would focus on optimizing the energy efficiency and operations of these farms to reduce energy and operational costs such that the benefits can also be realized by other indoor farms not funded by this initiative. Retrofitting empty warehouses or commercial buildings in under-resourced communities could create local jobs and serve as a template for other development projects in the community and elsewhere.

4. Optimizing Long-Duration Energy Storage to Improve Grid Resiliency and Reliability in Under-resourced Communities

Description

This initiative would demonstrate the increased resilience that clean, long-duration energy-storage systems can provide to critical facilities[68] in under-resourced communities. The proposed projects from this initiative would also take into consideration the potential risks of

[67] American Council for an Energy Efficient Economy. "Controlled Environment Agriculture." https://www.aceee.org/sites/default/files/pdfs/eo-indoor-ag.pdf

[68] Critical operations include any that, if interrupted, will cause a negative impact on a community's ability to safety operate business activities. Such impacts range from significantly hindering the management of community functions and losing revenue key to local community activities to the loss of life. Critical facilities include, but are not limited to, nursing homes, hospitals, and police, fire, and community emergency-response installations.

power outages from extreme weather conditions and wildfire mitigation plans while targeting under-resourced communities.

Climate change is contributing to extreme weather events, such as wildfires and heat waves, which are affecting the grid's ability to provide continuous power to customers. In the last few years, California's electrical grid experienced considerable challenges from wildfires, resulting in a greater application of PSPS. Additionally, the extreme heat events in 2020 resulted in rolling blackouts over two days in August. The impact on under-resourced communities can be significant, as back-up power options may be too costly, and when diesel is used as a backup, local air quality is negatively impacted.

This initiative would demonstrate how critical community facilities can modulate facility demand, energy-storage output, and renewable power to achieve optimal resiliency. Demonstrations would couple smart inverters, energy management systems, or a microgrid controller, in concert with energy storage, and document the strategies that best meet performance needs for critical loads while minimizing cost.

Long-duration energy storage offers a clean alternative to back-up diesel generators. Additionally, if the energy storage has long enough duration, it would allow critical facilities in under-resourced communities with high risk factors of power outages to endure PSPS events and other grid power-loss events. Over the last three to five years, long-duration energy-storage technologies have advanced significantly, and there are many emerging technologies that can provide enough energy-storage protection to manage through ("ride out") many of these power-loss events.

In 2020, the EPIC Program invested in seven different energy-storage research and demonstration projects that are anticipated to demonstrate 10 hours or more of energy-storage duration. Some of these projects are in under-resourced communities. With additional research and some system improvements, these emerging technologies can provide 14-16 hours of protection, and when matched with a renewable system like solar, the combined system can provide these critical facilities as many as 24-36 hours of protection. The last few years of experiencing these grid outage events throughout California have shown that having at least

24 hours of protection can result in the most critical facilities being able to manage through these power outage events and continue to provide necessary services to their residents.

Anticipated Impact

This initiative would increase customer resilience in under-resourced communities with high risk factors of power outages and demonstrate how these facilities can rely on clean renewables and energy storage to protect the community during unexpected grid outages. The proposed projects will take into consideration improvements anticipated in utilities' climate mitigation plans and General Rate Cases (GRCs). If successful, adoption would be realized in other communities throughout the state. Critical facilities would not have to rely on polluting, noisy back-up diesel generation systems, or worse yet, have no back-up power available.

Primary Users and Beneficiaries

Primary beneficiaries would be the participating communities, and the lessons learned would encourage non-participating communities to deploy similar arrangements. Research results would be available to communities and organizations representing under-resourced communities, CPUC, California Independent System Operator (California ISO), CEC, utilities, independent power producers, energy-storage developers, vendors, and service providers, DOE, national labs, California Energy Storage Association, Energy Storage Association, researchers, and policy makers.

Metrics and Performance Indicators

- Measurable improvement on resilience targeting under-resourced communities with high risk of power outages
- Survey community satisfaction with performance meeting critical loads
- Measured, repeatable ability to provide 24 hours of continuous and uninterrupted back-up protection to critical facilities during an actual or simulated power outage event
- Polluting emissions eliminated from reducing or eliminating operation of fossil-fueled back-up generators to provide the same level of outage protection
- Ability to serve critical loads such as refrigeration, exit lighting, and medical equipment for full duration of outage by optimizing storage, generation, and control strategies

• Improved business cases for longer duration energy storage in under-resourced communities	
Value Chain	**Program Area(s)**
Grid operations/market design Demand-side management	Technology demonstration & deployment

Background

During the Northern California PSPS events in October 2019, over 2 million individuals and operations were impacted by grid-outage events. The average outage lasted longer than 11 hours. Many critical facilities that did have a clean battery back-up system did not have enough storage to manage through the entire event. Many critical and sensitive patients in care homes and other medical facilities had to be moved to new locations or shelter in place without power. Decarbonization of the electric, gas, and transportation energy systems as California transitions toward a low-carbon energy future will require sustained record-breaking deployment of solar and renewable generation coupled with energy storage.

The majority of installed energy storage within California's electrical system is based on pumped hydroelectric storage ("pumped hydro") and lithium-ion batteries. There are limited opportunities for further large-scale deployment of pumped hydroelectric storage in California. Lithium-ion technology will be a significant part of California's energy future; however, it does not have the cost or performance capabilities to meet all of California's energy-storage needs, and a diversified portfolio of energy-storage technologies is required to achieve SB 100 goals. Compared to lithium-ion and pumped hydroelectric storage, alternative energy-storage technologies (such as alternative battery chemistries, flow batteries, solid-state batteries, fly wheels, thermal energy storage, hydrogen technologies, etc.) may offer longer duration storage at lower cost, longer system lifetimes, improved safety, thermal runaway immunity, environmental benefits, and energy and system net-efficiency benefits.

Projections from the CPUC in their Integrated Resource Plan show that the state will need almost 9 GW of energy storage and an additional 1 GW of long-duration energy storage by 2030. To meet this goal, the state currently projects that lithium-ion energy storage will be selected for the majority of these energy-storage systems and pumped hydroelectric energy storage will be used for long-duration energy storage for the next few years. While these technologies are currently

the most available systems, by 2030, new and emerging energy-storage technologies will meet some of these future needs with better performing and lower cost systems. The studies developed as part of the implementation of SB 100 show that California will need between 25 and 40 GW of new energy-storage systems and an additional 3-4 GW of long-duration energy storage by 2045 to ensure the future grid can operate reliably and safely. This research effort could help ensure the state has a portfolio of energy-storage options that includes short-term and long-duration energy-storage systems and can select the best, most cost-effective solutions to meet various application needs.

Research Themes and Policy Priorities Addressed

This initiative supports the **resilience and reliability** theme. Energy resilience is supported by storing energy in a battery or alternative energy-storage technology for use on demand. An energy-storage system connected to a residence, retailer, commercial building, critical facility, or connected directly to the utility, provides the ability to store energy and manage through variations in renewable generation and electrical power outages. Longer duration energy storage is required to meet the multi-hour to multi-day energy resiliency needs associated with PSPS events. These events are triggered depending on location and site-specific conditions such as temperature, terrain, and local climate. SB 901 requires electric utilities to develop annual wildfire mitigation plans to prevent, combat, and respond to wildfires within their service territories.

Emerging energy storage technologies based on different material compositions such as zinc, sodium, nickel and other materials are showing promise in being able to provide energy-storage durations in the 10 to 20-hour range. Energy-storage systems based on inexpensive thermal storage materials, compressed air systems, and pumped hydro are showing the potential to provide energy-storage durations of several days to as long as a week; energy-storage systems based on these materials are undergoing early stage development and demonstration. These new and emerging energy-storage systems need the opportunity to demonstrate their performance and cost-competitiveness in real-world applications to make the transition to commercial viability.

Energy storage is one of the technologies that can help ensure a future reliable, low-GHG, 24/7 energy supply. By advancing energy-storage technologies that reduce reliance on back-up diesel generators during energy outages, this initiative also supports the **decarbonization** theme.

Previous Research

Over the last decade, the cost of solar has decreased by over 95 percent, and the cost of energy storage has decreased by over 80 percent. These costs are expected to continue to decrease in the future, making these technology solutions more affordable to end customers. Over the last decade, the CEC has invested in more than 50 energy-storage research projects representing more than 15 different emerging energy-storage technologies. These investments have allowed these technology companies to improve performance attributes and lower cost. In 2020 alone, the CEC awarded over $53 million in new energy-storage research grants to 22 recipients. Including more than $45 million in awardee match funding, this represents the largest investment in emerging energy-storage technology advancements in the history of the CEC. This investment is helping address the key market challenge facing emerging energy storage: allowing new and emerging energy-storage technologies the opportunity to demonstrate their capabilities in real-world applications.

Key Technical and Market Challenges

Today, lithium-ion energy-storage technologies dominate California's new energy-storage deployments. However, lithium-ion technology is normally designed for three to five hours of duration and does not have the desired cost, safety, or performance capabilities to meet all of California's longer duration energy-storage needs. Additionally, with the growth of the stationary energy-storage market and the expansion of the EV market, lithium-ion based systems are expected to have challenges sourcing the materials needed meet all their future demands. A diversified portfolio of energy-storage technologies is required to achieve SB 100 goals. However, most alternative energy-storage technologies are largely pre-commercial, and public-sector funding is required to support these technologies through early commercialization. Many of these new energy-storage technologies have emerged in the last few years as the interest in energy-storage solutions has grown substantially globally. The new and emerging technologies provide the promise of lower cost, safer designs, longer lifetimes, and more environmentally friendly materials; however, they have not been built, demonstrated, and tested at a scale needed to support the rapidly growing market in California.

These emerging energy-storage technologies need to address the next major challenge of being able to provide long-duration energy-storage capabilities of 10 hours to 100 hours of back-up

power support at a cost that is competitive with the current alternatives. None of these technologies have reached these goals yet, but many are on a path to reach or exceed the goals in the future. The state needs to continue to support these emerging energy-storage technologies with additional demonstration projects so they can make a successful transition to truly commercial products. The greatest challenge will be accelerating the commercialization of these alternative energy-storage technologies fast enough for them to be able to provide a significant contribution to reaching California's 2045 energy goals. Being able to demonstrate the ability to provide 24 to 36 hours of clean backup that does not rely on any fossil-fuel system is the next major technology hurdle to cross. Not only must they work safely, reliably, and at a competitive price, but they must also demonstrate the ability to instill confidence in the end customer that they will work when called upon the first time and every time needed. This performance must be achieved to enable widespread replacement of fossil-fuel-based back-up systems.

Equity Considerations

This initiative is targeted to the needs of under-resourced communities, and demonstrations will be sited exclusively in under-resourced communities. The projects funded through this initiative will identify under-resourced communities with high risk of power outages. Priority will be provided to these communities that are in wildfire zones and/or experienced outages from previous PSPS events to then apply and demonstrate clean, long-duration energy-storage technologies to improve local resilience. California is experiencing a surge in the deployment of diesel-fueled back-up generators in stark contrast to state air-quality and energy goals. Clean, long-duration energy-storage systems will help reduce air pollution from diesel emission and improve air quality by reducing the need for, and provide an alternative to, diesel-fueled generators. This effort is extremely critical to the under-resourced communities that are exposed to higher levels of air pollution.

5. The Role of Green Hydrogen in a Decarbonized California—A Roadmap and Strategic Plan

Description

This initiative would analyze green hydrogen and make recommendations on its role in meeting the zero-carbon goals of SB 100 by 2045. Green hydrogen is defined in SB 1369 as "hydrogen gas produced through electrolysis and does not include hydrogen gas manufactured using steam reforming or any other conversion technology that produces hydrogen from a fossil fuel feedstock." It offers a unique capability to be a major emerging technology that could play a key role in the carbon-free energy sector of California's future. The challenge is that green hydrogen is currently much more expensive than grey or blue hydrogen.[69] The technical and research challenge is to reduce the cost of green hydrogen.

Detailed technical analysis needs to be completed for each energy sector to assess how green hydrogen compares to other technical alternatives for each of the potential uses. Additionally, an understanding of the compounding benefit and cost-reduction impact of multiple sectors relying on green hydrogen could result in an accelerated implementation schedule. However, as a nascent technology, there are many fundamental questions to be explored before committing significant research investments. Questions include:

- How much of the energy-storage capability planned for the state should be green hydrogen?
- What is the capacity need for seasonal energy storage that green hydrogen could be well-suited to address?
- What are the highest value uses of green hydrogen?

[69] "Grey hydrogen" is produced from fossil fuels by steam reforming of natural gas, partial oxidation of methane, and coal gasification. "Blue" hydrogen is a cleaner version where the carbon emissions are captured and stored or reused. Renewable energy is used to produce green hydrogen through water electrolysis. (https://www.californiahydrogen.org/resources/hydrogen-faq/#S32). Cost estimates for producing grey and blue hydrogen from natural gas are compared on a regional basis in the IEA publication: "Hydrogen production costs using natural gas in selected regions, 2018, IEA, Paris" (https://www.iea.org/data-and-statistics/charts/hydrogen-production-costs-using-natural-gas-in-selected-regions-2018-2).

- If green hydrogen is implemented significantly in one sector, does the transition to hydrogen in another sector become more cost effective over alternative technology options? How can this synergy be maximized by co-location or other strategies?

A roadmap prepared under this initiative would address these questions and inform potential research initiatives in the CEC's EPIC 4 Investment Plan.

Anticipated Impact

This initiative would provide a unique opportunity to research and report on the possible applications and uses of green hydrogen. As stated above, green hydrogen has the potential to become a key emerging technology to help California meet future planned decarbonization goals, especially in sectors with few other viable options. Most of the current information provided by the industry on the use of green hydrogen is potentially biased as the projections are developed by technology producers. An analysis from a neutral point of view would ensure policy makers and future planners have the actionable information available to help them make this important transition.

The state will develop its first implementation plan addressing the key elements needed to transition and meet the goals of SB 100 in 2021. This green-hydrogen initiative would develop a roadmap to inform the second iteration of the SB 100 implementation plan.

Primary Users and Beneficiaries

Key beneficiaries for this research include the CPUC; California ISO; CEC; utilities; independent power producers; energy-storage developers; EV developers, vendors, and service providers; DOE; national labs; California Energy Storage Association; Energy Storage Association; researchers; and policy makers developing their plans to meet the established state climate goals. The long-duration energy-storage, transportation, and the renewable-generation sectors could benefit from understanding the cost to transition to green-hydrogen applications when compared to other emerging and existing technologies.

Metrics and Performance Indicators

The measurable metric would be the number of citations to the roadmap as an indicator of its value to policy makers, research planners, and the industry. The roadmap would include performance metrics to evaluate the ability of green hydrogen to:

- Compete with alternative long-term energy-storage technologies on cost ($/MW) and performance (capacity, safety, duration, and life expectancy).
- Calculate if co-locating green hydrogen significantly lowers cost per MW.
- Calculate the cross-sector cost-reduction benefit of green hydrogen supporting multiple market segments (generation, grid reliability, transportation, industrial/agricultural decarbonization) in meeting future SB-100 goals.

Value Chain	**Program Area(s)**
Grid operations/market design Generation	Applied research & development

Background

Currently, approximately 95 percent of world-wide hydrogen is produced from fossil fuels by steam reforming of natural gas, partial oxidation of methane, and coal gasification.[70] This type of hydrogen is commonly called "grey hydrogen." A cleaner version is "blue" hydrogen, where the carbon emissions are captured and stored, or reused with carbon capture and storage. When renewable energy is used to produce green hydrogen, through water electrolysis, the entire process can be 100-percent emission-free.

One area receiving specific attention in California is hydrogen fueling stations. SB 1505 (Stats. 2006, Ch. 877) requires that 33.3 percent of the hydrogen dispensed at stations receiving state funds in California come from renewable energy sources. This bill requires all stations, regardless of funding source, to be 33.3-percent renewable once a certain volume threshold is reached. The Low Carbon Fuel Standard Hydrogen Refueling Infrastructure Program requires that participants (station owners) dispense at least 40-percent renewable hydrogen content on weighted average.[71] Two hydrogen fueling station owners, FirstElement Fuel and Shell, have both reported that they have supply agreements in place for 100-percent renewable hydrogen at their stations.[72] These programs will advance the use of green hydrogen, expand the market, and

[70] https://www.californiahydrogen.org/resources/hydrogen-faq/#S32
[71] https://ww2.arb.ca.gov/sites/default/files/2020-07/2020_lcfs_fro_oal-approved_unofficial_06302020.pdf
[72] Joint Agency Staff Report on Assembly Bill 8: 2019 Annual Assessment of Time and Cost Needed to Attain 100 Hydrogen Refueling Stations in California. https://ww2.energy.ca.gov/publications/displayOneReport_cms.php?pubNum=CEC-600-2019-039

lower the future costs of green hydrogen. Green hydrogen is a technology with applications for long-term energy storage, fuel switching for power plant generation, and decarbonization. Additionally, as California continues to push for more OSW generation, the potential for excess renewable generation could increase as these OSW systems are expected to have a much higher capacity factor than onshore wind systems and create an ideal environment for the large-scale generation of green hydrogen. SB 1369 calls for the CEC to "consider green electrolytic hydrogen an eligible form of energy storage, and to consider other potential uses of green electrolytic hydrogen." Additionally, in 2021, the state will develop its first plan on the key elements needed to transition and meet the goals of SB 100.

Research Themes and Policy Priorities Addressed

This initiative supports the **resilience and reliability** and **decarbonization** themes. Resilience is addressed as hydrogen enables large amounts of energy to be stored over long durations, providing energy resilience in the event of an electrical power outage. Electrical system reliability can be enhanced by using hydrogen as an energy carrier to distribute and store large amounts of energy for responding to normal variations in renewable generation.

Previous Research

Over the last five years, the CEC has researched the technology applications of green hydrogen. Initial research was focused on hydrogen fuel-cell applications and hydrogen as energy storage. In 2018, the state chaptered SB 1369, which requested the CEC to research additional applications of green hydrogen. In 2020, the CEC awarded three new grants to hydrogen technology companies to demonstrate applications of green hydrogen as energy storage that will improve the resilience and reliability of the utility grid. Additionally, the CEC completed a year-long study[73] on the vast variety of potential uses and applications of green hydrogen for all energy sectors and identified the key obstacles, barriers, and challenges to commercializing green hydrogen. The research provides an excellent baseline for understanding the roles green hydrogen could play in the future decarbonization of the state's energy sectors.

[73] The study occurred under Navigant Consulting's work authorizations entitled "Hydrogen Research to Enable Deep Decarbonization" and "Energy Storage Technologies and Market Status, California End Use Case Scenarios and Research."

The DOE "Hydrogen Program Plan"[74] updates and expands upon previous versions, including the "Hydrogen Posture Plan"[75] and the "Hydrogen and Fuel Cells Program Plan"[76], and provides a coordinated high-level summary of hydrogen-related activities across the DOE. The Fuel Cell and Hydrogen Energy Association published an industry-led "Road Map to a US Hydrogen Economy"[77] that stresses the versatility of hydrogen as an enabler of the renewable energy system, an energy vector that can be transported and stored, a fuel for the transportation sector, heating of buildings, and providing heat and feedstock to industry. Guidehouse (formerly Navigant), under a CEC Work Authorization, performed a preliminary assessment of the future uses of hydrogen in California in 2020.

Key Technical and Market Challenges

Currently, most hydrogen is produced from fossil fuels by steam reforming of natural gas, partial oxidation of methane, and coal gasification. For hydrogen to become a major element of the decarbonization efforts in the state, the technology must transition from this fossil fuel-based technology to green electrolytic hydrogen produced from renewable energy. One challenge is the cost of methods for green hydrogen conversion is several times the cost of the fossil fuel-based systems. New innovations are needed in the conversion process used to generate green hydrogen so equipment costs and conversion costs can be lowered substantially. Where small systems are currently operating that validate the process can be implemented successfully, more innovative solutions that take advantage of creative optimization protocols and designs that are simple to manufacture and operate will be needed in the future. Additionally, hydrogen storage is a bulky and expensive process that requires large space or the ability to store the hydrogen under high pressure or very low temperatures. New solutions are needed that can compress and store the hydrogen under more cost- competitive conditions.

Green hydrogen must compete with other solutions like long-duration energy storage, battery-based EVs, and technology solutions that have existing infrastructure. However, because of the expected growth and expansion of renewable technologies, green hydrogen may offer a flexible

[74] https://www.hydrogen.energy.gov/pdfs/hydrogen-program-plan-2020.pdf
[75] https://www.hydrogen.energy.gov/pdfs/hydrogen_posture_plan_dec06.pdf
[76] https://www.hydrogen.energy.gov/pdfs/program_plan2011.pdf
[77] http://www.fchea.org/s/Road-Map-to-a-US-Hydrogen-Economy-Full-Report.pdf

alternative for distributing and storing energy. Green hydrogen may be generated at a central location and piped to customer sites, bulk delivered in tanks to customer sites, or users can directly generate their own hydrogen at their customer site providing new options for the development of a green-hydrogen infrastructure. More research is needed to assess how hydrogen-based solutions can compete with alternative technology solutions in our future decarbonized world.

Renewable green electrolytic hydrogen energy-storage systems, focused on electricity in and electricity out, are unable to compete on a roundtrip efficiency basis with leading battery-based energy-storage technologies. However, renewable hydrogen energy systems and opportunities for infrastructure co-deployment offer multiple value streams beyond electricity, such as system-level cost savings, environmental, public health, and energy-efficiency benefits. Monetizing these added-value benefits of hydrogen will facilitate deployment.

Equity Considerations

This initiative is a broad analysis across all California demographics and does not have an exclusive focus on under-resourced communities. However, the needs of these communities will be included in the development of the roadmap and strategic plan so that future research efforts completed under EPIC will support them. However, the CEC envisions the following targeted benefits, if and when green hydrogen is widely deployed.

- Transitioning from grey hydrogen to an increasingly blue and green portfolio of hydrogen fuels will help to deliver the carbon-emission reductions needed to achieve California's 2045 energy goals.
- In response to PSPS events and with increasing prevalence of high energy-demand data centers, California is experiencing a surge in the deployment of diesel-fueled back-up generators in stark contrast to state air-quality and energy goals. Hydrogen energy systems that utilize fuel cells and hydrogen generated from renewable resources, may both reduce the need for, and provide an alternative to, diesel-fueled generators.

6. Valuation of Investments in Electricity Sector Resilience

Description

This initiative would contribute to the development of methods for valuation of societal benefits (including economic, public health, and other societal benefits)[78] of customer and grid-resilience investments, such as microgrids, distributed generation, and storage. As a starting point, this research would include analyses of recent historical weather-related events and other situations (e.g., PSPS events) that have precipitated power outages as a basis for understanding the types of impacts that could be valued in the context of climate resilience by state and local governments. It would also evaluate the distribution of these events among ratepayers, with particular consideration of equity concerns and impacts on Disadvantaged Vulnerable Communities (DVCs), as defined by CPUC for the climate-vulnerability context.[79]

Methods for valuing these investments would reflect the impacts on ratepayers from loss of power and benefits of improved reliability and avoidance of outages, with particular emphasis on capturing impacts for under-resourced communities. Clarifying the societal benefits of resilience investments is critical to properly incentivizing deployment of customer and grid-resilience measures. Research gaps include valuation of past extreme weather-related outages (such as PSPS events and heat-wave-related interruptions) and development of a conceptual framework for the value-of-resilience (VOR) investments that captures societal benefits on time scales relevant to GRCs and longer-term (20-30 years) adaptation planning.

Anticipated Impact

[78] In addition to the primary guiding principle that EPIC shall provide electricity ratepayer benefits, defined as promoting greater reliability, lower costs, and increased safety, CPUC Decision D. 12-05-037 includes societal benefits and economic development among a set of complementary guiding principles for EPIC. Also, Decision 12-05-037 finds that applied research and development should include activities that address environmental and public health impacts of electricity-related activities among other topics.

[79] In the context of CPUC's adaptation rulemaking, DVCs include the 25 percent highest-scoring census tracts according to the CalEnviroScreen, all California tribal lands, census tracts with median household incomes less than 60 percent of the state median income, and census tracts that score in the highest 5 percent of pollution burden within CalEnviroScreen, but with unreliable public health or socioeconomic data that preclude assignment of CalEnviroScreen score. For more information on DVCs and adaptation planning, see https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M345/K822/345822425.PDF.

A valuation of measures promoting customer and grid resilience would support development of a conceptual framework to assist policymakers in addressing resilience needs. The outcome of this research could be used, for example, to support development of a tool that would assist CEC in targeting research demonstrations to highest value applications. It would also provide investor-owned utilities (IOUs) and the CPUC with a foundation for considering benefits of resilience investments in the context of GRCs and longer-term planning. Enabling utilities to integrate valuation of resilience measures into GRCs as well as into longer-term planning, such as 20-30- year time horizons considered in adaptation planning, is critical to allowing IOUs to make appropriate investments to protect resilient and reliable electricity service. For example, without a basis for integrating resilience investments into GRCs, IOUs would have a limited basis for making or recouping resilience investments. Additionally, CPUC's decision on Phase 1, Topics 4 and 5 of the Adaptation Rulemaking, adopted in August 2020, requires IOUs to do extensive engagement of DVCs to support development of adaptation plans that prioritize investments in these communities. This research would complement research that IOUs are expected to undertake to provide substantial support for understanding climate-related impacts to DVCs as well as the value of investments to protect these communities.

Primary Users and Beneficiaries

CPUC, CEC, IOUs, energy technology industry stakeholders, Governor's Office of Planning and Research, DVCs, and under-resourced communities

Metrics and Performance Indicators

- Use of valuation frameworks by state and local agencies to incorporate societal benefits into adaptation planning
- Use of valuation frameworks by IOUs to support customer and grid-resilience investments and to inform their obligations to prioritize DVCs in the context of climate change
- Use of valuation frameworks by under-resourced communities in pursuit of funding to support customer and grid resilience

Value Chain	**Program Area(s)**
Grid operations/market design	Applied research & development

Background

Although issues related to extreme weather and other challenges to California's grid have created strong interest in microgrids and other resilience investments, California's state and local agencies currently lack a standardized approach for quantifying VOR. The lack of a standardized VOR method could impede investments—or alternately, lead to sub-optimal or misplaced investments—in customer and grid-resilience measures. The need to understand and appropriately value societal benefits of resilience investments has emerged repeatedly in public workshops, including IEPR workshops related to microgrids as well as climate adaptation workshops.

Research Themes and Policy Priorities Addressed

This initiative supports the **resilience and reliability** theme by helping to develop an empirically grounded methodological basis for valuing resilience investments.

Previous Research

The need for this research is an outgrowth of EPIC's applied research on climate vulnerability and resilience options for the electricity sector. Other organizations have conducted relevant research. For example, the Clean Coalition – a California non-profit – recently conducted a limited inquiry into the VOR for various tiers of customers. Also, the University of California, Santa Barbara examined the impacts of such a valuation approach on incentivizing microgrids in California. The National Associated of Regulatory Utility Commissioners provided (in 2019) an overview of the use of various approaches to valuing resilience of distributed energy resources (DERs). Additional studies and papers have been led by the National Renewable Energy Laboratory (NREL), Institute of Electrical and Electronics Engineers, and CPUC staff.

Key Technical and Market Challenges

Currently, there is no commonly accepted basis for incorporating VOR into public agency and IOU decision-making frameworks for resilience investments. This may result in sub-optimal investment in both customer and grid resilience measures. For example, investment decisions may not maximize net societal benefits or may not meet objectives for equitable distribution of benefits from resilience investments.

Equity Considerations

This research is intended to deliver broad benefits across all California demographics. It would, however, include an emphasis on DVCs by investigating the impacts of resilience investments on low-income and disadvantaged communities—who are among the DVCs defined by CPUC's adaptation rulemaking and identified in a decision adopted in August 2020 for special consideration in IOU adaptation planning.

7. Vehicle-to-Building Technologies for Resilient Back-up Power

Description

This initiative seeks to accelerate development, deployment, and commercialization of plug-in electric vehicles (PEVs) and charging equipment capable of powering critical loads in homes and buildings during electric grid outages (referred to as vehicle-to-building or "V2B" technologies). The initiative will explore demonstrations with publicly and/or privately owned vehicles and facilities (e.g., municipal transit buses) powering community buildings (e.g., emergency shelters) as well as private vehicles powering individual residences to evaluate both individual and community resilience applications.

The initiative structure reflects recent decisions in Rulemaking 17-07-007 by seeking innovations in one of two groups: 1) V2B solutions that are compliant with existing Rule 21 language in which an appropriately certified off-vehicle smart inverter is used; and 2) V2B solutions that are not covered in existing Rule 21 language but have been approved for pilot projects, which rely on the on-vehicle inverter for power conversion and conditioning. Each approach has tradeoffs in complexity, cost, and near-term pathway to deployment that would be evaluated through this initiative. Projects would pursue cost reductions and demonstrate key safety and performance requirements of V2B technologies through hardware and software development, integration, manufacturing scale-up, and demonstration activities. Successful projects would advance products to commercialization enabling V2B with equal performance and lower cost than available alternatives and could inform development of future policies and programs that incentivize zero-emission vehicle deployment.

Anticipated Impact

This initiative would increase individual and community resilience while supporting the state's goals for rapid transportation electrification by accelerating development of products that allow PEVs to provide back-up power to homes and other buildings. The core technologies developed, such as efficient bi-directional power electronics hardware and open standards-based charger monitoring and control systems, would be transferable to a variety of vehicle-grid integration use cases, helping to maximize the benefits of simultaneous transition to zero-emission transportation systems and electric sector decarbonization. Projects would build partnerships among automakers, PEV drivers, and utilities, and build confidence in V2B technology capabilities, helping accelerate commercialization of V2B and vehicle-grid integration technologies. Experience in the demonstrations would also directly inform Rule 21 updates for streamlined interconnection processes enabling the use of PEVs as distributed energy resources (DERs).

Primary Users and Beneficiaries

PEV charging equipment manufacturers, PEV charging service providers, and automakers are the primary technology developers targeted for this initiative. PEV owners would benefit from the products developed by enabling their vehicle to act as a controllable DER that enhances their energy resilience, with secondary benefits for utilities and IOU ratepayers achievable through more efficient utilization of existing electric infrastructure.

Metrics and Performance Indicators

- Number of homes, buildings, and individuals with access to zero-emission back-up power provided by PEVs during grid outages (duration)
- Power and energy provided to building and home loads during real and simulated outages (kW/kWh)
- Cost of zero-emission back-up power and energy ($/kW and $/kWh) provided by PEVs
- Number of new V2B commercial product offerings developed by vehicle and equipment manufacturers

Value Chain:	**Program Area(s)**:
Demand-side management	Applied research & development Technology demonstration & deployment

Background

As California pursues a rapid transition to zero-emission transportation systems,[80] PEVs will contribute a growing fraction of load on the state's electric system. Most PEVs have significant flexibility in charging schedule, and the battery capacity of commercially available models is growing, potentially making them a low-cost DER that can contribute to individual, community, and electric system resilience without sacrificing driver mobility. The scale of this potential resource will grow as more PEVs come onto California's roads; a preliminary analysis funded by CEC suggests that PEV charging may contribute up to 4,000 MW of charging load by 2035.[81] There is a critical opportunity to develop technologies that take advantage of unused battery capacity in PEVs to provide a flexible, low-cost DER that delivers resilience benefits to both individuals and communities. Simultaneous electrification of other end uses such as industrial processes and residential heating will also reinforce the need for new loads to act as grid assets and limit stress on the electric grid.

Research Themes and Policy Priorities Addressed

This initiative fits principally within the **resilience and reliability** theme by supporting development and demonstration of low-cost alternatives to stationary storage or diesel back-up generators that can power critical loads during outages, including PSPS events. The initiative indirectly supports **decarbonization** by helping accelerate transportation electrification through the creation of additional resilience benefits that further incentivize adoption as well as through reduction of uncertainty and cost to deploy PEV charging infrastructure.

The initiative responds to numerous policies and recent decisions, because V2B spans efforts related to transportation electrification, DER interconnection, and vehicle-grid integration, including the following examples.

[80] EO-N-79-20 established the statewide target for 100 percent of passenger car and truck sales to be zero emission beginning in 2035, with all medium- and heavy-duty vehicle sales being zero-emission by 2045 where feasible. Available at: https://www.gov.ca.gov/wp-content/uploads/2020/09/9.23.20-EO-N-79-20-text.pdf.

[81] Preliminary results from EVI-Pro 2. Available at: https://efiling.energy.ca.gov/getdocument.aspx?tn=234215.

- EO-N-79-20 establishes targets for 100 percent of passenger vehicle and truck sales being zero-emission by 2035 followed by 100 percent of medium- and heavy-duty vehicles by 2045 where feasible.
- R.18-12-006 "Development of Rates and Infrastructure for Vehicle Electrification" includes extensive discussion of V2B for resilience and recently CPUC Decision D.20-12-029[82] (December 21, 2020) agreed with stakeholder prioritization of these technologies for development and demonstration.
- R.17-07-007 "Streamlining Interconnection of Distributed Energy Resources and Improvements to Rule 21" includes clarifications on V2B interconnection procedures for off-vehicle inverter-based systems as well as encourages utility piloting of on-vehicle inverter-based systems.

Previous Research

V2B technology has been the subject of applied research and development and technology demonstrations over the past five years in California and globally. The Joint Agencies Vehicle-Grid Integration Working Group final report published in June 2020 identified near-term priority use cases that can provide value to PEV drivers and ratepayers with the goal of comparing these to conventional DER such as stationary storage.[83] Although lack of data has prevented quantitative comparisons, the Working Group provided recommendations for a variety of V2B demonstration activities that can build stakeholder confidence and reduce barriers to widespread market adoption of grid-supportive PEV charging. V2B for resilience applications was also selected as a near-term, high-priority research area in the Draft DER Research Roadmap prepared for CEC by Guidehouse.[84]

Previous investments by the CEC, DOE's Vehicle Technologies Office, California's IOUs, and other research organizations have evaluated and improved bi-directional charging hardware; communications interfaces between vehicles, chargers, and electric grid systems; and networked

[82] Decision Concerning Implementation of Senate Bill 676 and Vehicle-Grid Integration Strategies (D.20-12-029). https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M355/K794/355794454.PDF
[83] Final Report of the California Joint Agencies Vehicle-Grid Integration Working Group. June 2020. https://gridworks.org/wp-content/uploads/2020/07/VGI-Working-Group-Final-Report-6.30.20.pdf
[84] Draft DER Research Roadmap available at: https://efiling.energy.ca.gov/GetDocument.aspx?tn=233081&DocumentContentId=65563

and local controls systems. V2B technologies have been tested in laboratory settings and demonstrated at controlled sites, such as the UC San Diego Microgrid. Recent product announcements for off-vehicle inverter-based systems that meet necessary safety and performance requirements demonstrate early commercialization activity; however, these systems generally have higher cost and complexity and are not widely available. The EPIC Policy + Innovation Coordination Group highlighted several recent CEC projects advancing V2B technologies in its October 22, 2020 workshop on vehicles as a source of back-up power, prioritizing this topic for coordination between EPIC program administrators in 2020.[85]

Key Technical and Market Challenges

Despite improvements in V2B technologies and enabling policies, actual product availability, customer enrollment, and utilization remain limited. Technology improvements in both hardware and software for V2B technologies will be required to reduce costs and support widespread adoption alongside PEV deployment. Today, there are limited commercial offerings of V2B systems, which are expensive in large part because of the need for an off-vehicle smart inverter. Technologies that utilize on-vehicle power conversion equipment do not require off-vehicle inverters and are expected to have significantly lower cost. However, demonstration of smart inverter functionalities and safety requirements using on-vehicle power conversion equipment are required to build automaker experience and capabilities into PEV product offerings. Most major automotive manufacturers do not currently offer or warranty vehicles for V2B capabilities, although there are some early international examples (such as adoption of vehicle-based back-up power in Japan using CHAdeMO standards in Nissan vehicles).

Equity Considerations

Twenty-five percent of the demonstration project funding in this initiative will be reserved for projects located in and benefitting low-income and disadvantaged communities. By including demonstrations of V2B technologies at community buildings (e.g., emergency shelters) and with publicly funded vehicles such as transit and school buses, this initiative would help bring benefits to those who do not personally own PEVs. In these projects, researchers will be

[85] Presentations from the October 22, 2020 workshop as well as background information on the Transportation Electrification workstream of the Policy + Innovation Coordination Group can be found at: https://epicpartnership.org/transportation.html

encouraged to identify and partner with individuals and organizations representing under-resourced communities, such as those that experience frequent PSPS events or suffer air-quality and health impacts of fossil-fuel back-up generation. Additionally, in the long-term, this initiative would accelerate development and deployment of technologies that provide resilience benefits and that will drive down cost and open up V2B opportunities to a broader cross-section. Non-demonstration activities located in and benefitting low-income and disadvantaged communities would receive additional preference in proposal scoring.

8. Offshore Wind Energy Technologies

8a. Manufacturing and Testing of Floating Offshore Wind Energy (FOSW) Components

Description

This initiative would spur innovation in manufacturing, assembly, and installation processes for floating offshore wind (FOSW) component(s), such as substructure, foundation, and support substructure, and demonstrate at a pilot scale to validate the expected benefits, such as levelized cost of energy (LCOE) reduction. This initiative would demonstrate manufacturing techniques and processes locally to make large-scale deployment of FOSW structures more feasible and cost-effective and to deliver greater economic benefits for the state.

Anticipated Impact

California has an opportunity to become one of the first global manufacturing centers for FOSW infrastructure. The continued development of floating offshore component designs could be particularly advantageous, attracting established companies in the FOSW market to move their operations to California or partner with California manufacturers. Investing in FOSW manufacturing in the state would also help decrease the costs of transportation of FOSW components, generate additional economic benefits, and create jobs. California is also well-positioned to become an international leader in floating platform development across the Pacific. The development of FOSW will provide a valuable resource for achieving the goals of SB 100 and for supporting grid reliability, as FOSW has a daily generation profile that complements solar.

Primary Users and Beneficiaries

Project developers and technology developers.

Metrics and Performance Indicators

- Achieve LCOE for FOSW lower or equal to $75/MWh.
- Advance the FOSW components to technology readiness level (TRL) 7-8.

Value Chain	Program Area(s)
Generation	Applied research & development

8b. Inspection and Monitoring Systems for FOSW Applications

Description

This initiative would test and validate monitoring systems for FOSW components that support reduction of installation and operation and management (O&M) costs and increase commercial readiness. This could, for example, use suites of sensors and advanced computer algorithms to predict failures and allow planned interventions that reduce downtime and operation costs. O&M accounts for 25-30 percent of the total lifecycle costs for OSW farms and represents a major hurdle for the OSW industry. Data from OSW farms currently in operation show that technological advancements in O&M can reduce the number of required site visits from five per year to three per year, delivering important cost savings and improved safety for maintenance workers.

Anticipated Impact

Remote monitoring could reduce the number of trips from land to offshore facilities for monitoring and inspection, with potential for significant cost savings and worker safety improvements.

Primary Users and Beneficiaries

Project developers and project operators.

Metrics and Performance Indicators

- Achieve LCOE for FOSW lower or equal to $75/MWh.
- Advance the FOSW inspection and maintenance tools to TRL 7-8.

Value Chain	Program Area(s)
Generation	Applied research & development

8c. Environmental Research for FOSW Development

Description

This initiative would develop tools or methods for assessing and monitoring the environmental impacts associated with the assembly and operation of FOSW components, such as impacts to biodiversity, habitat, and coastal upwelling.

Anticipated Impact

Innovative environmental research would help identify potential risks to wildlife and habitat from FOSW deployment and enable mitigation and management of potential impacts. Approaches that combine the environmental monitoring with FOSW operations monitoring could further improve cost-effectiveness.

Primary Users and Beneficiaries

Project developers, project operators, and permitting agencies.

Metrics and Performance Indicators

- Advancement of the FOSW inspection and maintenance tools to TRL 7-8
- Adoption of practices by state and federal environmental agencies based on research results

Value Chain	Program Area(s)
Generation	Applied research & development

8d. Pilot Demonstration of FOSW Technology

Description

This initiative would pilot demonstrate a FOSW system and components offshore of California to identify unique hurdles and associated solutions for commercial-scale FOSW

projects. This initiative may leverage DOE efforts to fund California projects focused on implementing innovative technologies for FOSW at pilot or full scale.

Anticipated Impact

The pilot demonstration of FOSW technology in California can help provide important insights for deployment at scale and help position the state as an early global leader in manufacturing and production of FOSW technologies. Public financial support is critical to promote further market development in California and would help identify hurdles and research needs to make FOSW technology competitive.

Primary Users and Beneficiaries

Project developers, project operators, agencies, and interested groups.

Metrics and Performance Indicators

- Achieve LCOE for OSW lower or equal to $75/MWh.
- Advance the FOSW technology to TRL 7-8.

Value Chain	Program Area(s)
Generation	Applied research & development

Background

California has a massive 112 GW of accessible OSW energy. Nearly all of this potential (96 percent) is located in coastal waters deeper than 60 meters, where traditional OSW technologies are not suitable.[86] These deeper waters require floating wind technology, which is advancing toward commercialization in both Europe and Asia. California coastal OSW resources have diurnal characteristics that are complementary to the state's solar resource, where the average peak generation occurs at the end of the day and evening.[87]

[86] https://www.boem.gov/sites/default/files/environmental-stewardship/Environmental-Studies/Pacific-Region/Studies/BOEM-2016-074.pdf

[87] Gilman et al 2016. Gilman, P., B. Maurer, L. Feinberg, A. Duerr, L. Peterson, W. Musial, P. Beiter, J. Golladay, J. Stromberg, I. Johnson, D. Boren, A. Moore. 2016. National Offshore Wind Strategy: Facilitating the Development of the Offshore Wind Industry in the United States. U.S. Department of Energy and Bureau of Ocean Energy Management. Available at https://www.boem.gov/sites/default/files/renewable-energy-program/National-Offshore-Wind-Strategy-report-09082016.pdf

FOSW is a subset of OSW and refers specifically to systems that use floating technology (OSW as used in subsequent discussion below refers to offshore wind in general). The average LCOE of FOSW projects is estimated at approximately $230/MWh as of 2019 and is expected to decrease to about $75/MWh by 2030, according to the DOE. However, the true cost of commercial-scale FOSW remains unknown, as commercial-scale floating wind farms have not yet been deployed in the United States. The global FOSW project pipeline is about 5 GW, with just 46 MW installed and the rest in varying stages of development.[88] While case studies from these projects could provide overarching lessons for California, they would not be indicative of potential cost in the state due to a variety of factors, including differences in government support, funding mechanisms, interconnection policies, transmission development, among other factors. Fixed (non-floating) OSW projects remain a more costly alternative to land-based wind, solar, and conventional generation in most locations. The first commercial-scale FOSW projects are projected to have a higher LCOE than fixed turbines due to higher substructure costs, less-established supply chains and manufacturing processes, and greater financial and technical uncertainty. For the proposed FOSW R&D initiatives, the CEC is adopting the DOE's projected cost reduction ($75/MWh) as a cost target to improve cost-competitiveness.

Research Themes and Policy Priorities Addressed

The FOSW initiatives fall within the research themes of **decarbonization** and **resilience and reliability**. FOSW technology will provide another significant source of renewable energy that can help meet the state's decarbonization goals. This emerging technology will allow California to exploit the generally higher and steady wind resources offshore, to potentially achieve GW-scale projects. This makes FOSW an important addition to the portfolio of renewable technologies available to decarbonize the economy. Advances in technology innovation, O&M approaches, supply-chain efficiencies, and logistical synergies with closely linked markets increase cost-competitiveness. Additionally, the expected daily generation profile of FOSW is also complementary with that of solar generation, helping meet loads that cannot be easily met with solar and thereby enhancing grid reliability.

Previous Research

[88] Research and Development in Offshore Wind in California, 2020. https://ww2.energy.ca.gov/2020publications/CEC-500-2020-053/CEC-500-2020-053.pdf

In recent years, the DOE has prioritized two key areas of R&D for FOSW technology innovation: 1) design of turbine platforms, anchors, and moorings; and 2) simulation and testing to accelerate learning with limited demonstrations. Currently, the DOE is funding the University of Maine to install and test a pilot FOSW project of up to 12 MW using a concrete semi-submersible foundation design at a test site off Monhegan Island, Maine.

The National Offshore Wind Research and Development Consortium (NOWRDC) – a non-profit partnering with DOE, several states along the East Coast, and independent and private entities – has three research pillars: 1) OSW plant technology advancement, which includes floating structure mooring concepts for shallow and deep waters; 2) OSW power resource and physical site characterization; and 3) installation, O&M, and supply chain solutions. In 2019, the NOWRDC selected seven projects addressing challenges on floating structure mooring concepts for shallow and deep waters.

The CEC released the EPIC solicitation "Next Wind," which funded four agreements on OSW focusing on increasing generation productivity, reducing the LCOE, addressing potential wildlife impacts through real-time and remote monitoring, and understanding and mitigating potential impacts to sensitive species and habitat. Furthermore, two EPIC-funded studies identified R&D opportunities for OSW: the "Utility-Scale Renewable Energy Generation Technology Roadmap"[89] and the "Research and Development Opportunities for Offshore Wind Energy in California" study.[90]

Key Technical and Market Challenges

Innovation is key to reducing the LCOE of FOSW, including advancements in floating substructures, anchoring and mooring components, and inspection and monitoring strategies. Previous studies indicate that manufacturing of the turbine, floating substructure, and anchoring systems make up the main portion of the lifecycle cost of a FOSW project, followed by O&M

[89] Schwartz, Harrison, Sabine Brueske. 2020. Utility-Scale Renewable Energy Generation Technology Roadmap. California Energy Commission. Publication Number: CEC-500-2020-062. https://ww2.energy.ca.gov/2020publications/CEC-500-2020-062/CEC-500-2020-062.pdf

[90] Sathe, Amul, Andrea Romano, Bruce Hamilton, Debyani Ghosh, Garrett Parzygnot (Guidehouse). 2020. Research and Development Opportunities for Offshore Wind Energy in California. California Energy Commission. Publication Number: CEC-500-2020-053. https://ww2.energy.ca.gov/2020publications/CEC-500-2020-053/CEC-500-2020-053.pdf

and installation costs. R&D efforts can advance innovative technologies and manufacturing approaches for anchors, mooring, and cabling, including inter-array cabling webs and dynamic cabling. For instance, the development of synthetic mooring lines (nylon, polyester, aramid, etc.) could improve performance and reduce O&M costs and susceptibility to fatigue in dynamic ocean environments. The development of manufacturing approaches that optimize existing supply chains, local materials, and manufacturing or assembly solutions may improve operational efficiency, reduce LCOE, ease logistics challenges, and promote local labor and economic development.

Limited data are available on floating technology performance and project development at commercial scale. Currently, there is no FOSW platform system in the world that operates in an environment directly comparable to California's northern and central coasts in terms of wind, waves, and water depth. Developing technologies to ease installation and O&M costs in extreme wind and wave conditions that would prevent regular repair and maintenance, including remote monitoring and robotic maintenance, is key to reducing the LCOE. Floating platform technology has been proven to be technically viable, but because it is still relatively new, few large-scale operational projects exist globally.

Additional data collection is needed on the potential impacts of OSW projects on commercial fisheries, wildlife, migration, and offshore ecosystems in California. Both environmental and fishing stakeholders cautioned against attempting to transfer knowledge from studies conducted in other countries. Stakeholders see potential biodiversity impacts in California as more significant than those in the North Sea or other global fixed-turbine project areas due to California's high level of biodiversity and key coastal migratory routes. To solve specific OSW challenges with fish, birds, and marine mammals, stakeholders suggest that data collection on ecosystems and migratory routes is needed. Research on advanced mitigation technologies like smart curtailment (using sensors to manage turbine rotation to mitigate bird-strike risk), sonar deterrence (to reduce entanglement of marine animals), and robotic mooring line cleaning (to prevent lines from snaring nets and other debris that can trap sea mammals) could help reduce wildlife impacts.

Equity Considerations

This initiative is expected to benefit Californians broadly. Potential benefits of OSW development for California communities – including under-resourced communities –include jobs in coastal regions, economic growth, and enhanced electricity reliability and affordability by balancing and complementing solar generation. The potential of OSW to provide power during the night could also reduce dependence on natural gas power plants that are disproportionately located in under-resourced communities. Successful deployment of OSW and the resulting increase in clean and renewable generation will help the state reach its clean energy goals, delivering an array of human health and climate change mitigation benefits. Recent research[91] has indicated significant potential positive impacts of OSW to California communities; however, further comprehensive assessment of macroeconomic benefits from OSW development in California is needed to boost current insights on the value propositions for OSW projects.

9. Entrepreneurial Ecosystem

The CEC developed the Entrepreneurial Ecosystem to stage-gate new technologies and energy technology-related businesses through the energy innovation development pipeline in a manner that can meet the timelines and requirements of the private sector. The Entrepreneurial Ecosystem consists of a statewide network of entrepreneurial support services combined with three direct-funding initiatives – CalSEED, BRIDGE, and Realizing Accelerated Manufacturing and Production (RAMP) – targeted to key stages of a technology's development. The Entrepreneurial Ecosystem has been important in helping clean energy start-up companies advance their technologies and gain traction with the private sector. Clean energy start-up companies supported through the Entrepreneurial Ecosystem have attracted over $1.5 billion in follow-on private investment.

Initiatives 9a through 9c would provide funding for future cohorts of the CalSEED, BRIDGE, and RAMP programs. Prior to releasing the solicitations for these programs, CEC staff update the list of eligible technology topics to reflect emerging research advancements and state policy priorities. For example, in 2020 the CEC updated the list of eligible technology topics in CalSEED to take advantage of emerging advancements in machine learning, artificial

[91] For example, see https://laborcenter.berkeley.edu/offshore-wind-workforce-grid/.

intelligence, and sensing to better support wildfire threats to the electricity system. In addition, the CEC may make changes to the eligibility requirements of each program based on applicant and stakeholder feedback. For example, the 2020 BRIDGE solicitation required applicants to secure private investment in the amount of at least 50 percent of their EPIC award size. The CEC in future BRIDGE solicitations may adjust this amount.

9a. California Sustainable Energy Entrepreneur Development (CalSEED)

Description

This initiative would build upon the CalSEED Initiative efforts established under the first three EPIC Investment Plans. The small-scale funding provided by the CalSEED Initiative gives entrepreneurs starting capital to develop their ideas into proof-of-concepts and early prototypes. This level of funding fills a crucial niche in the financing landscape for clean energy entrepreneurs because venture capital firms have decreased their investments at this level over the past several years. The goal of this initiative is to allow the CalSEED Initiative to reach more entrepreneurs throughout California.

Anticipated Impact

CalSEED is often the CEC's first touch point for many clean energy start-up companies, providing a small amount of funding that can set up these companies to be successful when applying to larger funding opportunities and attracting interest and investment from the private sector. In addition, CalSEED provides a path for Intellectual property developed at research institutions to spin out of the lab and into commercial ventures. Through November 2020, CalSEED has provided funding for 91 start-up companies. These companies have gone on to receive $37.40 million in public funding and $28.36 million in private investment. The CEC expects this impact to continue with the proposed funding in this Interim Plan.

Primary Users and Beneficiaries

Clean energy entrepreneurs, research institutions, private investors, project developers and systems integrators, energy solution providers.

Metrics and Performance Indicators

- Follow-on Private Investment

- Follow-on Public Funding
- TRL
- Commercial Readiness Level (CRL)

Value Chain	Program Area(s)
Grid operations/market design	Applied research & development
Generation	
Transmission	
Distribution	
Demand-side management	

9b. Bringing Rapid Innovation Development to Green Energy (BRIDGE)

Description

BRIDGE seeks to: 1) accelerate early-stage research funded by the federal government and the CEC through the later-stages of the TRL spectrum; 2) help start-up companies minimize the time between when their successful publicly funded project ends and the time new public funding becomes available; and 3) mobilize more early-stage capital in the clean energy space by providing non-dilutive, matching investments in promising clean energy companies alongside investors and commercial partners. This provides increased support for the most promising clean energy technologies that have already attracted interest from the market as they are developed and continue their path to market adoption. For example, Ubiquitous Energy transitioned federally funded research on organic photoactive material at Massachusetts Institute of Technology (MIT) into a commercial venture to develop solar power-generating glass. Under BRIDGE, Ubiquitous Energy has been able to develop and install the first public demonstration of its power-producing window façade prototype and commissioned its first pilot production line in Redwood City. In addition, Ubiquitous Energy has received national attention, such as being featured in Forbes and appearing on CNN Business.

Anticipated Impact

This initiative will leverage and build on the CEC's and federal government's significant investments in basic and applied research and provide an accelerated pathway for that research to transition out of universities and national laboratories and into commercial ventures. New inventions are often incubated for years at research institutions as the science is advanced and potential energy applications are identified. In addition, federal agencies such as National Science Foundation and DOE's Advanced Research Projects Agency – energy (ARPA-e) support technologies at the earlier stages of the TRL spectrum but have limited ability to support these technologies further down the TRL spectrum. BRIDGE provides a streamlined pathway for the CEC to pick up these technologies and move them quickly through the TRL stages. For example, with BRIDGE funding, SkyCool Systems has been able to move quickly to pilot demonstrations following research developed at Stanford and funded by ARPA-e. SkyCool Systems has developed a thin film coating and rooftop cooling panel that passively reject heat to the sky. "Depending on the application and climate conditions, the technology could cut the energy used to cool structures by 10 to 70 percent."[92] In addition, this initiative will help reduce delays faced by technology innovators that result from a lack of secure funding sources and send a strong signal to private investors regarding the technology's merits given the higher requirements for selection into BRIDGE.

Primary Users and Beneficiaries

Clean energy start-up companies, skilled workers, universities and national laboratories, federal research programs, private investors

Metrics and Performance Indicators

- Private investment leveraged in BRIDGE award
- Follow-on private investment; company employment growth
- TRL and CRL achieved at the end of the project

Value Chain	Program Area(s)
Grid operations/market design	Applied research & development

[92] Temple, J. 2017. "A Material That Throws Heat into Space Could Soon Reinvent Air Conditioning", *Massachusetts Institute of Technology* (*MIT) Technology Review,* www.technologyreview.com/2017/09/12/149205/a-material-that-throws-heat-into-space-could-soon-reinvent-air-conditioning/

Generation

Transmission

Distribution

Demand-side management

9c. Realizing Accelerated Manufacturing and Production (RAMP)

Description

This initiative provides financial assistance to help clean energy entrepreneurs successfully advance their emerging best-of-class, innovative technology to the Low-Rate Initial Production (LRIP) stage, also referred to as Manufacturing Readiness Level 8. LRIP is the first step in making the transition from highly customized hand-built prototypes, which are used for performance testing and vetting the production process, to the final mass-produced end product produced in the Full-Rate Production phase. Ten companies were selected for the first RAMP cohort and the CEC expects to award the next RAMP cohort in early 2021. RAMP has already helped start-up companies scale-up production in California. Caban Systems is developing a software-enabled modular energy storage system for telecommunication towers and other critical infrastructure. This technology offers a cleaner, more robust, low-maintenance alternative to diesel back-up generators that can also withstand harsh environments and be monitored and operated remotely: a key feature for telecommunication tower owners and operators since many towers are located in remote locations. Under RAMP, Caban has been able to increase production capacity of its energy storage solution from one unit per month to one unit per day, enabling the company to meet customer demand for its energy-storage product. Sepion Technologies, another RAMP awardee, is developing a nanoporous membrane separator for lithium batteries. Sepion's separator overcomes the limitations of current ceramic-based separators, enabling lithium batteries that have higher energy density, longer life spans, less susceptibility to thermal runway, and no cobalt requirement. Under RAMP, Sepion has been able to increase production of its advanced battery membrane from 0.01 square meters per hour (m^2/hr) to 6 m^2/hr, which would be able to supply up to 24 EV battery packs (50 kWh).

Anticipated Impact

This initiative would help start-up companies scale-up their production levels to: 1) improve their per-unit costs; 2) increase their production capacity to meet customer demand; and 3) increase their production yields; and 4) demonstrate to private investors that they have overcome manufacturing challenges that make clean energy technologies a risky proposition. In addition, this initiative would help increase the number of clean energy manufacturing jobs in California. To date, the first cohort of RAMP companies have collectively hired 65 skilled workers since their RAMP award started and are expected to hire another 181 by the time their RAMP projects have completed. These companies collectively employed 55 skilled workers prior to their RAMP award. This would represent a 336-percent increase in the number of skilled workers employed by these companies.

Primary Users and Beneficiaries

Clean energy start-up companies, California-based manufacturers, skilled workers, customers

Metrics and Performance Indicators

- Number of companies that reach Manufacturing Readiness Level 8
- Follow-on private investment
- Increase in production capacity and yields
- Increase in manufacturing jobs at start-up companies

Value Chain	Program Area(s)
Grid operations/market design	Market facilitation
Generation	
Transmission	
Distribution	
Demand-side management	

9d. Market Research

Description

This initiative would conduct market research on emerging technologies that are expected to replace incumbent technologies or create new markets not served by incumbent technologies.

It could also provide executive-level expertise to companies to accelerate product commercialization and secure financing. This initiative would contract with a consultant to conduct market research. Since it can be difficult to predict the market topics years in advance, the CEC – after selecting a consultant – would solicit stakeholder input through a public process to identify market research topics and activities, and then develop work authorizations for those topics and market research activities. Market research conducted under this initiative would, among other activities, identify:

- Near- and mid-term markets where emerging technologies can be competitive with incumbent technologies;
- Specific cost components that account for the overall cost of emerging technology solutions; and
- Technical and cost targets that need to be met – both at the cost-component level and the overall technology package – for these emerging technologies to gain market traction.

Anticipated Impact

This initiative would provide clear targets for public and private decision-makers to use for investment decisions. In addition, this initiative would provide targets for researchers and clean energy start-up companies to drive toward with their innovations.

Primary Users and Beneficiaries

Researchers, clean energy start-up companies, government agencies, industry, investors

Metrics and Performance Indicators

- Number of citations of market research under this initiative referenced in other reports and publications
- Number of EPIC solicitations that are informed by the market research conducted under this initiative

Value Chain	Program Area(s)
Grid operations/market design	Market facilitation
Generation	
Transmission	
Distribution	
Demand-side management	

9e. Cost Share for U.S. Department of Energy (DOE) Funding Opportunities

Description

This initiative would provide cost share to California-based organizations applying to funding opportunities issued by the DOE that are consistent with the goals and objectives of EPIC. The CEC Cost Share for DOE Funding Opportunities ("Federal Cost Share") solicitation has been a key tool in promoting the efficient use of ratepayer funds and attracting federal funding to California. Through this solicitation, the CEC has provided $10.9 million in EPIC funding, which has leveraged $112.8 million in federal funding. For example, the CEC awarded $3 million in EPIC funds, which helped a research consortium led by LBNL win a $100-million award from DOE to establish an Energy-Water Desalination Hub.

Anticipated Impact

This initiative would help California-based organizations meet the cost-share requirements of funding opportunities by DOE and be more competitive in the selection process. In addition, this initiative will help attract federal funding to California as well as promote the efficient use of ratepayer funds.

Primary Users and Beneficiaries

National laboratories, private clean energy companies, California universities, non-profit clean energy organizations

Metrics and Performance Indicators

- Amount of federal funding leveraged
- Amount of federal funding brought to California

Value Chain	Program Area(s)
Grid operations/market design	Applied research & development
Generation	Technology demonstration & deployment
Transmission	
Distribution	
Demand-side management	

Background

Clean energy entrepreneurship is vital to realizing California's ambitious energy and climate change policy goals and providing benefits to electric ratepayers. Clean energy start-up companies have become the primary market segment responsible for developing and introducing new technology solutions into the electricity sector – especially as large energy providers have found it more cost-effective to strategically partner with or acquire start-up companies with new technology solutions than to develop their own in-house R&D activities.

The CEC launched the Entrepreneurial Ecosystem in 2016 to better support clean energy entrepreneurs developing breakthrough technology solutions. The Entrepreneurial Ecosystem consists of direct-funding initiatives along with entrepreneurial support services to stage-gate new technologies through the energy innovation development pipeline. Through the Entrepreneurial Ecosystem, the CEC has supported 223 clean energy start-up companies. These companies hold more than 418 patents, employ more than 1,081 individuals, and have gone on to receive more than $426 million in follow-on funding.

Research Themes and Policy Priorities Addressed

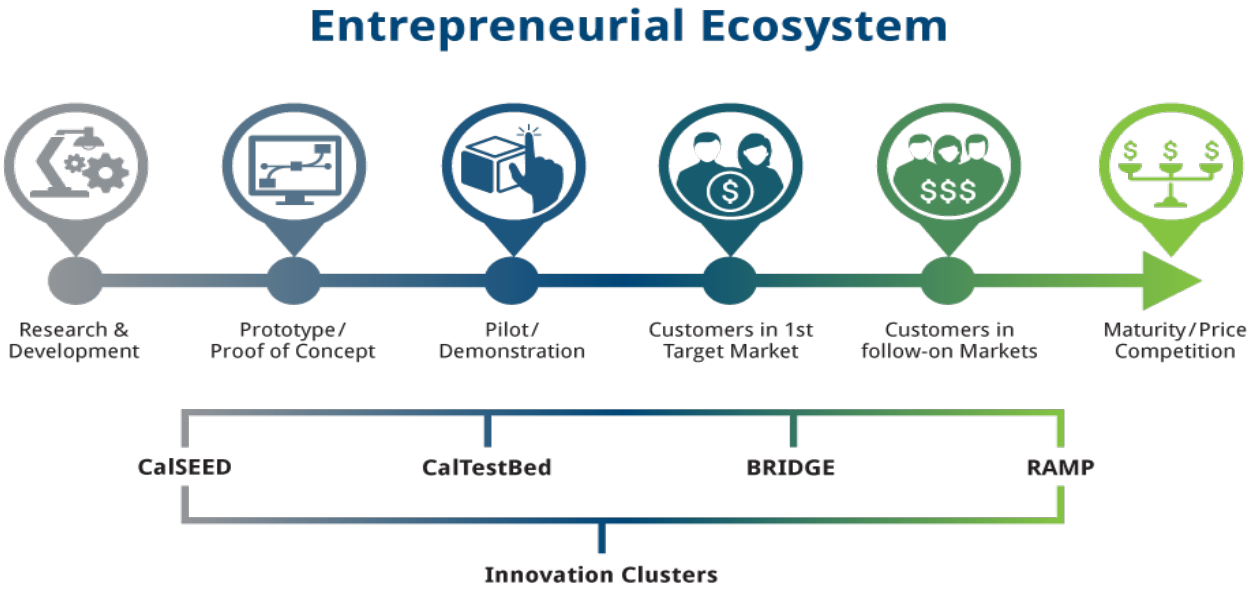
The CEC through EPIC has taken significant steps to bring private investment back into clean energy innovation. EPIC has provided certainty to the private sector by providing funding at key stages in technology development that the private sector is not able to fund. Also, by providing consistent funding and a commitment to R&D funding, EPIC has provided increased confidence to researchers and private-sector investors to pursue clean energy ventures. More importantly, the CEC has provided validation to the private sector of new energy technologies' merits. The primary driver has been the Entrepreneurial Ecosystem developed under EPIC to mobilize California's vast resources around clean energy entrepreneurship and make new clean energy ventures investable. Supporting **entrepreneurship** fosters research under the themes of **decarbonization** and **resilience and reliability** as well. The CEC's Interim Plan initiatives would continue to provide funding for clean energy entrepreneurs targeted at key stages in development of their technologies.

Previous Research

Following the steep drop in private investment for early-stage clean energy technologies and companies, a number of studies and organizations identified the need to reimagine the existing

model for delivering clean energy technologies to the market. Starting in 2016, the CEC has led a series of programs, comprising the clean energy Entrepreneurial Ecosystem (Figure 1), and providing this new model.

Figure 1. The Entrepreneurial Ecosystem Mobilizes and Organizes a Wide Array of Stakeholders and Resources Throughout the State to Provide Clean Energy Startups with the Technical and Business Support Needed to Advance Their Technologies



As mentioned above, CEC's CalSEED is a small-grant program under EPIC that provides help to early stage California clean energy startups to bring their concepts and prototypes to market. More information is available at: www.calseed.fund. CalTestBed is a voucher program that provides clean energy entrepreneurs access to nearly 30 testing facilities throughout the state to conduct independent technology testing and validation. More information is available at www.caltestbed.com. As discussed earlier, BRIDGE is an EPIC solicitation program that provides support to clean energy startups that have previously received federal or CEC funding to continue working on their technologies without waiting for a new public funding opportunity or pausing to raise private funding. RAMP is an EPIC solicitation program that supports clean energy entrepreneurs' transition from one-off prototype manufacturing to an initial pilot production line capable of conducting low-rate initial production. Finally, the Innovation Clusters are a set of four EPIC-funded projects that collectively provide entrepreneurial support services —such as laboratory equipment and buildings, business plan development, and connections to investors —throughout the state.

Key Technical and Market Challenges

Clean energy entrepreneurs developing new technologies face a number of technical and market challenges on their way to commercializing their inventions, including:

- *Lack of early-stage private sector investment*. In 2013, a year before the first CEC EPIC awards were made, venture capital and other early-stage private sector investors largely pulled out of the clean energy innovation sector after a series of failed investments.[93] In a July 2016 Energy Initiative paper,[94] MIT reported that venture capital investment had dropped to $2 billion, down from a peak of $5 billion in 2008, after investors learned through firsthand experience that new energy technologies have longer development timelines and higher capital requirements than software start-up ventures. Additionally, a National Academies of Sciences study found that, "many investors at the venture and similar investment stages lack the technical capability to assess which energy technologies hold the greatest potential."[95]
- *Significant gaps between funding awards*. For even the most promising energy innovations, researchers and technology developers typically require multiple rounds of public funding to advance their technology to a state where it can attract interest and investment from the private sector. However, the time between when a successful publicly funded project ends to the time new public funding opportunities become available can be years apart. Even under a best-case scenario, this delay in funding can significantly slow the pace of a new technology's development.
- *Transitioning from prototype to production-scale.* Startups that attempt to scale-up face several hurdles when moving from prototype to production, including a series of new design challenges that impact a host of innovations. Start-up companies typically lack the practical manufacturing experience to successfully move their energy technology innovation to production. Moving a technology into production requires understanding of a

[93] Gaddy, Benjamin, Varun Sivaram, Francis, O'Sullivan 2016. Venture Capital and Cleantech: The Wrong Model for Clean Energy Innovation. https://energy.mit.edu/wp-content/uploads/2016/07/MITEI-WP-2016-06.pdf.
[94] Ibid.
[95] National Academies of Sciences, Engineering, and Medicine. 2016. The Power of Change: Innovation for Development and Deployment of Increasingly Clean Electric Power Technologies. Washington, DC: The National Academies Press. https://doi.org/10.17226/21712

wholly different set of considerations than the initial technology development, including material selection, supply-chain management, and assembly steps.

- *Information gaps on technical and cost targets that need to be met for market traction.* New technologies must exceed specific technical and cost requirements to gain traction over incumbent technologies in existing markets or to enable new markets. Currently, market and government actors have little to no visibility on what technical and cost targets need to be met, the cost components that contribute to the overall costs, and the near-term market applications where emerging technologies can be competitive with incumbent technologies. As a result, private investors and government funders have little information on which to make more targeted investment decisions. In addition, researchers and technology developers need information and analysis on the key pain points customers face so they can design technology solutions that provide a compelling value proposition over incumbent technologies.

Equity Considerations

Equity has been a key focus and priority in the CEC's design and implementation of the Entrepreneurial Ecosystem. For example, the CEC set a minimum funding target in CalSEED of $4 million for diverse businesses such as minority-, women- and lesbian, gay, bisexual, transgender, queer (LGBTQ)-owned businesses, and businesses in a disadvantaged community or rural part of the state. To date, $8.1 million in CalSEED funding has already gone to these businesses. In addition, the CEC designed the Innovation Clusters to support geographic diversity and ensure entrepreneurs in every part of the state have access to incubator and accelerator programs. Further supporting geographic diversity, CalSEED applicants are grouped and selected based on their geographic region. The four innovation clusters have all made equity a part of the incubator/accelerator programs they offer. This includes:

- Providing mentoring to clean energy start-up companies on how they can make equity part of their businesses' core values as they grow and scale.
- Conducting outreach to bring clean energy entrepreneurs from diverse and underrepresented backgrounds into the incubator/accelerator program.
- Targeting start-up companies with technologies that can specifically benefit under-resourced communities and low-income customers.

- Ensuring incubator services are available and accessible to clean energy entrepreneurs in rural locations of the state.

This has enabled the four clusters and CalSEED to attract an additional $3.8 million in federal funding to expand their respective programs in under-resourced parts of the state. CalSEED has committed to providing $4 million of funding specifically to focus on equity within the clean energy and entrepreneur space. The CEC's RAMP Program is also increasing the number of manufacturing jobs in California, helping to provide skilled jobs, good wages, and on-the-job training. As mentioned previously, RAMP recipients have collectively hired 65 skilled workers since their RAMP award started and are expected to hire another 181 by the time their RAMP projects have completed. In addition, the CEC has helped make start-up companies aware of Daughters of Rosie, an organization that trains women for manufacturing jobs. The initiatives under the Entrepreneurial Ecosystem will continue to support equity in entrepreneurship including the following:

- CalSEED will continue to set a minimum target for the amount of funding that goes to entrepreneurs from underrepresented groups such as minority-, women- and LGBTQ-owned businesses, and businesses in a disadvantaged community or rural part of the state.
- CalSEED will continue to group and select proposals based on their geographic region in California. This will continue to ensure geographic diversity of CalSEED recipients.
- Applicants to RAMP will be evaluated in part on the number of skilled manufacturing jobs, good wages, and on-the-job training they are providing to California residents.
- The Market Research initiative will conduct customer discovery to identify what features and functionality low-income customers want in clean energy technology solutions and what specific pain points low-income customers face that prevent access to clean energy technologies. In addition, this initiative will identify cost and performance targets that need to be achieved for clean energy technologies to be affordable for low-income customers.

Administration

This section discusses the procedures and processes the CEC will follow for conducting program outreach efforts; selecting, funding, and managing projects and programs; and sharing

knowledge and lessons learned. Stakeholder engagement is a key component of all phases of CEC EPIC program administration.

Outreach, Diversity, and Equity

Advancement of pre-commercial energy technologies and approaches can only reach full potential when current information about funded activities and improvements is available to all appropriate audiences, stakeholders, and users.

Diversity and Inclusion

The CEC is also committed to increasing the participation of businesses owned by women, minorities, disabled veterans, and those identifying as LGBTQ through undertaking a comprehensive outreach plan to ensure that a diverse range of potential applicants know about, and understand how to participate in, EPIC program activities, especially solicitations for projects. Such businesses are encouraged to apply for CEC funding opportunities. The CEC will build on the infrastructure built over the past decade. 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.[96] In October 2015, AB 865 (Stats. 2015, Ch. 583) 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, 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."[97]

The CEC created a new professional networking platform, Empower Innovation, to help members and organizations more easily identify relevant funding opportunities, resources, and potential project partners. The CEC Public Advisor's Office has conducted outreach to diverse businesses to enhance awareness and participation in Empower Innovation. Also, in designing

[96] CEC, April 8, 2015, Resolution 15-0408-3: Resolution Regarding Diversity Policy Statement. https://www.energy.ca.gov/sites/default/files/2020-07/diversity_policy_resolution_ada.pdf.
[97] See Public Resources Code Section 25230(b)(1).

and managing the programs that make up the Entrepreneurial Ecosystem, the CEC has taken specific actions, where allowable, to increase the business and geographic diversity of clean energy entrepreneurship. Such actions include ensuring entrepreneurs in every part of the state have access to incubator services and setting a minimum funding target in CalSEED for underrepresented groups and businesses in a disadvantaged community or rural part of the state. One of the initiatives in the Interim Plan is to continue to invest in the Entrepreneurial Ecosystem. This is an important series of interrelated programs that are empowering the next generation of startups in diverse communities across the state.

Advancing Energy Equity

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.[98] Through 2019, the CEC invested 65 percent of EPIC program funding for TD&D in projects in disadvantaged communities and low-income communities. The CEC exceeded the requirements set forth in AB 523 for at least 25 percent of the TD&D funds to be expended on projects in and benefitting disadvantaged communities. Also, the CEC exceeded the AB 523 requirement for an additional 10 percent of the TD&D funds to be expended on projects in and benefitting low-income communities. This trend will be continued in the execution of the EPIC Interim Plan.

The Empower Innovation platform can help communities more easily identify relevant funding opportunities, describe their priorities in clean energy projects, and find technology solution providers to partner with on potential projects. Through January 2021, Empower Innovation has quickly grown to over 1,800 members representing more than 500 organizations. Members can opt to receive the Empower Innovation Equity Digest to learn about funding opportunities focused on advancing energy equity. Though the Empower Innovation Platform has filled an

[98] 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/sites/default/files/2020-07/diversity_policy_resolution_ada.pdf). In 2016, the CEC's Low-Income Barriers Study recommended the CEC's EPIC program should target a minimum of 25 percent of TD&D funding for sites located in disadvantaged communities (https://efiling.energy.ca.gov/getdocument.aspx?tn=214830). The CEC committed to targeting 35 percent of TD&D funding for sites located in disadvantaged or low-income communities.

important need, the CEC realizes more is needed to reach the many varied communities across the state that hope to participate in the research program. The CEC is developing events to incorporate active listening with a diverse set of communities and stakeholders to facilitate relationship building and inform solicitation development. The first "Empower Innovation Event: Developing Sustainable, Affordable Housing in California's Communities," was held on January 28, 2021. The CEC consulted with the DACAG EPIC Working Group on January 8, 2021 to seek input into the design of the events to engage communities meaningfully, address community priorities, and support relationship building. The CEC intends to consult with the DACAG to gather additional input into future events to ensure that communities are well represented, and the events achieve the desired outcomes related to enhanced stakeholder engagement.

SB 350 prioritizes maximizing benefits to low-income customers and those in disadvantaged communities, as well as manufacturing and installing clean energy and pollution reduction technologies that create employment opportunities, including high-wage, highly skilled employment opportunities, and increased investment in the state. Opportunities for these communities exist throughout all EPIC program areas and are explicitly called out in Interim Plan initiatives. For example, for EPIC TD&D solicitations with set-aside funding for proposed projects located in and benefitting low-income and/or disadvantaged communities within IOU service territories, each proposed project must allocate appropriate funding for engagement with CBOs for relevant tasks under the scope of work. Required scoring criteria for such proposed projects also contain equity considerations as shown below in Table 3. The CEC plans to use this scoring criteria in the implementation of the Interim Plan and continue to monitor whether the scoring criteria result in high-impact projects benefitting under-resourced communities.

Table 3: EPIC's Required Disadvantaged/Low-Income Community Scoring Criteria for TD&D Solicitations With Set-Aside Funding

8. Benefits to Disadvantaged/Low-Income Communities and Localized Health Impacts	

8.1 Benefits to Disadvantaged/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, and small-businesses, economic development, and expanding community investment. • Identifies how the projects' primary beneficiaries are residents of the identified disadvantaged/low income community(ies) and describes how they will directly benefit from the project outcomes.	15
8.2 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 the applicant will disseminate educational materials and career information that is appropriate for the culture, and in the language(s) that are primarily represented in the community. This includes whether any translating services will be used. • Identifies how the project, if successful, will build community capacity.	10
8.3 Localized Health Impacts • Summarizes the potential localized health benefits and impacts of the proposed project and provides reasonable analysis and assumptions to support the findings. • 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.	15

• Identifies health-related Energy Equity indicators and/or health-related factors in CalEnviroScreen 3.0* that most impact the community and describes how the project will reduce or not otherwise impact the indicators or factors.	
8.4 Technology Replicability • Identifies how the project, if successful, will lead to increased deployment of the technology or strategy in other disadvantaged or low-income communities.	5
8.5 Project Support Letters Includes letters of support from technology partners, community based organizations, environmental justice organizations, or other partners that demonstrate their belief that the proposed project will lead to increased equity, and is both feasible, and commercially viable in the identified low-income and/or disadvantaged community.	5

Source: California Energy Commission

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

While not required by AB 523, the CEC also reaches out to California Native American tribes to encourage their participation in EPIC funding opportunities. The CEC tribal consultation policy states: "…the [CEC] recognizes the importance of Tribal Consultation in energy planning and policy and is committed to ensuring *California Native American tribes* have the *opportunity to participate in and benefit* from [CEC] programs…"[99] The CEC has increased outreach to these communities, including conducting two public workshops in 2019 in and for low-income and disadvantaged communities and another for California Native American tribes to hear the needs of these communities and inform them about the EPIC Program.

Sharing Knowledge and Lessons Learned

The CEC's EPIC Program shares knowledge and lessons learned among technology innovators, technology adopters, architectural and engineering firms, start-up services, funding providers,

[99] CEC Tribal Consultation Policy: https://www.energy.ca.gov/sites/default/files/2020-01/2017CEC_Tribal_Consultation_Policy_ADA.pdf

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. Some past examples that will be amplified going forward, are included below:

- Through 2020, EPIC-funded projects have resulted in more than 460 academic publications and more than 2,900 citations. Researchers use and cite academic publications to learn and build upon recent advancements.
- With the exception of 2017, the CEC hosts a symposium each year in coordination with the three IOU EPIC administrators.[100] CEC staff estimates nearly 1,000 people attended the 2020 online virtual EPIC Symposium. The symposium brings together policy leaders, technology adopters, entrepreneurs, and others to discuss clean energy research, results, and challenges.
- The CEC shares EPIC project results online through the CEC Energy Innovation Showcase.[101] 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. In 2020, the CEC launched the Energize Innovation web site[102] to highlight innovation by the numbers, summarize featured research topics by investment area, and provide updates on CEC EPIC-funded projects in the news. An EPIC project portal will be coming soon to Energize Innovation as well, replacing the Energy Innovation Showcase with enhanced features.
- The CEC publishes a final report online for each EPIC project. As of December 2019, sample data from Google Analytics indicate the EPIC final reports available online (50+) were viewed more than 6,800 times.
- In 2020, the CEC hosted two technology forums to share results from EPIC-funded research and showcase innovative approaches and technologies. The first technology forum was held in Long Beach and focused on technologies to power resilient communities. The second

[100] 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.
[101] https://www.energy.ca.gov/showcase/energy-innovation-showcase
[102] https://www.energizeinnovation.fund/

technology forum was held online and showcased advances in building decarbonization technologies. Plans for 2021 include at least two additional technology forums.

- A number of CEC EPIC-funded projects organize knowledge-sharing workshops and webinars to receive feedback on technology development and share results. For example, the CEC EPIC-funded Innovation Clusters host multiple such events each year to raise awareness of start-up companies' clean energy innovations and expand business development opportunities. In addition, Cal-Adapt webinars introduce attendees to data sets and data visualizations available through the online platform[103] and gather input to inform development of future climate data online tools.

Coordination with Other Research, Development, and Demonstration Efforts

The CEC will stay up to date with both in-state and national RD&D activities. The CEC will pay close attention to the new Biden-Harris administration to look for opportunities for California to leverage federal investments in clean energy technologies. Agencies with energy-related activities or research such as the DOE, the United States Department of Defense, the CPUC, the California Air Resources Board (CARB), and California Ocean Protection Council (OPC) can provide key input into EPIC gap analysis and road-mapping activities. CEC staff have also participated in DOE's, OPC's, and other agencies' research planning, project scoring, and/or program evaluation activities. This coordination is an invaluable tool both to avoid duplication and to leverage related efforts. The DOE and California's energy agencies (CPUC, CARB, California ISO, and CEC) have initiated a high-level dialogue to facilitate improved collaboration.

California's national labs, academic institutions, and other private organizations are leaders in clean energy research innovation. The CEC will encourage participation across the state in EPIC implementation through public stakeholder workshops, meetings, and outreach efforts. Interested individuals can provide input on implementing EPIC Investment Plans; identify synergies and path-to-market opportunities; and share program results.

The CEC is committed to on-going collaboration with the three utility administrators. CEC will also support PICG efforts. In D.18-10-052, the CPUC established the PICG, which is comprised

[103] Cal-adapt.org

of a project coordinator, the four administrators, and the CPUC, to increase the alignment and coordination of EPIC investments and program execution with CPUC and California energy policy needs. On-going collaboration will be a cornerstone of the program to assure EPIC activities return the highest benefit to California ratepayers.

EPIC Solicitation and Agreement Management

The EPIC Program, with limited exceptions, awards funds through a competitive bid process, as required by Public Resources Code (PRC) Section 25711.5. The majority of initiatives included in this Interim Investment Plan will be implemented through the CEC's competitive solicitation process to ensure a fair, open, and transparent opportunity for interested parties. The procedures for competitive solicitations will follow applicable requirements from the State Contracting Manual, State Public Contracts Code, PRC, and other laws and regulations, such as civil service restrictions, prevailing wages, and the California Environmental Quality Act.

EPIC solicitations typically will be open to all public and private entities and individuals interested in electricity-related applied R&D, TD&D, and market facilitation. However, some solicitations may target specific entities, such as universities or local governments, or locations, such as disadvantaged communities; or prohibit certain applicants if their participation could represent a conflict of interest.

Under Legislative oversight, as described in PRC 25711.5 subparagraph (h)(2)(A), the CEC may use a sole-source or interagency agreement to award funds if the project cannot be described with sufficient specificity so that bids can be evaluated against specifications and criteria set forth in a solicitation for bid and if both of the following conditions are met:

- The CEC, at least 60 days prior to making an award pursuant to this subdivision [PRC 25711.5, subparagraph (h)(2)(A)], notifies the Joint Legislative Budget Committee and the relevant policy committees in both houses of the Legislature, in writing, of its intent to take the proposed action.
- The Joint Legislative Budget Committee either approves or does not disapprove the proposed action within 60 days from the date of notification.

Solicitation Process

Solicitations are developed in alignment with one or more strategic initiatives identified in one or more of the EPIC Investment Plans. Solicitation objectives are designed to remove specific clean energy deployment barriers and are mapped to achieve specific clean energy goals. These objectives are typically derived from a roadmap, through stakeholder workshops, responses to questionnaires sent to stakeholders on the EPIC Listserve, or from expertise gained in current research projects.

Once a solicitation is developed, it is publicly noticed through a number of available listserves and posted on Empower Innovation to encourage potential applicants to use the platform to find partners and encourage collaboration among interested stakeholders. The solicitation, either a Grant Funding Opportunity (GFO) or a Request for Proposal (RFP), is posted on the CEC's website with all the information necessary to apply, including the solicitation's objectives, requirements, scoring criteria, application form, and all other necessary templates. Each solicitation will identify the terms and conditions to be used in the solicitation.

The vast majority of EPIC agreements are awarded through a competitive grant (i.e., GFO) process; thus, the discussion below is focused on that solicitation type. EPIC funds awarded through a competitive contract process (i.e., RFP) largely align with the GFO process; there are additional requirements placed on the contract process that require the CEC to adjust the solicitation process.

Shortly after a solicitation has been posted, CEC staff will hold a publicly noticed workshop to review the solicitation purpose, requirements, eligibility, and research topics with interested parties. The public workshop will provide an opportunity for potential applicants to ask questions on the solicitation and the application process. There will also be an opportunity for interested parties to submit written questions about the solicitation. The staff's responses to all questions will be posted on the CEC website to ensure that all potential applicants have access to the same information. Any revisions, corrections, and clarifications on the solicitation will also be posted on the CEC website and announced through the appropriate listserve(s). An estimation of a typical one-phase solicitation schedule is shown in Table 4.

Table 4: Solicitation Timeline

Estimated Solicitation Schedule	Approximate Timeline (calendar days)
Solicitation Release	Day 0
Pre-Application Workshop	Day 18
Deadline for Written Questions	Day 20
Post Questions, Answers and Addenda to Website	Day 50
Deadline to Submit Applications	Day 80
Post Notice of Proposed Awards	Day 130
Business Meeting Date	Day 240
Agreement Start Date	Day 270

Source: California Energy Commission

Some solicitations may use a two-phase selection process. The first phase involves preparing a brief abstract to determine technical merit. The abstract will be evaluated on a pass/fail or scoring scale basis according to specific criteria. The abstract must pass all criteria (if using pass/fail basis) or achieve a minimum score on all criteria (if using a scoring scale) to proceed to the second phase and submit a full proposal. The full proposal will be evaluated in the same manner as a proposal for a one-phase solicitation.

Once the scoring for a solicitation is complete the proposals will be ranked and a Notice of Proposed Award (NOPA) will be released showing the rank of each proposal based on overall proposal score, applicant name, funds requested, and CEC staff's recommended funding amount, match funding, and score status. Funding will first be awarded to the top-ranked proposal and then to the next-ranked proposal(s) until all funds have been expended.

After the NOPA is released, all the applicants will be notified of the results and a CEC representative will begin working with the awardees to develop an agreement for the awarded project. Once the agreement is finalized, it will be presented and voted on at a CEC Business Meeting. If approved at a CEC Business Meeting, the contract will be signed by all parties and work may begin on the project.

The EPIC 3 Investment Plan[104] provides more detail on the CEC's solicitation process including a sample NOPA, information on one- and two-phase solicitations, and screening and scoring criteria.

Project Management

A project agreement establishes a contractual relationship between the CEC and the recipient of EPIC funds. A Commission Agreement Manager (CAM) will be assigned to the project and will be responsible for coordinating with funding recipients and serving as the CEC's point of contact for stakeholders interested in receiving more information about the project. The CAM also provides technical oversight of the project, reviewing and providing feedback on all deliverables, and ensuring that the project adheres to the scope and schedule that was agreed upon by the CEC and the recipient.

All EPIC recipients will be required to participate in kick-off meetings to establish deliverable expectations, roles and responsibilities, accounting procedures, and reporting requirements; submit monthly or quarterly progress reports to ensure the contractor is complying with the task schedules specified in the project agreement; and provide final documentation in the form of data, engineering plans, final construction and operation of facilities, or final reports documenting research results and other agreement deliverables.

EPIC projects will typically include a technical advisory committee (TAC). These committees may be composed of diverse professionals, academics, technology experts, and regulatory specialists. The TAC can provide valuable perspective and guidance on the project related to the direction of the project, the content of deliverables, and relevant information dissemination and market strategies. The number and composition of the committee members can vary depending on potential interest and time availability. The recipients will be responsible for proposing TAC members for the project, and reaching out to form the TAC; however, the committee members will serve at the discretion of the CAM.

EPIC projects will also usually include at least one critical project review meeting at a pre-designated milestone(s) in which the CAM will review the progress to date, determine whether it justifies proceeding to the next phase of the project, and make necessary corrections to ensure

[104] https://efiling.energy.ca.gov/getdocument.aspx?tn=217117

project success. CAMs may also call a critical project review at any time during the project, if the CAM believes there is a significant issue with the progress or administration of the project that needs discussion and could result in a change to the project or its termination. This is an important management tool for projects that do not meet their initial goals and need decisions on whether to terminate or re-scope a project based on interim findings.

Terms and Conditions

The agreement's terms and conditions set forth the recipient's rights and responsibilities. When submitting a proposal, the applicant must sign the application form whereby the applicant agrees to use, without modification, the version of the EPIC grant or contract terms and conditions[105] that correspond to their organization.

Intellectual Property

Intellectual property (IP) refers to products of the mind protected by law such as copyrights, trademarks, and patents. One of the basic benchmarks of any RD&D program is whether it results in new, commercially successful technology. IP rights play a significant role in commercialization. For example, IP rights that inappropriately share ownership or make proprietary information public would prevent the commercialization of new technologies. An entity would no longer have a competitive advantage, and thus the impetus for developing new technologies would be reduced. However, IP rights must also allow the sharing of new scientific knowledge, which fosters further advances and prevents duplicative research, which in turn preserves RD&D funds for new research.

Details of the standard IP rights under EPIC can be found in the EPIC Standard Grant Terms and Conditions, Sections 20 – 22.[106] These were developed with the directions in the CPUC's D.13-11-025 and PRC Section 25711.5. The following are some key areas:

- As directed by statute, the CEC consulted with the California State Treasurer's Office in developing the IP terms.

[105] EPIC terms and conditions are available at https://www.energy.ca.gov/funding-opportunities/funding-resources.
[106] https://www.energy.ca.gov/sites/default/files/2020-02/EPIC_Standard_Grant_Terms_and_Conditions_ada.pdf

- Each EPIC RD&D project needs to identify the IP that it will create in the form of new technology, advances in existing technology, or advances in scientific knowledge, and how the new IP will benefit the contributing ratepayers.
- In general, the rights of IP developed under EPIC will be held by the entity developing it. The CEC and the CPUC have licenses to use the IP to benefit EPIC ratepayers.
- The CEC will have march-in rights to take IP that entities develop with EPIC funds but do not use. This will protect the ratepayers' investment in the IP and ensure that the benefits from the developed IP are received.
- IP derived from EPIC-funded general energy research that is geared toward new knowledge rather than product development should be put in the public domain, made publicly available, or if kept by the entity, used such that the results are made public (for example, the University of California or national labs might keep the copyright to research papers, but then publish the results to make them known and available). This advances science and prevents other entities from performing duplicative research.
- Royalties will be collected as indicated in Section 22 of the aforementioned terms and conditions.

The CEC is authorized to grant load-serving entities (LSEs), which include IOUs, a free license to use EPIC-funded models and analytical tools that can inform distribution planning and decision-making that benefits electric ratepayers. The licenses allow LSEs to utilize EPIC-funded IP in their service to EPIC ratepayers. More information on IP can be found in the EPIC 3 Investment Plan.

EPIC Program Benefits

The CEC measures EPIC program benefits at the program, portfolio, and project levels. Because realizing the full impact of clean energy innovations can take several decades, the CEC assesses both achieved and projected benefits. Ratepayer benefits are embedded in each aspect of the CEC EPIC funding lifecycle:

- Initiatives in each EPIC Investment Plan are developed to benefit electricity ratepayers and lead to technological advancement and breakthroughs to overcome the barriers that prevent achieving the state's statutory energy goals.

- Within the scope of each approved EPIC Investment Plan, the CEC designs competitive solicitations with strategically focused requirements to address high-priority technical performance and cost reduction challenges.
- Scoring criteria for submitted proposals include impacts and benefits for California electric IOU ratepayers, including:
    - Estimates for energy benefits, such as annual electricity savings, energy cost reductions, peak load reduction and/or shifting, infrastructure resiliency, infrastructure reliability. Estimates for non-energy benefits, such as GHG emission reductions, air emission reductions (e.g., NOx), water savings and cost reduction, and/or increased safety.
    - Expected financial performance at demonstration scale, such as payback period or return on investment.
    - Specific programs which the technology intends to leverage, such as feed-in tariffs, rebates, demand response, storage procurement; and extent to which technology meets program requirements.
    - For demonstration projects, the scoring criteria also measure benefits to disadvantaged/low-income communities and localized health impacts.
- TAC members are selected to include potential end users to ensure the project is informed by their concerns.
- A summary of anticipated advancements is prepared through a draft benefits questionnaire as a project begins.
- Meetings with the TAC and critical project reviews assess whether each project is on track to achieve anticipated benefits.
- Completion of a final benefits questionnaire summarizes achieved project-level performance metrics. These data are also used as input into portfolio-level assessment of progress on key barriers, such as improved interoperability, functionality, efficiency, and safety.
- Annual survey of completed projects updates information on follow-on funding, commercialization, and other key performance indicators. These data are used to measure the overall success and impact of the CEC EPIC Program to advance technology

development and commercialization; technology diffusion; knowledge generation and dissemination; diversity, equity, and inclusion; and economic impact.

Benefits are quantified differently, depending on the technology stage or project type. For example, success for a technology in the pre-prototype stage may entail successful validation at the lab scale and using the results to secure additional public and/or private funding to further develop and scale the technology. Success for a technology at the full-scale demonstration stage includes, but is not limited to, identifying and overcoming scale-up challenges, successfully validating the real-world performance of the technology, and using the results to prove-out the technology's merits to customers and policymakers.

Metrics and Areas of Measurement

CPUC Decision D.12-05-037[107] determined the primary and mandatory guiding principle of the EPIC Program is to provide electricity ratepayer benefits, defined as promoting greater reliability, lower costs, and increased safety. In addition, the CPUC adopted these complementary guiding principles:

- Societal benefits
- GHG emissions mitigation and adaptation in the electricity sector at the lowest possible cost
- The loading order[108]
- Low-emission vehicles/transportation
- Economic development
- Efficient use of ratepayer monies

CPUC Decision D.13-11-025 modifies the EPIC administrators' investment plans by adopting a list of proposed metrics and potential areas of measurement "that may be evaluated and/or measured in preparing solicitation materials, performing project work, assessing project results, and preparing annual reports for the EPIC Investment Plans." The decision states that EPIC

[107] https://docs.cpuc.ca.gov/PublishedDocs/WORD_PDF/FINAL_DECISION/167664.PDF

[108] The state's "loading order" was adopted in the 2003 Energy Action Plan, establishing the preferred or priority set of resources and technologies on which the state should rely in the provision of energy services. Energy efficiency and demand response are the resources of first choice, followed by renewable energy, followed by clean fossil generation, if necessary.

Administrators "may choose metrics on a project-by-project basis from those included as Attachment 4 or additional metrics where appropriate. However, the Administrators must identify those metrics in the annual report for each project." The following proposed measurement areas are identified in the list adopted by the CPUC for the EPIC Program:

- Potential energy and cost savings
- Job creation
- Economic benefits
- Environmental benefits
- Safety, power quality, and reliability (equipment, electricity system)
- Other metrics (to be developed based on specific projects through ongoing administrator coordination and development of competitive solicitations)
- Identification of barriers or issues resolved that prevented widespread deployment of technology or strategy
- Effectiveness of information dissemination
- Adoption of EPIC technology, strategy, and research data/results by others
- Reduced ratepayer project costs through external funding or contributions for EPIC-funded research on technologies or strategies

Consistent with EPIC requirements set by the CPUC and the Legislature, the CEC staff will identify the barriers or issues each project aims to resolve and select measurement areas and metrics to be applied for each project. These metrics will be based on the barriers addressed, type of project and technology, energy-use sector, the specific project funded, and the project's development stage in the energy innovation pipeline. The CEC staff notes the close connection of energy savings, cost savings, job creation, and economic benefits. Table 5 shows an example of three project performance metrics.

Table 5: Example of Performance Metrics for a CEC EPIC Project

Performance Metric	Metric Category	Performance Metric Unit	Benchmark Performance	Current Project Performance	Minimum Target Performance	Goal Target Performance	Evaluation Method	Significance of Metric
Electrolyzer specific energy consumption	Energy - Energy efficiency and generation related	kWh/kg	50-70	20.00	15.00	10.00	Controlled experiment with data analysis and modeling	Reduction of specific energy consumption to levels below 15 kWh/kg H2 is necessary for this technology to have an advantage over conventional water electrolysis, with energy consumption of greater than 50 kWh/kg.
Production rate of hydrogen for energy storage	Technology - Industry standards and barriers being advanced	mA/cm^2	NA	200.00	300.00	400.00	Controlled experiment with data analysis and modeling	Increase in rate of hydrogen (and thus energy) production is necessary to ensure AES can meet the energy consumption demands of the end user. No data available for determining a benchmark performance.
Round-trip electrical efficiency	Energy - Energy efficiency and generation related	%	25-36	50.00	60.00	80.00	Controlled experiment with data analysis and modeling	A high overall roundtrip efficiency is necessary to reduce AES operating costs and ensure that AES is economically competitive.

Source: CEC staff

The CEC staff is actively working to simplify and streamline the benefits assessment process by developing new recipient surveys and tools that will use industry-standard performance metrics and incorporate information on California's diverse climates and end users as a complement to measures of success related to project-specific goals and objectives. It is the aim of this effort to simplify the benefits evaluation process for innovators and enable more robust benefits analyses that can be used to compare directly the benefits of one technology or advancement to another.

Table 6 shows an example of key barriers addressed by a portfolio of CEC EPIC-funded electric vehicle-grid smart charging technologies.

Table 6: Example of Barriers Addressed by CEC EPIC-Funded Vehicle-Grid Technologies

The following key is used:
● - successfully demonstrated the research or technology in a real-world environment in real-world conditions.
◒ - successfully demonstrated the research or technology in a controlled or simulated environment such as a laboratory setting.
○ - project has the potential to address the challenge or barrier but is still in progress.

Project	Use case(s) explored	Charger segment Vehicle segment	This project evaluated and informed standards to enable greater interoperability	This project advanced power flow algorithms for managed and/or bi-directional charging	This project developed new charger power electronics with greater functionality, efficiency, and/or safety
Demonstrating Plug-in Electric Vehicles Smart Charging and Storage Supporting the Grid (EPC-14-056)	Time-of-Use (TOU) optimization Demand reduction Vehicle-to-grid	Public, Fleet/ Light-duty	●	●	●
Smart Charging of Plug-in Electric Vehicles with Driver Engagement for Demand Management and Participation in Electricity Markets (EPC-14-057)	TOU optimization Demand reduction Proxy Demand Response (PDR) market	Public, Fleet/ Light-duty	●	●	
Next-Generation Grid Communication for Residential Plug-in Electric Vehicles (EPC-14-078)	TOU optimization	Residential/ Light-duty	●	●	
Distribution System Aware Vehicle to Grid Services for Improved Grid Stability and Reliability (EPC-14-086)	Vehicle-to-grid	Residential, Public, Workplace/ Light-duty	◒	◒	◒

Source: CEC staff

The CEC will leverage a suite of tools and analysis developed by Industrial Economics Inc. to estimate portfolio benefits that address the guiding principles of EPIC, such as the following:

- On-bill energy savings
- Increased safety, reliability, and resiliency
- GHG reductions
- Increased equity
- Improvements in cost of technology

Program-level benefits of the CEC EPIC Program are grouped into the following categories: technology advancement and commercialization; technology diffusion; knowledge generation and dissemination; diversity, equity, and inclusion; and economic impact. Table 7 shows examples of benefits from CEC EPIC investments.

Table 7: Quantifiable Benefits of CEC EPIC Investments by Impact Category

Impact Category	Quantifiable Benefits through 2019
Technology Advancement and Commercialization	• Companies that have received EPIC funding or support have leveraged EPIC's initial investment to raise over $2.2 billion in follow-on private investment through 2020 collectively. • EPIC recipients were able to leverage their EPIC awards to attract nearly $180 million in federal and state (non-EPIC) funding. • More than 34 technologies and related services companies have been successfully commercialized. • 5 companies supported by EPIC have executed successful exits, defined as a merger, acquisition, or secondary transaction. This is a significant measure of market interest in the technologies developed in EPIC.
Technology Diffusion	• 34 EPIC projects have improved the effectiveness of energy-related codes and standards: a key tool to enabling widespread diffusion of new technologies and data-driven practices. • 5 of these projects could lead to over $1 billion in annual energy cost savings if adopted in regulatory codes. • The CEC has built an extensive EPIC network with over 1,800 people representing a broad and diverse set of stakeholder groups critical to meeting the program's multiple objectives. • CEC EPIC funding has reached over 580 organizations, which include entrepreneurs, startups, CBOs, universities, national labs, project developers, local governments and nonprofits, at over 650 sites throughout California.

Knowledge Generation and Dissemination	• EPIC Annual Symposium in-person attendance grew from roughly 100 in the first year (2015) to nearly 1,000 in 2020. • Through 2020, results of CEC EPIC-funded projects have been published in more than 460 academic publications with more than 2,900 citations. • EPIC projects have been viewed over 120,000 times by over 9,000 users on the CEC's online project database, the Energy Innovation Showcase. • EPIC projects have advanced 17 tools that make complex information and data more accessible, scalable, lower-cost to use. • These tools are estimated to have over 700,000 users.
Diversity, Equity, and Inclusion	• 65 percent of the CEC's TD&D funds have gone to projects located in and benefitting low-income or disadvantaged communities as defined by SB 535 and CalEnviroScreen. • Although not a program requirement, through 2020, more than $17 million have gone to projects located in and benefitting a tribal community, including the world-renowned microgrid at the Blue Lake Rancheria. • 19 percent of EPIC agreements include a woman-, minority-, or LGBTQ-owned business as the prime recipient or a subcontractor. • CEC staff have participated in nearly 100 outreach and community events to promote knowledge about EPIC funding opportunities.
Economic Impact	• $7 billion in economic output projected by 2024 from EPIC investments from 2014 through 2019, including CEC EPIC encumbered funds and matching/follow-on funds (IMPLAN* analysis) • More than 34,000 job years projected by 2024 from EPIC investments from 2014 through 2019, including CEC EPIC encumbered funds and matching/follow-on funds (IMPLAN analysis) • From a sample of 70 companies with fewer than 250 employees prior to their EPIC agreement, companies have grown their employment by approximately 31 percent, which is an average of 6.7 employees.

Source: California Energy Commission staff

* IMPLAN is a platform combining extensive databases, economic factors, multipliers, and demographic statistics with a highly refined, customizable modeling system. Economic impact analyses are built upon a foundation of the input-output model. See implan.com for more information.

Annual Reporting Requirements

The CEC will submit an annual report to the CPUC each year. Although these reports were only required through 2020, the CEC will voluntarily continue to provide them. As articulated in the CPUC Phase 2 Decision (D. 12-05-037), annual reports will provide a program status update, including all successful and unsuccessful applications for EPIC funding awarded during the

previous year. In addition, Senate Bill 96 (Stat. 2013) added section 25711.5 to the PRC, requiring the CEC to prepare and submit to the Legislature no later than April 30 of each year an annual report in compliance with Section 9795 of the Government Code. Including subsequent amendments, section 25711.5 requires the annual report to include all of the following:

- A brief description of each project for which funding was awarded in the immediately prior calendar year, including the name of the recipient and the amount of the award, a description of how the project is thought to lead to technological advancement or breakthroughs to overcome barriers to achieving the state's statutory energy goals, and a description of why the project was selected.
- A brief description of each project funded by the EPIC Program that was completed in the immediately prior calendar year, including the name of the recipient, the amount of the award, and the outcomes of the funded project.
- A brief description of each project funded by the EPIC Program for which an award was made in the previous years but that is not completed, including the name of the recipient and the amount of the award, and a description of how the project will lead to technological advancement or breakthroughs to overcome barriers to achieving the state's statutory energy goals.
- Identification of the award recipients that are California-based entities, small businesses, or businesses owned by women, minorities, or disabled veterans.
- Identification of which awards were made through a competitive bid, interagency agreement, or sole source method, and the action of the Joint Legislative Budget Committee pursuant to paragraph (2) of subdivision (g) for each award made through an interagency agreement or sole source method.
- Identification of the total amount of administrative and overhead costs incurred for each project.
- A brief description of the impact on program administration from the allocations required to be made pursuant to Section 25711.6, including any information that would help the Legislature determine whether to reauthorize those allocations beyond June 30, 2023.

In addition, CPUC D.15-04-020, Ordering Paragraph 6 requires the identification of any specific CPUC proceedings addressing issues related to each EPIC project. Regarding projects that

received follow-on funding, SB 115 Section 19 (Committee on Budget and Fiscal Review, Stats. 2020, Ch. 40s) specifies reporting requirements for the EPIC annual reports for 2020 and 2021. Further requirements are specified in D.13-11-025 and D.15-04-020 and summarized in Appendix A of the 2019 EPIC Annual Report.[109]

Dollars Spent on Program Administration

The CEC will monitor its administrative costs to manage the EPIC Program within the cap established by the CPUC in D.12-05-037 Ordering Paragraph 5. The dollars spent on program administration will be stated in the EPIC Annual Report. A possible administrative cap increase to 15 percent is being considered in Phase 2 of CPUC R.19-10-005.

Interim Investment Plan Development

To develop the Interim Investment Plan, CEC staff consulted regularly with the Commission's Energy Division staff on the scope and details of the draft research initiatives. In addition, the CEC presented draft research initiatives to the EPIC Working Group of the DACAG on December 7, 2020 and incorporated their input. The CEC edited the draft initiatives after considering technical comments from the Commission's Energy Division on early initiative concepts. After publishing the draft interim initiatives on January 4, 2021, the CEC held a virtual public workshop on January 6, 2021 to review the approach for developing the draft plan and the preliminary set of research themes and initiatives. The CEC considered and made edits to the draft based on public comments and questions received at the workshop as well as and those submitted to the CEC Docket (20-EPIC-01). Staff again revised the draft based on multiple sets of comments and questions received from Commission Energy Division staff following the workshop. Appendices B, C, and D contain summaries of the aforementioned comments and coordination. Public comments received by the Commission on this Motion and the Commission's Proposed Decision will also be considered.

EPIC 4 Investment Plan Development

The CEC will hold workshops in 2021 that will feed into the completion of the full EPIC 4 Investment Plan and will also consult with the DACAG. The CEC is also developing Empower

[109] https://ww2.energy.ca.gov/2020publications/CEC-500-2020-009/

Innovation events to seek input and engagement from communities, such as CBOs, tribes, local governments, and community choice aggregators. The CEC will release a draft EPIC 4 Investment Plan prepared in accordance with CPUC D.20-08-042 and provide opportunities for public comment prior to consideration of the plan for adoption at a CEC Business Meeting. The CEC will file an application with the Commission on October 1, 2021, seeking approval of the EPIC 4 Investment Plan.

The CEC's EPIC website (https://www.energy.ca.gov/programs-and-topics/programs/electric-program-investment-charge-epic-program) provides information and activities associated with EPIC funding, including information on past workshops, public comments, upcoming events, how to sign up for the EPIC listserve, and the latest documents associated with the program. The website also lists all active and closed solicitations, all the documents needed to submit a proposal, and notices of proposed awards for all solicitations.

As required by CPUC Decision D.12-05-037, the CEC will consult with interested stakeholders no less than twice a year, both during the development of each investment plan and during its execution. The CEC will invite members of the public to participate in stakeholder meetings. The following types of stakeholders will be consulted, at a minimum:

- Members of the Legislature, to the extent their participation is not incompatible with their legislative positions
- Government, including state and local agency representatives
- Utilities
- Investors in energy technologies
- California ISO
- Consumer groups
- Environmental organizations
- Agricultural organizations
- Academics
- Business community
- Energy efficiency community
- Clean energy industry and/or associations
- Other industry associations

Conclusion and Next Steps

The research initiatives presented in this Interim Investment Plan will ensure the CEC's EPIC Program continues to provide clean energy leadership and innovation necessary to carry out California's progressive energy policies and inform decisions and actions during the EPIC 4 Investment Plan's development. The initiatives were prepared with particular emphasis on enhancing equity and energy benefits to all Californians.

Through the public workshop, coordination with the Commission's Energy Division staff, public comments, and DACAG EPIC Working Group meeting in December 2020, the CEC gained valuable stakeholder input, which helped shape the funding initiatives proposed in this plan. If the Commission approves the Interim Plan, the CEC will prepare and issue solicitations to fund the identified initiatives. The CEC looks forward to implementing these EPIC projects in the interim and seeing them come to fruition for the benefit of ratepayers who fund this program.

The full EPIC 4 Investment Plan is due to the Commission in October 1, 2021, with possible approval expected in early 2022. The EPIC 4 Investment Plan will include a more diverse set of research initiatives shaped by additional stakeholder outreach afforded by the full plan-development cycle.

APPENDIX B: Disadvantaged Communities Advisory Group's (DACAG) EPIC Working Group Comments

Informal Meeting with the EPIC Working Group of the DACAG
Comments on Draft EPIC Interim Plan Initiatives
12/7/2020

Attendees: DACAG EPIC Subcommittee - Stephanie Chen and Roman Partida-Lopez; CEC Staff - Noemí Gallardo, Laurie ten Hope, , Mike Gravely, Abbi Jacob, Erik Stokes, Virginia Lew, Linda Spiegel, Dorothy Murimi, Jonah Steinbuck, and Misa Werner.

Proposed Initiative 1: Advanced Prefabricated Zero-Carbon Homes

DACAG EPIC Working Group Comments:

1. How do you plan to deploy and determine target pilots to make this a long-lasting effort?
2. How do you plan to scale up and have a life after the grant?
3. Since the median price for homes are different in every county, how do you plan to target particular areas? Will you be grouping communities?

CEC Response to Comments 1 and 2: Our objective is to have applicants partner with prefabricated home builders so that production of zero-carbon homes can be standardized to minimize cost and increase affordability. These standardized production methods and concepts then could be passed on to other builders. All CEC grants include a technical transfer element to facilitate sharing lessons learned and technology adoption. As part of the solicitation development, we will also explore including the requirement that the builder/developer prepare a business plan on how they intend to maximize production of homes post grant, and that the learnings would be shared with other builders. The business plans would be evaluated as part of the selection process to determine proposals that have the most potential for deployment after the grant. There is also the potential to make the business case with builders/developers currently selling Energy Star prefabricated homes to increase efficiency and reduce energy bills by

including PV and storage. To increase customer demand, we would inform participating communities of the benefits and costs of zero-carbon home ownership.

To ensure California manufacturers are able to adopt these designs without costly upgrades to their factories, these prefabricated home builders would be encouraged to use current factory equipment or propose low-cost upgrades that are TRL 9 or higher.

CEC Response to Comment 3: A possible metric is to focus on the construction cost and not include the land cost which could vary by location. The metric could focus on the lower price point for prefabricated construction versus conventional construction. During the solicitation development phase, we will consider locations/regions for the demonstrations/pilots that may have good potential for further deployment of the prefabrication techniques and technologies used during the grant. This will promote sustainability beyond the grant.

Proposed Initiative 2: Energy Efficiency and Demand Response in Industrial and Commercial Cold Storage

DACAG EPIC Working Group Comments:

Be sure this initiative covers small businesses—local markets and restaurants and small operators that are not associated with chains. Open it up to small commercial (and family-owned) businesses who need more help than the large industrial cold storage facilities.

CEC Response: We will establish two groups: one for large industrial cold storage businesses to include energy efficiency, use of low global warming potential (GWP) refrigerants and DR to enable shifting and shedding of refrigeration/freezer loads and the other for commercial businesses that mainly focus on energy efficiency, use low-GWP refrigerants, and reduce refrigerant leakage. DR will be optional for this second group and, small grocers can participate and install advanced refrigeration technologies that are efficient and use low-GWP refrigerants. This combination will result in reductions in overall GHG emissions.

Proposed Initiative 3: Energy Efficiency and Load Shifting in Indoor Farms

DACAG EPIC Working Group Comments:

Make sure you collaborate with other urban agriculturists who are interested, such as those in the San Diego area. Perhaps there is opportunity to connect researchers with these local farmers.

CEC Response: We welcome collaboration and obtaining contacts of potential farmers interested in doing urban agriculture.

Proposed Initiative 4: Optimizing Long-Duration Energy Storage to Improve Grid Resiliency and Reliability in Under-resourced Communities

DACAG EPIC Working Group Comments:

1. We are interested in the definition of long-duration energy storage.
2. We want to know if Native American tribes were included in the grant.
3. We are interested in the use of microgrids in disadvantaged communities and low-income communities.

CEC Response to Comment 1: There is not an industry-accepted definition for long-duration energy storage, however, for this research initiative, we are looking to demonstrate energy storage systems that can provide 12-16 hours of energy-storage duration, and when paired with renewables, can provide at least 24 hours of continuous power protection.

CEC Response to Comment 2: Native American tribal lands with high risk of power outages, located in established wildfire zones, and/or which have previously experienced PSPS events will be identified as part of the under-resourced community demonstration component of the initiative.

CEC Response to Comment 3: CEC staff provided some examples of current microgrid grant agreements involving Native American tribal lands to the subcommittee during the meeting; the most recognized is the Blue Lake Rancheria. During 2020, the EPIC Program's GFO-19-306 awarded five long-duration energy storage grants to Native American tribes; two of these grants included microgrids as part of their solution.

Proposed Initiative 5: The Role of Green Hydrogen in a Decarbonized California—A Roadmap and Strategic Plan

DACAG EPIC Working Group Comments:

1. We are very supportive of the research especially if it could address some of the air quality issues in disadvantaged communities and low-income communities.
2. Comments about making hydrogen vehicles accessible to disadvantaged communities.

CEC Response to Comment 1: CEC staff appreciates the supportive comments on this initiative and air quality assessment will be included.

CEC Response to Comment 2: The barriers and opportunities for hydrogen deployment in disadvantaged and low-income communities will be included in the plan. CEC staff discussed currently planned research efforts focused specifically on green hydrogen and mentioned that future initiatives will address more green hydrogen use in electric vehicles. Efforts by the CEC Fuels and Transportation Division are also addressing the addition of more hydrogen fueling stations in under-resourced communities; this issue is one of the limiting factors to the commercial growth of hydrogen fuel cell vehicles. The development of the future EPIC 4 Investment Plan is expected to consider potential research initiatives on the growth of hydrogen fuel cell vehicle use in under-resourced communities and how green hydrogen plays a part in that growth.

Proposed Initiative 6: Value of Resilience

No comments or questions.

Proposed Initiative 7: Vehicle-to-Building for Resilient Backup Power

DACAG EPIC Working Group Comments:

1. Consider focusing the initiative more directly on low-income and disadvantaged communities. The Central Valley, for example, has higher rates of low-income homeowners that could benefit from back-up power and also suffers from air-quality issues that diesel back-up generators exacerbate.
2. Consider opportunities for merging deployment efforts for vehicle-to-building technologies with clean vehicle incentive programs at the California Air Resources Board to provide packaged solutions low-income communities.

CEC Response to Comment 1: The initiative description has been revised to include an increased focus on under-resourced communities. Specifically, the Equity Consideration section was revised to (1) specify that twenty-five percent of demonstration project funding will be reserved for projects located in and benefitting disadvantaged and low-income communities and (2)

encourage use of public electric vehicles (e.g., transit buses) to provide resilience benefits at publicly accessible locations (e.g., community emergency shelters). Applicants will be encouraged to identify and partner with impacted communities, such as those that experience frequent Public Safety Power Shutoff events or suffer air quality and health impacts of fossil-fueled back-up generation. Non-demonstration activities located in and benefitting low-income and disadvantaged communities would also receive additional preference in proposal scoring.

CEC Response to Comment 2: The pairing of vehicle-to-building and clean vehicle incentive programs is a promising avenue for spurring broader, more inclusive adoption of vehicle-to-grid technologies and electric vehicles. This is now highlighted in the initiative description as a policy development opportunity that could follow successful technology development and demonstration, which is the focus of the initiative. The initiative description now includes: "Successful projects would advance products to commercialization enabling V2B with equal performance and lower cost than available alternatives and could inform development of future policies and programs that incentivize zero-emission vehicle deployment."

Proposed Initiative 8: Offshore Wind Energy Technologies

DACAG EPIC Working Group Comment:

Could offshore wind provide similar grid services as existing peaker plants?

CEC Response: Future offshore wind could provide a complementary daily generation profile to solar, offering a valuable resource that can help meet net (of solar) load requirements important to ensuring reliability, which existing peaker plants help meet today. However, since offshore wind energy is an intermittent resource, it would not provide dispatchable ramping generation in the same way as existing peaker plants.

Proposed Initiative 9: Entrepreneurial Ecosystem

DACAG EPIC Working Group Comment:

Partners of CalSEED raised concerns about CalSEED, expressing that the program's primary focus is on innovation and does not put enough emphasis on equity.

CEC Response: The CEC issued the solicitation for the CalSEED program with the primary focus being on innovation. While innovation was the primary focus, CEC staff built in objectives

into the program to address diversity and equity by setting a target for a minimum of $4 million to go to entrepreneurial companies representing under-represented businesses and/or from under-resourced communities. While CalSEED is on track to meet and exceed that target, CEC staff recognize there are additional opportunities to better incorporate equity into the program while still maintaining EPIC's statutory direction to support energy technology and scientific advancements. Since learning about the issue, the CEC has had multiple conversations with CalSEED Managers, to listen, learn more about, and discuss their recommendations for better incorporating equity into CalSEED. Through these conversations, the CEC has identified two recommendations on which staff plans to work with the CalSEED administrator to implement. In addition, the CEC plans to have additional discussions with community stakeholders to determine whether other improvements to CalSEED 2.0 can be made.

APPENDIX C: CEC and CPUC Energy Division Staff Coordination on Proposed Interim Initiatives

The CEC and CPUC Energy Division staffs consulted on the EPIC Interim Investment Plan approach, schedule, and technical content through regular meetings and via email November 2020 through February 2021. In December 2020, CEC staff shared a draft of proposed initiatives with CPUC Energy Division staff for input ahead of the CEC public workshop and considered CPUC staff input in the summary of initiatives released on January 4, 2021. After the public workshop held on January 6, 2021, CPUC staff provided three additional sets of comments and questions, which CEC staff evaluated for incorporation into the plan. There were also conference calls held with CPUC staff to discuss their comments and seek deeper cross-agency understanding. This appendix summarizes the CPUC staff comments, which CEC staff incorporated into the plan, organized by topic. CEC staff thank the CPUC staff for their thoughtful comments, which helped improve the final proposed plan.

Administration

- Explained the general timelines expected for the projects.
- Included DACAG meeting feedback
- Clarified the term "under-resourced"
- Described the Energy Equity Outreach proposal
- Clarified how CEC designs and tracks disadvantaged and low-income community benefits as well as other research-benefit types

Initiative 1 – Advanced Prefabricated Zero-Carbon Homes

- Clarified the expected business-case deliverable to include workshops/webinars to inform additional communities, beyond the EPIC demonstrations, of benefits of zero-carbon homes

Initiative 2 – Energy Efficiency and Demand Response in Industrial, Agricultural, and Commercial Cold Storage

- Clarified why these projects are a priority for both resilience in the short term and GHG reductions in the mid term

- Clarified anticipated potential to load shift and shed and reduce grid impacts during periods of stress
- Clarified equity considerations and job benefits

Initiative 3 – Energy Efficiency and Load Shifting in Indoor Farms

- Clarified why these projects are a priority in a market sector that is expanding and is more energy intensive than field-based agriculture
- Clarified anticipated benefits and potential to load shift
- Clarified equity considerations and job benefits

Initiative 4 – Optimizing Long-Duration Energy Storage to Improve Grid Resiliency and Reliability in Under-resourced Communities

- Included the relative risk of power outage in the targeting of under-resourced communities

Initiative 5 – The Role of Green Hydrogen in a Decarbonized California – A Roadmap and Strategic Plan

- Clarified equity considerations section

Initiative 6 – Valuation of Investments in Electricity Sector Resilience

- Confirmed that a suggested relevant paper was indeed referenced in the initiative

Initiative 7 – Vehicle-to-Building for Resilient Back-up Power

- Made revisions to background section (e.g., coordination with related efforts)

Initiative 8: Offshore Wind Energy Technologies

- Considered and clarified the scope of in-state manufacturing

Initiative 9: Entrepreneurial Ecosystem

- Included more background on the Entrepreneurial Ecosystem
- Clarified minimum equity-related targets

APPENDIX D: EPIC Workshop Docketed Comments (20-EPIC-01)

Organization / Name	Comment Excerpts[1]	CEC Staff Responses
Green Hydrogen Coalition	[a] GHC commends the CEC and staff's work in developing the Draft EPIC Interim Investment Plan 2021-2022 and strongly supports initiative #5: *The Role of Green Hydrogen in a Decarbonized California – A Roadmap and Strategic Plan*… Research or studies conducted under initiative #5 must be thorough and detailed. GHC recognizes that studying potential applications and scale of green hydrogen for decarbonization across several sectors is a complex and relatively new undertaking. As such, it is critical that initiative #5 receives the appropriately high level of funding and incorporates a key focus on aggregating demand for green hydrogen across various sectors in strategic locations. Cost reductions for green hydrogen can be achieved faster through simultaneously scaling up supply and demand. This means any	a. CEC staff (Staff) appreciate the supportive comments and will incorporate these recommendations in the grant funding opportunity (GFO) stage after plan approval. Regarding the comment on initiative #5 receiving a high level of funding, this roadmap is a paper study to help inform future research needs. Staff intends to hold a stakeholder workshop to help scope the focus areas addressed in the roadmap. b. The green hydrogen initiative was developed in support of SB 1369 and

1 To read the full text of docketed comments, visit **https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=20-EPIC-01**.

	study or research conducted under initiative #5 must address strategies for aggregating demand for green hydrogen across various sectors in strategic locations. A focus on strategic locations is important, as it will facilitate targeted repurposing of existing gas infrastructure as well as the development of new, dedicated hydrogen supply infrastructure. Both infrastructure pathways are essential to lowering the delivered cost of green hydrogen. Initiative #5 should incorporate an inclusive and meaningful stakeholder engagement process to support guide data collection, develop scenarios, and interpret results. The GHC hopes the study can address gaps from other recent decarbonization studies, such as the SB 100 Joint Agency Report, which did not model hydrogen as a drop-in fuel replacement due to inadequate cost and supply data. We acknowledge that these challenges exist, and believe that the CEC and any potential supporting research teams can overcome them by leveraging the collective expertise of the broader green hydrogen community. To do this, any research, study, or action plan developed under initiative #5 should incorporate opportunities for meaningful stakeholder engagement early and often with nonprofits, industry, government agencies, academic and research institutions, and other interested stakeholders. GHC recommends initiative #5 include a	uses the definition of green electrolytic hydrogen provided in that bill. The research under this initiative will look at alternatives to this definition and determine whether other green hydrogen concepts are compatible with SB 100 and SB 1369. c. SB 18 should be addressed through CEC's Office of Governmental Affairs. Staff cannot comment on pending legislation. We will follow the outcome of this bill and implement applicable elements if passed. We note that CEC's Fuels and Transportation Division is leading efforts on a Strategic Plan in support of SB 18. It is important to note that the schedule for SB 18 cannot be met with the EPIC Interim Plan (i.e.,

	focus on an inclusive stakeholder engagement process to guide data collection, develop scenarios, and interpret results, which we believe follows best practices in energy research and planning. [b] The GHC strongly urges the definition of green hydrogen in the Draft Interim Investment Plan be revised to include additional pathways for green hydrogen production, not just electrolytic green hydrogen as defined by SB 1369. In the Draft Interim Investment Plan, initiative #5 references green electrolytic hydrogen as defined in SB 1369 as "hydrogen gas produced through electrolysis and does not include hydrogen gas manufactured using steam reforming or any other conversion technology that produces hydrogen from a fossil fuel feedstock." In contrast, GHC defines green hydrogen broadly *as hydrogen that is not produced from fossil fuel feedstocks*. While this may include green electrolytic hydrogen, as noted in the Draft Interim Investment Plan and defined in SB 1369, it also includes hydrogen produced from eligible organic waste feedstocks via steam methane reforming, autothermal reforming, or methane pyrolysis of renewable gas as well as the thermochemical conversion of biomass. As such, the Interim Investment Plan should incorporate GHC's more inclusive definition of green hydrogen.	more time is required for plan approval, funding allocation processes, etc.). The estimated start time for these projects would be around June 2022.

	As a general recommendation, GHC believes EPIC should include funding for the demonstration of each of the various pathways of producing green hydrogen in California. Research and demonstration needs for biomass-based pathways to producing green hydrogen include: how to leverage existing processing infrastructure, testing facilities for pollution controls, methods for tracking environmental benefits, measuring volatile organic compounds ("VOC") emissions from steam reformation of biogas, comparing different biogas conversion technologies, determining optimal scale for biogas-to-hydrogen, and understanding of modular configurations and approaches. GHC recommends these R&D gaps be addressed in this or future EPIC funding cycles. <u>GHC recommends initiative #5 begin immediately to guarantee enough time to solicit the right expert research team and align with pending legislation.</u> The GHC recommends initiative #5 start as soon as possible to solicit an expert research consultant with experience in holistic energy systems modeling and a strong track record of fair, unbiased assessments, such as the National Renewable Energy Laboratory. Due to the relatively complex nature of a green hydrogen roadmap study, GHC expects the development of the solicitation, responses from qualified experts, and evaluation of	

	bids to take considerable time and resources. [c] Additionally, SB 18, recently introduced by Senator Skinner, would direct the CEC to submit to the legislature a report on potential green hydrogen applications and scale by June 1, 2022. As such, GHC recommends initiative #5 align with that timeline. GHC believes the anticipated long lead time for initiative #5 combined with the potential statutory directive under SB 18 merit immediate implementation of initiative #5.	
Tandem PV	We recommend that the CEC further accelerate next-generation solar technology commercialization by investing in public-private collaborations on common challenges to bring game-changing perovskite solar technology into the marketplace and help California reach its carbon and climate goals	Staff will consider next-generation solar (including perovskite) in its full investment plan for EPIC 4, considering opportunities to build on existing R&D under EPIC 3 on thin-film PV (e.g., CEC funded three projects involving perovskite manufacturing and perovskite-silicon tandem: two with UC San Diego [UCSD] and one with Tandem PV). Solar PV is an eligible area under the CEC BRIDGE and RAMP solicitations.

SineWatts	.. For the interim investment plan, proportional emphasis be given to pursue fundamental research for vehicle grid integration (VGI). When holistically constructed, V2G and V2B, as VGI, is the holy grail of distributed infrastructure for the grid and electric transportation. We request that due to its colossal significance, VGI merits a proportional funding allocation in EPIC's interim investment plan. Any setback in enabling and demonstrating the full potential of VGI will delay the adoption of the necessary standards by many years, making it almost impossible to meet California's 2030 objectives of true VGI deployment per the Senate Bill 676.	Staff will consider V2G R&D opportunities in its full investment plan for EPIC 4. V2G is an important technology area for meeting the state's goals for transportation electrification and grid reliability. In past research, we have pursued research on smart (or managed) charging (e.g., with ChargePoint, Nuvve, and SLAC). Staff welcome further input on specific VGI and VGI-enabling R&D needs. Staff continue to coordinate with sister agencies and stakeholders on VGI including SB 676 implementation.
Swift Solar	…recommends that the CEC leverage this opportunity to accelerate the CA-based production of next-generation thin-film solar technologies, by supporting collaborative CA-based efforts to solve common challenges in bringing perovskite technology to market.	Staff will consider next-generation thin-film solar in its full investment plan for EPIC 4, considering opportunities to build on existing R&D under EPIC 3 on thin film (four projects, with Tandem PV, UCLA, and two with UCSD). Solar PV is an eligible area under the CEC BRIDGE and RAMP solicitations.

Wind Harvest International	EPIC Interim Investment Plan - *Validating near-ground wind speeds in existing wind farms and California's wind resource areas and improving LCOEs* Encourages the CEC to use EPIC 2021-22 funds to do the following: ● Evaluate old wind speed data and other resources to determine the value of the near-ground layer of wind below 100 feet that blows through the state's Wind Resource Areas. Our studies show that over 15,000 MWs of capacity could be added to these areas if much shorter turbines were available for purchase. ● Work with NREL and the renewable energy industry to produce Levelized Cost of Energy calculations and give the utilities, the industry and state decision makers a key tool they need to plan to plan and support the lowest cost, 100% renewable energy sources and produce the most positives for ratepayers, disadvantaged communities, wildlife habitat and local economies as possible. We propose that the CEC hire meteorologists such as Rich Simon who have near-ground wind speed data in these areas that can be used to validate the UL analysis in more detail and accuracy than we can afford to do. A report could be quickly completed because no additional field data should be needed to confirm our maps. The maps would help wind industry and property owners value near-ground wind resources. Ideally a positive report would be used to	Staff will consider the proposed assessments and tool for the full investment plan for EPIC 4. Staff notes however that the value proposition and R&D need of near-ground wind assessment will need to be clarified to justify investment. Wind resource potential and quality improves with height and, in recent years, U.S. DOE and NREL have focused on assessments of tall wind due to the superior generation potential. Note that EPIC has funded a project in the environmental research area that developed an improved methodology for capturing wind vectors (speed and direction) at a variety of elevations, both surface and near-surface (EPC-16-063). Two new projects (EPC-20-006 and EPC-20-007) under EPIC 3 are leveraging the results from that project

	support CEC and DOE grant funding in 2023 and beyond to help the manufacturers and developers of near-ground wind turbines and projects conduct the following research that will be needed before the full potential of near-ground wind resources can be used for the benefit of utility ratepayers. Lastly, we want to address the potential that these near-ground wind resources will benefit state ratepayers. Using existing Levelized Cost of Energy Analyses to compare different renewable energy options for the decade to come is rife with problems. [comment includes data tables]	to improve understanding of climate-related changes to wind (speed, direction) in California.
SDG&E	…high-level comments: • Increased transparency on initiative funding allocation and selection criteria should be included, • Investment initiatives should focus on providing incremental value to existing efforts, • Research for technology recycling could help promote circularity and avoid a hazardous waste management catastrophe down the road. Two elements, key to advancing the State's Energy Transition goals. • Expanding criteria of community impact is a welcomed approach, and • Recommended adjustments to proposed initiatives [below]	High-level comments and a. CEC's final Motion for the Interim Plan will include funding amounts by research program type (i.e., applied R&D, technology demonstration and deployment, market facilitation). EPIC investment plans are designed to be flexible because sometimes not all initiatives get fully funded and funding amounts can change after plan approval. Therefore, the detailed funding breakdown by initiative is developed after plan

	[a] Increased transparency on initiative funding allocation should be included The DRAFT Proposed EPIC Interim Investment Plan 2021 notes the "authorized budget of $147.26 million per year for the first investment cycle of January 1, 2021 through December 31, 2026." The Plan notes that under-resourced communities will receive dedicated funding, anywhere from 25 percent up to 100 percent within an initiative's funding but fails to discuss details regarding funding levels for each of the nine identified initiatives proposed within the Plan. The lack of transparency around selection criteria and funding allocation creates concern around whether the initiatives appropriately follow the guiding principle of the EPIC program of providing net benefits to electric ratepayers. SDG&E recommends that the CEC include proposed funding allocations to each initiative for public and stakeholder comment prior to submitting the plan for approval by the California Public Utilities Commission (CPUC). [b] *Proposed Initiative 6 – Valuation of Investments in Electricity Sector Resilience* would contribute to the development of methods for valuing public benefits of customer and grid resilience	approval, in the solicitation phase. The solicitation process is described in the Administration Section of the Interim Plan. Investment initiatives are focused on providing incremental value to existing efforts. The key selection criteria shaping Interim Plan research include: o Addresses key state policy priorities o Near-term importance to the state o Builds on stakeholder-vetted EPIC 3 Investment Plan o Supports under-resourced communities o Builds on learning from the 380+ projects in the CEC EPIC portfolio Ratepayer benefits assessment is discussed in the Administration Section of the Interim Plan. b. Staff respectfully decline the recommendation to remove the proposed

	investments. On January 14, 2021, the CPUC approved the proposed decision in Track 2 of the Microgrid Order Instituting Rulemaking (R.) 19-09-009 (Microgrid OIR) which included directing the CPUC's Energy Division Resiliency and Microgrids Working Group to examine the "costs and value propositions of microgrids." As identified in the decision, microgrids involves many cross-overs with other policies and as such, a siloed effort within this plan would detract from participation in ongoing efforts directed by the CPUC to occur at the same time as the timing of this Plan. To offer a multi-faceted and cross-over policy approach as envisioned by the CPUC "to establish a consistent policy framework", SDG&E recommends that the efforts in this proposed initiative be removed from the Plan and instead directed towards the CPUC's Resiliency and Microgrids Working Group's efforts to determine the value of resiliency within the context of the Microgrid OIR. [c] Research for technology recycling could help promote circularity and avoid a hazardous waste management catastrophe down the road The draft 2020 IEPR Volume I recommends: "the CEC should continue to fund and explore opportunities for second-life batteries and battery recycling." Battery recycling or any type of recycling seems to be missing from this Investment Plan. As many of the solar	initiative. The proposed research initiative builds on stakeholder-vetted and CPUC-approved initiatives in the EPIC 3 Investment Plan and has a broader scope and different focus from the CPUC's efforts within the context of the Microgrid OIR. The proposed initiative will consider societal benefits and its findings will extend to technologies and grid resilience investments beyond microgrids. c. Recycling and end-of-life management of energy technologies remain a priority for CEC EPIC investments. The topic was not included in this interim investment plan in part because, in the past year, the CEC released two separate funding opportunities focused on end-of-life strategies for clean energy technologies, specifically: 1) demonstrating plug-in electric vehicle (PEV) battery second use,

	panels installed during the initial years of the California Solar Initiative are approaching their end of life, California will have an increasing issue with solar panel disposal. The CEC should invest in research to reduce the amount of waste that goes into landfills from these technologies and increase reuse and recycling. Battery storage have an even shorter useful life and so the vehicle and station batteries installed five or so years ago may reach the end of their useful life in the next couple years and again will create problems on disposing of them. The CEC should create a focused initiative that promotes solar and battery recycling. [d] Upgrading electrical infrastructure and investing in new technologies Wildfire is one of the most pressing hazards threatening a resilient electrical grid – throughout California. SDG&E is implementing several fire mitigation strategies that aim to harden and upgrade existing and future infrastructure. Some of these include programs to leverage wind and meteorology data to improve design criteria, replace #4 and #6 copper conductors, upgrade wood poles to steel poles, install additional overhead SCADA sectionalizing switches, perform pole loading calculations, coordinated strategic use of data from fault indicators and other data sources to more rapidly locate	and 2) advancing lithium-ion battery recycling processes. • The battery second use solicitation evaluates opportunities to extend the useful life of PEV batteries by repurposing them after primary use in a vehicle and redeploying them as stationary storage paired with onsite solar at commercial sites. (see https://www.energy.ca.gov/solicitations/2020-02/gfo-19-310-validating-capability-second-life-batteries-cost-effectively) • The battery recycle solicitation seeks to advance technologies that recover more valuable materials from batteries at end of life and introduce recovered materials directly back into battery manufacturing to avoid upstream impacts (see

	electrical faults, and support future growth of falling conductor protection. Additionally, the utility is strategically undergrounding lines in high-risk areas, avoiding the use of SF6 gas – where possible – in circuit breakers and distribution switches, and plans to pilot a Virtual Power Plan (VPP) that further expands and leverages available distribution-level demand response (DR), flexible load management as a means to reduce GHG emissions, advance resource adequacy and enhance grid resiliency. Investing in research beyond what utilities are doing/proposing in their grid hardening plans will be critical for supporting climate resiliency and wildfire mitigation, especially as the probability and intensity of wildfires in California grows in the coming decades. [e] Expanding criteria of community focus is a welcomed approach The Plan appears to identify "under-resourced communities" as disadvantaged, low-income communities, and Native American tribes. We support and appreciate the expansion of targeted communities of concern to include low-income and tribal communities, since these communities are the exact communities that deserve attention in a just and equitable energy transition in California. This expansion mirrors the strategy taken by the California legislature in Assembly Bill 841 Section 1 and in the	https://www.energy.ca.gov/solicitations/2021-01/gfo-20-308-research-and-development-high-value-recycling-pathways-lithium-ion). Battery reuse and recycling will continue to be considered for the full investment plan for EPIC 4. Staff also continue to engage with sister agencies and stakeholders, for example participating in meetings of the Lithium-ion Carb Battery Recycling Advisory Group. d. Wildfire risk. Through EPIC, CEC has advanced applied research to support strategic, cost-effective deployment of technologies to improve situational awareness of wildfires, to provide historical weather and projected climate data as a scientific foundation for understanding how wildfire-related risks are changing, and to improve our

	CEC's Senate Bill 1000 report, where it was shown seems to serve as a strong proxy for both disadvantaged communities and race. In the Plan, the discussion around under-resourced communities was focused more on how each initiative could support these communities but did not offer any specifics to help determine which communities may qualify as under-resourced. SDG&E is interested in hearing more about the specific criteria that would qualify a community as "under-resourced" in the CEC's Plan to be filed for approval by the CPUC. Consistency in definitions when evaluating the needs of communities of concern is key to ensuring that climate justice and equity concerns are fully addressed and proposed solutions are appropriately designed to fulfil local community needs, which vary across the region... [f] *Proposed Initiative 3 – Energy Efficiency and Load Shifting in Indoor Farms* is focused on demonstrating pre-commercial technologies, hardware systems, control systems, and operational procedures of a digitized indoor farm that would increase energy efficiency and develop the potential to shift load. Farming in an urban setting can promote education, provide fresh produce to those in under-resourced communities, and lessen energy	understanding of Wildfire behavior in unprecedented conditions. For example, in 2019, the CEC initiated an EPIC-funded project ($5M) aimed at developing next-generation wildfire models for grid resiliency and safety. The project seeks to advance wildfire modeling with regard to extreme weather and wind events, the effects of widespread tree mortality, the dynamics of vegetation/fuel with climate change, and fire behavior in the wildland-urban interface (see EPC-18-026). Further, the CEC's recent approval of two EPIC-funded projects ($5M total) will support the development of downscaled climate projections, stakeholder-informed analytics, and a data platform. This research will support electricity sector stakeholders' ability to anticipate and adapt to climate and weather-related

	costs as fewer air conditioners will be running as these efforts can reduce "urban heat islands" as identified by the United States Environmental Protection Agency. For example, the City of San Diego has an Urban Agriculture Incentive Zone Program that promotes urban farming within city limits that could serve. In Addition to developing technological advancements as proposed in this initiative, utilizing the Earth's natural processes, from increasing carbon sequestration in agriculture, implementing re-forestation programs such as SDG&E's "Right Tree, Right Place" initiative, partnering with local community groups to manage forest land to better mimic natural ecological cycles, monitoring sol health, would all result in greenhouse gas (GHG) emission reductions and reduced energy usage especially when paired with advancements in AI, GIS, etc. [g] *Proposed Initiative 4 – Optimizing Long-Duration Energy Storage to Improve Grid Resiliency and Reliability in Under-resourced Communities* is focused on clean long-duration energy storage systems that can provide resilience to critical facilities in under-resourced communities. There has been significant interest in the development of long-duration energy storage technologies for a	challenges (see EPC-20-006 and EPC-20-007). It is also worth noting that, historically, demonstrations for grid hardening have been in the domain of the IOUs. The CEC has pursued – and continues to pursue – research initiatives that contribute to a scientifically rigorous foundation for supporting investment in a resilient and reliable electricity grid. e. "Under-resourced communities": o Include low-income and disadvantaged communities as defined AB 523 (2017) o Was expanded to include Native American Tribes. California Native American Tribes are those on the contact list maintained by the Native American Heritage Commission for the purposes of Chapter 905 of the Statutes of

	multitude of reasons and SDG&E supports the inclusion of investing funds to continue to develop these technologies. [h] Proposed Initiative 7 – Vehicle-to-Building Technologies for Resilient Back-up Power is similarly focused on providing power to critical loads during grid outages. Hydrogen is a key component to innovative and transformative breakthroughs while providing the long-duration grid reliability benefits being sought in this initiative. Hydrogen can also be used as a fuel in vehicles to both power the vehicle and provide back-up energy storage to provide resiliency. SDG&E recommends that technologies utilizing hydrogen be explicitly eligible for these initiatives. Other non-battery storage technologies should also be considered. In addition to economics (levelized cost), safety risk, community and climate impact should also drive the diverse technology-mix selection and resilience criteria. [i] *Proposed Initiative 8 – Offshore Wind Energy Technologies* is split into four tracks. The first track is focused on manufacturing, assembly, and installation of offshore wind (OSW) components, while the second track is targeted towards the testing and validation	2004 (Pub. Resources Code, § 21073) and other underrepresented groups. Within these definitions, solicitations could provide additional targets – such as particular geographical areas in CA – or focus on one particular type of under-resourced community like tribal lands. f. o Staff appreciate that SDG&E comments are supportive. However, SDG&E's comments focus on outdoor urban farming on vacant lots. o Some aspects of SDG&E's program could be helpful during the solicitation phase, but growing crops outdoors is not within scope of EPIC where direct **energy** savings and benefits to rate payers need to be demonstrated.

	of monitoring systems for components that would reduce both the installation and operation and maintenance costs of OSW technologies. The third track is to develop tools or methods for assessing and monitoring the environmental impacts associated with assembly and operation of OSW technologies. The fourth track is a pilot of an OSW system offshore of California to identify hurdles associated with commercial-scale OSW projects. While wind generation, especially offshore, offers a profile complementary to solar in many areas of the state of California, there are many other hurdles associated with OSW technology. The first track appears to be focused on making California "one of the first global manufacturing centers for FOSW infrastructure." EPIC is funded by California IOU electric ratepayers and as such, they should benefit from the investment of EPIC funds. The viability of OSW solutions in California, especially Southern California is fraught with challenges. Given the nascency of feasibility and the unique challenges this pathway faces, it may be too early to pass on the cost of R&D to California Utility ratepayers. Barring job growth benefits, California Utility ratepayers should not be burdened to pay for manufacturing of products we may not be able to deploy at scale in California or capture as benefit in our path to carbon neutrality.	○ Past CEC agricultural projects focused on irrigation controls to reduce pumping energy. Outdoor urban farms use municipal water and there are no direct electricity benefits to the grower. g. CEC staff appreciate the supportive comments. h. Staff appreciate SDG&E's interest in hydrogen for transportation applications including heavy duty vehicles, and staff continue to advance R&D related to hydrogen vehicles and infrastructure through the Natural Gas R&D Program. For example, staff recently released a funding opportunity exploring hydrogen technologies for rail and marine applications (see https://www.energy.ca.gov/solicitations/2020-07/gfo-20-604-hydrogen-fuel-cell-demonstrations-rail-and-marine-

	The fourth track piloting OSW technology does not seem to fit within the timeline of this interim investment plan. As identified in the proposed initiative, there is much work to be done before this technology could be commercially ready and therefore should not be included in this interim investment plan. OSW technology will require significant infrastructure investment to get the energy produced from OSW onto shore – whether that includes undersea and underground transmission lines or floating energy storage devices which are transported between the OSW location and onshore. Also, the environmental impact of large-scale development of OSW on sea life (plants and animals) should be thoroughly examined before committing significant funds to this area. Additional discussion should occur before including this effort in an investment plan. SDG&E recommends deferring tracks I and IV from this proposed initiative and limiting funding for tracks II and III, till the feasibility of deploying OSW becomes clearer off the coast of California. Allocating ratepayer funds R&D initiatives that advance climate resilience, sustainable economic growth and desired social impact within the investment plan and have a clear deployment roadmap are advisable till the efficacy of OSW become clear.	applications). R&D for hydrogen production, distribution, and end use applications is featured in recent Natural Gas R&D budget plans (e.g., the FY20-21 plan accessible here: https://www.energy.ca.gov/event/workshop/2020-01/staff-workshop-discuss-proposed-natural-gas-research-initiatives-fy-2020-21). Although the proposed V2B initiative is not focused on hydrogen fuel cell electric vehicles (FCEVs) as a source of backup power, FCEVs will be considered in solicitation development. i. The proposed OSW initiative would support R&D for component and system development. Although in-state manufacturing capacity is not the focus, it could be a potential longer-term benefit. OSW technology is not entirely new; there are now commercial deployments happening in other parts of the world. The

		proposed initiative is an initial targeted investment to investigate, develop and demonstrate OSW technology in California with anticipated benefits rather than burden to ratepayers. Demonstration projects are instrumental in making large-scale deployment of floating offshore wind components more feasible and cost-effective. The demonstration project would likely be at a pilot-scale, helping move toward commercial scale systems. The initiative focuses on development of components, such as the substructure, substructure supports, and foundation. R&D staff are actively participating in discussions within the CEC and other agencies, including the Bureau of Ocean Energy Management, Ocean Protection Council, Department of Energy, and New York State Energy Research & Development Authority. A joint state-federal task force was established in 2016

		to help identify areas off California's coast suitable for potential offshore renewable energy. Leading to the development of these initiatives, the CEC solicited feedback from agencies and stakeholders. On October 22, 2020, CEC staff hosted a scoping workshop to seek input from research community stakeholders and other interested parties to inform the direction and scope of this initiative (https://www.energy.ca.gov/event/workshop/2020-10/notice-scoping-workshop). It is also worth noting that offshore wind is a promising resource for helping meet the mid-century goals of SB 100.
Berkeley Lab	[a] Decarbonization: ● Berkeley Lab suggests incorporation of a greater focus on innovative approaches and methods to scale up building retrofits for deeper energy efficiency and decarbonization to much higher volumes by evaluating potential for innovative policies such as more on- bill financing, block level retrofits, or integrated approaches for	a. • EPIC is currently funding several building retrofit projects—including programmatic approaches to identify technologies and strategies for

	building shell retrofits, electrification, rooftop PV, and vehicle electrifications; and piloting or demonstrating in the field. ● In addition to modulating (time shifting) power demand, we recommend supporting projects to reduce power demand and enhance climate resilience through efficiency measures for critical facilities (especially those that are residential such as nursing homes) through approaches such as designing or retrofitting to employ passive or low- energy cooling measures that minimize power demand during extreme heat events. When power needed for HVAC is lost, it is important to ensure that tight building envelopes do not exacerbate indoor temperatures during such events. ● Develop an industry decarbonization roadmap that could be organized by end use application (e.g. steam systems, drying systems) and/or process temperatures (low/med/high temperature process heating). This could include for example, more focused R&D on the potential and demonstrations for electric boilers and/or hybrid electric and gas boiler systems for decarbonized steam systems and responsive to utility rates; and more development and demonstration of decarbonized high temperature process heating technologies e.g., for the cement and glass-making sectors.	scaling up retrofits such as with RMI and Sonoma Clean Power. • Block level retrofits are occurring through EPIC's Advanced Energy Community projects. • Some retrofits have included rooftop solar for multifamily buildings or new manufactured housing construction. • Suggestions listed could be considered for EPIC 4: o Integrated EE, PV, storage retrofits for retrofits, pending results of current projects o Advanced low-energy cooling measures o Industry decarbonization roadmap; consider roadmaps under Market Research Initiative (9d). o Negative-emissions Technology and Science

	● Develop a Negative Emissions Technology & Science (NETS) Roadmap to enable the state to meet its carbon neutrality target by 2045 (e.g. 50-150MMt CO2e by 2045). Even with aggressive electrification and other carbon reduction measures, studies on California pathways to achieve carbon neutrality generally agree on the need for implementation of significant carbon removal to compensate for sectors that cannot achieve full carbon neutrality. There remain substantial uncertainties or technology needs associated with a number of these pathways.… [b]● Intensify focus on the "demand side" to sharply reduce material consumption, reduce demand for virgin materials, and reduce energy consumption. We believe that the three areas that need more R&D focus and policy development include: (1) materials efficiency (e.g., using less concrete, cement, steel in buildings); (2) designs, technologies and systems to enable a circular economy (e.g., materials recovery upon building deconstruction and planning for more recovery during building design and construction phase; development and broad deployment of products developed from waste streams, such as bio-based substitutes produced through sustainable low-carbon processes); and (3) deep conservation such as evaluation of international policies and or innovative programs for deep energy and/or material conservation – e.g., pilots or	Roadmap with carbon capture and utilization b. Topic area requires more exploration for determining what areas are within the scope of EPIC for providing ratepayer benefits, including reliability, lower costs, and safety. If within scope, could consider in the full EPIC 4 Plan. The Interim Plan only builds on previous research. c. Staff will clarify in the plan that cost share is not applicable to just entrepreneurs. d. Staff will consider the suggested R&D areas in the full investment plan for EPIC 4, including risk assessment and decision-making tools and technologies and for adaptation. e. Staff appreciate the supportive comment. f.

	demonstrations for feebates for vehicles or other high GHG goods, congestion charges, incentives for deep reductions in utility/water/plastic use. Some of these policies have been explored or implemented in other countries (such as feebates in France), but few have been implemented here. The potential for energy and GHG savings of these programs and policies needs to be better understood and quantified. [c]● In addition to leveraging and complementing the RDD&D funding available through the incoming federal administration as proposed in Initiative 9, the Commission should consider collaborations with federal agencies like the U.S. Department of Energy in the many areas beyond the entrepreneurship areas where collaborations provide strong opportunities to advance California priorities, leverage limited California resources, and bring to scale solutions developed in the State. The Commission should reserve sufficient flexibility to maximize opportunities for partnerships in these areas in the coming year. [d] Resilience: In addition to the metrics and measurements to enable the valuation of resilience, we recommend that CEC consider funding for -	• Including multi-family is challenging due to the pricing and different manufacturing process needed to construct. Staff could consider this in the full EPIC 4 Plan. • Staff could consider large-scale retrofits focused on decarbonization as part of EPIC 4 pending the results of current projects. In addition, the concepts of a better indoor air quality and healthy buildings could also be considered in this initiative or in EPIC 4. g. Staff appreciate the support of this initiative. h. Staff appreciate the supportive comments, and some of the recommended topics have been taken into consideration in the existing EPIC energy-storage

	● Modeling, simulation and prediction to support risk assessment, and decision-making tools; ● Design and development of bundle packages of technologies for scaled adoption to improve community infrastructure; ● Technologies and processes to provide design stronger community response strategies to address vulnerable communities in their adaptation to extreme weather events. [e] Regarding the need to ensure an equitable transition, the Commission's proposal references a four prong strategy to embed equity into the EPIC program going forward including increasing awareness of EPIC and the opportunities it provides, encouraging technology/project developers to seek out projects in under-resourced communities (where more than 60% of the CEC's demonstration projects are now located, as well as including community based organizations as paid partners); scoping many solicitations around specific issues facing under- resourced communities; and embedding equity in clean energy entrepreneurship. Berkeley Lab supports this strategy and encourages the Commission to include sufficient support in its solicitations to enable full participation by researchers and organizations representing under- resourced communities. …	program. A few examples are provided here: • Mobility of energy storage assets in the case of resiliency is part of EPIC Mobile Renewable Backup Generation (MORBUGs) GFO to be released soon. See https://www.energy.ca.gov/solicitations/2020-11/mobile-renewable-backup-generation-morbugs for more info. • EPIC awarded two grants for pumped hydro in groundwater wells in GFO-19-306. The other recommendations will be considered in EPIC 4. Energy storage is an area of high interest to the DOE, and with their new $100M annual energy storage budget starting in 2021 for 5 years, they are expected to support this area. This could be a Federal Cost Share opportunity.

	[f] INITIATIVE 1: Advanced Prefabricated Zero-Carbon Homes. Berkeley Lab agrees that prefabricated zero-carbon homes with fire- and energy-resilient design features offer the potential to save energy, increase resistance to wildfires, lower costs and help communities build back better and more quickly. The Commission may wish to consider whether to expand eligibility to multi-family units. The Commission has been thoughtful in incorporating fire-resistant designs. To advance broader state objectives, the Commission may wish to consider coordination with the Joint Institute for Wood Products Innovation, which has recommended the use of mass timber to encourage the use of wood fiber gleaned from forest thinnings in new construction. In addition to zero-carbon new constructions, the Commission should continue its pioneering work in building efficiency/decarbonization to support innovative approaches and methods to scale up retrofits of existing building stock for deeper energy efficiency and decarbonization to much higher volumes are recommended. More than 12 million existing housing units in California are more than 10 years old. Critical challenges include upgrading the predominantly older housing stock to higher levels of energy efficiency, electrified heating (fuel switching), required panel upgrades, deferred maintenance, and roof repair (many single-family	i. Berkeley Lab's recommendations and questions on the hydrogen initiative will be considered by staff when developing the GFO for the hydrogen roadmap. The eventual grant awardee will meet with Berkeley Lab to explore and address these topics and questions in developing the roadmap. It should be noted, however, that abandoned oil and gas wells as hydrogen storage facilities would be covered under Initiative 4 regarding energy storage. j. The findings of the proposed research to support valuation of resilience investments would be applicable to projected future events and could be leveraged by future research efforts targeting development of modeling, simulation, and forecasting to support risk assessment and decision-making. Please note that there are Natural Gas R&D as well as EPIC agreements

	homes are not "solar PV" ready). We recommend that the CEC consider evaluating the potential for furthering progress on innovative policies such as more on-bill financing, block level retrofits, or integrated approaches for building shell retrofits, electrification, rooftop PV, and vehicle electrifications. [g] INITIATIVE 2: Energy Efficiency and Demand Response in Industrial and Commercial Cold Storage. Berkeley Lab supports the focus on commercial refrigeration equipment (CRE) energy efficiency improvements and shifting to low global warming potential (GWP) refrigerants. CRE represents about 40% of total refrigerant leakage and CRE units typically operate 7x24. LBNL authored a report in 20191 on this topic, finding a very large potential GHG savings (over 200 Gt CO2e by 2050 globally) from shifting the global stock of air conditioning and commercial refrigeration equipment to high energy efficiency and low GWP refrigerants. [h] INITIATIVE 4: Optimizing Long-Duration Energy Storage to Improve Grid Resiliency and Reliability in Under-resourced Communities. Significant quantities of energy can be stored on a long-term (i.e. seasonal) basis in the form of heat or cold in the subsurface below all types of communities. These energy reserves	underway that lay the groundwork for improved assessment of risks related to climate extremes and compound events. This work, as well as additional investments that could be made in EPIC 4, will address decision support. k. • Staff appreciate the detailed suggestions for functionalities to include in Initiative 7, which will be considered during solicitation scoping. • Several CEC EPIC-funded transportation electrification projects have called attention to the importance of interoperability and integration with building loads, for example a project with UC Berkeley (https://ww2.energy.ca.gov/2020publications/CEC-500-2020-005/CEC-500-2020-005.pdf), and current

	can provide direct grid services by reducing heating and cooling loads. Development of technologies for energy storage in the form of temperature gradients, i.e. heat or cold is recommended under this initiative. The Commission may wish to consider support of R&D projects in California for repurposing depleted oil and gas reservoirs for energy storage, either using compressed air, H2 or other energy-rich chemicals/fuels. On the technical side, subsurface energy storage in depleted natural gas reservoirs has been carried out successfully in over a dozen places in California for many decades as demonstrated by the seasonal storage of natural gas. Use of the same or similar reservoirs for compressed air energy storage has been demonstrated (e.g., PG&E, 2018; https://www.osti.gov/servlets/purl/1434251). Much of this opportunity is located in parts of the southern San Joaquin Valley where there is high unemployment. Repurposing idle oil and gas infrastructure for energy storage can provide continuity of employment and sustainability for the local oil and gas workforce as the state moves toward electrification of transportation. We recommend that long duration storage consider including a green fuel that can be stored or used and not be limited to just batteries.	solicitations emphasize the importance of open standards l. Staff recognize the significant cost of offshore wind demonstrations and will give consideration during solicitation development to allow for a range of match support. Due to the level of funding anticipated, demonstrations may be small-scale. The comments indicate there are many challenges that need to be addressed to allow for cost-effective large-scale floating offshore wind deployment. The initiative focuses on the development of components, such as substructure, substructure supports, and foundation. m. Staff appreciate the supportive comment regarding the Federal Cost Share solicitation (Initiative 9e). One point of

	Mobility of energy storage assets in the case of resiliency can be useful. This can also include inexpensive and green storage where the primary storage is done off site and delivered to a generator when needed in response to an event such as PSPS or wildfires. While this could be thought of as similar to the way diesel generation sets currently operate, we recommend considering inexpensive green alternatives beyond biofuels which could include delivering green hydrogen or other chemicals for fuel cells and electrode materials for rechargeable and primary batteries. Supplies of lithium and other critical elements can play a limiting role in multiple types of resiliency strategies due to their essential role in battery technology. In addition to the CEC's leadership in advancing recovery of lithium from Salton Sea brines, efforts that look at lithium battery recycling, other non-conventional natural lithium resources and other critical element availability, and new cost-effective extraction technologies that are relevant under this research topic. [i] INITIATIVE 5: The Role of Green Hydrogen in a Decarbonized California—A Roadmap and Strategic Plan. Berkeley Lab recommends that the roadmap consider ways in which hydrogen fuel cells can be leveraged to other manufacturing technologies such as	clarification, the Federal Cost Share is open to all California organizations, not just entrepreneurs.

	CO2 reduction to enable decarbonization. We recommend that the roadmap/study under this initiative consider answer the following questions for Green H2: ● Particularly as the Commission considers hard-to-decarbonize sectors, green hydrogen use in manufacturing should be included. ● What is the role for bridge pathways to green hydrogen such as blue hydrogen? ● What are future likely/prospective demand ranges for hydrogen by application (e.g., what can H2 provide that is unique and economic relative to other technologies?) ● Transportation, energy grid support, industrial applications are three potential areas for green H2 – how would these be efficiently linked or coordinated as either decarbonization pathways or in supporting policies? Would there be the need for some sort of "industrial policy" that goes beyond what is currently practiced due to the potential interlinkage and synergies between the sectors? ● Hydrogen storage: California does not have a recognized unconventional oil or gas resource that can benefit from long-reach horizontal wells and hydraulic fracturing. Because of this, unlike other areas of the U.S. that have seen large increases in oil and gas production with the use of hydraulic fracturing, California's oil and	

	gas production are in decline. The result is depleted oil and gas reservoirs and idled oil and gas wells. At the same time, a critical part of the hydrogen economy is large-scale and long-term hydrogen storage. Research into re-purposing depleted oil and gas reservoirs for hydrogen storage is needed to develop this technology and allow green hydrogen to become a significant part of California' decarbonization goal. There is a large volume of activities on hydrogen and hydrogen systems internationally and at the DOE's Hydrogen and Fuel Cell Technologies Office. We recommend that the roadmap make an effort to comprehend and synthesize the various activities, learnings, and policies from outside of California. [j] INITIATIVE 6: Valuation of Investments in Electricity Sector Resilience. For the approach to "Include analyses of recent historical weather-related events and other situations (e.g., PSPS) that resulted in power outages," we recommend that the valuation of scenarios also focus on future weather-related events and worst-case possibilities, since climate conditions are shifting and are quite different from the past. It would be informative to try to model (or compile) the risk of low probability events such as coronal mass discharges as well as the risk of a confluence of events such as	

	extremely hot weather across the West, concurrent wildfires, earthquakes, and any other known risks, to bound the scale of the problem. [k] INITIATIVE 7: Vehicle-to-Building Technologies for Resilient Back-up Power. We recommend that the research and development of Vehicle-to-Building technologies consider the following: ● The communication interoperability between the electric vehicle charging infrastructure and the building needs to provide maximum demand flexibility with long duration while meeting resilient back-up power needs (e.g., open-source communication standard OCCP for electric vehicle charging, building automation and control protocol such as BACnet, Modbus) ● Vehicle-to-Building technologies should include the event-ahead (power outage notification), day-ahead or real-time prediction of essential building load during the critical operation mode, as well as predictive energy allocations considering uncertainties of individual electric vehicles that are available for resilient back-up power. ● The use of electric vehicles for resilient back-up power in buildings should be integrated with other kinds of building demand flexibility in HVAC, lighting and plug loads.	

	[l] INITIATIVE 8: Offshore Wind Technologies. Given the large cost of deploying a structure in the ocean which far exceeds the typical funding level from CEC, the program should emphasize subcomponents or partial integrations that can be tested in simulated marine environments. [m] INITIATIVE 9: Entrepreneurial Ecosystem. 9e. Cost Share for U.S. DOE Funding Opportunities. Technologies developed in the national lab and university ecosystem in California provide a valuable source of cutting-edge ideas and patents in the areas of clean energy such as energy efficiency, renewable energy generation, and energy storage, that in turn provide a robust pipeline of early and low technology readiness level (TRL) technologies with commercialization potential to be developed further by entrepreneurs for meeting California's energy goals. For example, Berkeley Lab has been a beneficiary of the cost share offered by CEC for the U.S. DOE Funding Opportunities, most recently, the $3 million cost share from CEC for the DOE funded $100 million NAWI Energy-Water Desalination Hub awarded to the Berkeley Lab-led National Alliance for Water Innovation. It is likely that we will see significant opportunities to align U.S. Department of Energy and California policy objectives. This will	

	present California with opportunities to attract significant federal and outside investment that supports state objectives, potentially scale solutions developed here and make the best possible use of limited state resources. As previously noted, we recommend that the Commission continue to provide robust support for cost share for the U.S. Department of Energy projects supporting early stage technologies that can be developed and scaled by California-based entrepreneurs.	
Form Energy	1. The CEC should broaden the focus of proposed Initiative 4 to ensure that it supports in front of meter (IFM) applications of long-duration energy storage as well as customer-sited applications. 2. The CEC should ensure that proposed Initiative 4 can support projects that are potentially 5MW to 20MW in scale, if not larger. 3. The CEC should establish a new sub-part of Initiative 4 to demonstrate new multi-day energy storage technologies deployed in Front of Meter Applications (to parallel proposed Initiative 8d: Pilot Demonstration of Floating Offshore Wind Technology) 4. We support the CEC's proposed Realized Accelerated Manufacturing Production (RAMP) initiative, and we encourage the	1. Staff appreciate the supportive comments. The existing EPIC research has funded multiple projects to support IFM applications. Staff agree that IFM applications require more research to address the challenges on interconnection and business models. Staff will consider part of the recommendation (IFM) in EPIC 4 and incorporate the other part in GFOs for the Interim Investment Plan. 2. This initiative is expected to support projects with sizes that could reach as high as 5 MW but not 30 MW. Funding

	CEC to take a broad interpretation of eligible manufacturing processes to ensure that RAMP funding can support activities that range from the manufacturing of individual components to the manufacturing, assembly and integration of modules and systems. Additionally, we encourage the CEC to allow grant recipients to spend funds on building infrastructure upgrades that are necessary to achieve accelerated manufacturing or production 5. We support the CEC's proposed DOE cost-share initiative, and we encourage the CEC to ensure this funding is continuously available and has a rapid, streamlined approval process to account for the unpredictability of when DOE funding opportunities are available.	potential projects in the 20-30-MW range is difficult for EPIC to support due to the high costs of the energy storage system, California Environmental Quality Act timing limitations, and the limited demonstration applications that can be supported with this large of an energy storage system. 3. Staff will consider other areas not covered under the interim plan initiative (including additional manufacturing processes) for EPIC 4. For example, future initiatives could include exploring and assessing the feasibility of integrating various energy storage technologies, including green hydrogen, in offshore wind demonstrations, etc. 4. Staff appreciate the supportive comments for the RAMP initiative. With regard to the comments about eligible

		manufacturing process and funds, those processes and funds are eligible as long as they help scale the technology to the pilot production stage. Technologies or technology components that have already reached the pilot production stage are not eligible. 5. Federal cost share will be continually available until the funding allocated for it runs out, then funding is pending the new investment plan's approval to add more funds. CEC has already streamlined approvals.
Pacific Gas & Electric Company	*[Initiative]1. Advanced Prefabricated Zero-Carbon Homes* • Given that the 2022 Title 24 code will be adopted in July 2021, PG&E recommends using the 2022 code for target-setting and to help prefabricated home builders to adopt future methods. • PG&E suggests that the CEC consider indoor air quality measures. • PG&E recommends that the CEC consider CALGreen topics such as the water/energy measures and embodied carbon.	Initiative 1. • We agree with the use of Title 24, 2022 code and will reference this. • We will consider the potential of including the evaluation of indoor air quality in these homes as part of this initiative or for future consideration in EPIC 4.

	[Initiative] 3. Energy Efficiency and Load Shifting in Indoor Farms • For new buildings, consider the upcoming 2022 Title 24 code as the target for the Controlled Environment Horticulture spaces. *[Initiative] 7. Vehicle-to-Building Technologies for Resilient Back-up Power* Given PG&E's fire-prevention Public Safety Power Shutoffs, we strongly support this initiative's focus on a VGI resiliency use-case. We recommend considering cybersecurity to be part of this initiative as it is essential to ensure customer safety while using highly digitalized systems. We recommend consideration of the following in establishing metrics and performance indicators: • Load profiles of the homes and buildings utilizing zero-emission, vehicle-provided back-up power during grid outages; • Estimated Greenhouse Gas (GHG) reductions and, to the extent practical, estimated air pollution reductions using emission factors developed by the California Air Resources Board and other relevant data; • Include geospatial data in addition to the number of homes, buildings and individuals with access to zero-emission, vehicle-provided back-up power during grid outages; and	• We may consider CALGreen measures during solicitation development for this initiative. However, water and embodied carbon measures may be beyond the scope of EPIC. Initiative 3. We agree with use of Title 24, 2022 code. Initiative 7. Staff appreciate the support of the initiative and will consider – as appropriate and possible – the suggested metrics and issues of cybersecurity during solicitation development.

	• Provide cost-effectiveness analysis and include detailed software, hardware, and integration-related costs to provide actionable insight for the lower-cost objectives.	
Bill Leighty, Earth Protection Program	The memo suggests expanding the scale, scope, and horizon of the project so that we may thoroughly consider, and attempt to achieve by policy, the optimum allocation of markets and investment in CO2-emission-free, "green", energy systems based on hydrogen vis-a-vis electricity, i.e. "The Grid", as large and as smart as we may conceive and build it. The attached memo may be useful in crafting the EPIC plans. "A Systems Analysis of the Future Role of Hydrogen in a Carbon-neutral California, before 2050"	Staff will consider this suggestion in the development of EPIC 4, not this plan (due to timeline and scope). These ideas will be evaluated when developing the roadmap and strategic plan in Initiative 5.
CalETC	[a] CalETC supports the CEC's focus on under-resourced communities and we recommend soliciting ideas from stakeholders on the types of criteria that would qualify a community as under-resourced or specifying that an under-resourced community will be those that fit the statutory definitions referenced on page A-7. Even if the statutory definitions are used, it would be valuable to solicit stakeholder feedback on the process of analyzing and identifying which communities will qualify. [b]	a. We will consider the suggestion on stakeholder feedback and analysis for identifying qualifying communities in the solicitation phase and in EPIC 4. For the Interim Plan, "under-resourced communities": o Include low-income and disadvantaged communities as defined AB 523 (2017) o Was expanded to include California Native American tribes

	We support Staff's inclusion of the topic of V2B/V2X in of draft research initiative number 7 and want to ensure it focuses on vehicle-to-grid technology that is not already commercially available, as well as avoid redundancy with other state policy and programs. Research initiatives should continue to focus on reviewing the technology available to allow safe, reliable, and cost-effective integration of V2B/V2X use cases. Additionally, we recommend cybersecurity be included in initiative number 7, and as appropriate, in the other draft initiatives. According to staff's presentation (slide 9), projects for transportation electrification (TE) and vehicle grid integration (VGI) have received less than 5% of the $713 million in EPIC funds from 2012 to 2019. Given the CEC's focus on reducing greenhouse gases and air pollution, and the very large contribution to these problems from transportation emissions, we recommend more EPIC funds be allocated to TE and VGI in the future. Finally, we recommend the CEC include the many recent developments on VGI in the final proposal to the CPUC and describe how the CEC will work closely with the CPUC, California Air Resources Board (CARB), US Department of Energy (USDOE), and the utilities to coordinate efforts on VGI to achieve the best	(i.e., those on the contact list maintained by the Native American Heritage Commission for the purposes of Chapter 905 of the Statutes of 2004 (Pub. Resources Code, § 21073), and other underrepresented groups. Within these definitions, solicitations could provide additional targets – such as particular geographical areas in California – or focus on one particular type of under-resourced community like tribal lands. b. Staff appreciate the supportive comments on Initiative 7 and agree the solicitation should not focus on commercially available products. Staff will consider the suggested topics, including cybersecurity, when appropriate and feasible in developing the solicitation. Staff appreciate the list of other proceedings and programs related to V2B technology (and vehicle-grid integration

	results and avoid duplication with EPIC projects. Specifically, we recommend the inclusion of, and coordination on, the following: • CARB's Low Carbon Fuel Standard recently enacted smart charging credits and low carbon intensity electricity credits monetize and provide greenhouse gas signals for smart charging and renewable integration. These credits are additive to the recently updated time-varying rates from the three IOUs that encourage residential and commercial charging at appropriate times. • SB 676 proceedings for both the CEC and CPUC on VGI, emphasizing the broad definition of technology neutral VGI. • The CPUC recently adopted decisions that direct up to $45M for VGI pilots (including V2B), demonstrations, and studies. As well as a 10-year strategy on VGI (D-20-12-029) and potentially additional VGI (including V2B) funds for TE resiliency projects over the next decade and beyond (D-20-12-027). • The Final Report of the VGI Working group (VGIWG) from June 2020, and the CPUC approved funding (D-20-12-029) to continue the next steps from the VGIWG. • In May 2020, the CPUC opened a rulemaking (R-20-05-12) that is considering V2B issues and has a working group that is continuing to consider changes to Rule 21 (interconnections) for AC vehicle to grid (mobile inverters on EVs).	more broadly), and continue to engage with colleagues in sister agencies and other stakeholders, including partners in IOUs, to coordinate on funding for VGI broadly, for example in SB 676 implementation and the V2G AC interconnection working group. CEC staff recently hosted a workshop (January 25, 2021) on the V2B market, technologies, and policies to improve coordination and solicit stakeholder input (see https://www.energy.ca.gov/event/workshop/2021-01/staff-workshop-vehicle-building-v2b-resilient-backup-power).

	• The 2020 omnibus spending bill that was signed in December 2020 has funds for VGI programs at USDOE.	
SCE	SCE finds all of the CEC's key research initiatives to have value toward advancing changes in electric power supply and customer use of energy. … [a] SCE finds the CEC's Initiative 4: Optimizing long Duration Energy Storage to Improve Grid Resiliency and Reliability in Under- resourced Communities to be closely aligned with SCE's existing work and focus. SCE's EPIC III Wildfire Prevention & Resiliency Technologies Demonstration and Smart Cities project, as well as the Wildfire Mitigation Plan pilots, are helping to test distributed energy resources, including energy storage as a means of resilient power to critical facilitates in communities at risk of extreme weather conditions, such as wildfires. As the CEC continues to plan this initiative, SCE requests to partner with the CEC and build on SCE's and the CEC's EPIC III projects through a future joint project. A joint project between SCE and the CEC would help support the CEC to demonstrate how critical communities' facilities can modulate facility demand, energy storage output, and renewable power to achieve optimal resiliency for these communities and the grid as a whole. SCE as a project partner could help to ensure smart inverters, energy management	a. Staff will consider this suggestion during the information gathering stage of GFO development, and staff will reach out to SCE to better understand SCE's activities and how the two efforts overlap and complement each other. b. Staff appreciate SCE's interest in collaboration on this topic. Close collaboration with IOUs will be critical to ensuring high-impact research in this area.

	systems, or a microgrid controller with energy storage all in concert are optimized for grid resiliency. A joint project would thus enrich the lessons learned by better understanding the performance needs for critical loads at these facilities and grid resiliency needs arising from these facilitates. [b] Another of the CEC's key initiatives that SCE is particularly interested in is Initiative 6: Valuation of Investments in Electricity Sector Resilience. SCE supports the CEC conducting research to evaluate the types of impacts that could be valued in the context of climate resilience by state and local governments, as well as the distribution and impacts of these events among ratepayers, especially on Disadvantaged Communities. SCE agrees with the CEC that "clarifying the public benefits of resilience investments is critical to properly incentivizing deployment of customer and grid resilience measures."6 SCE looks forward to closely collaborating with the CEC under this initiative to help the CEC create a conceptual framework that most appropriately values "resilience investments that captures public benefits on time scales relevant to GRCs and longer-term (20-30years) adaptation planning."	
Bill Hartman	Re-Consideration of Ocean Wave Energy Utility-Scale Electricity Generation	Staff will consider near-shore ocean wave energy for the EPIC 4 full investment plan.

	1. The near-shore ocean wave energy resources of the California coast line could provide California over 34 GW's of always-on base load zero carbon electricity with little-to-no backup systems at a cost competitive with onshore wind and solar with backup. 2. California led the way in the US in 2008-2010 with the PG&E Wave Connect project to investigate converting this available ocean wave resource to low-cost electricity. 3. Significant, order of magnitude improvements in utility-scale generation at low LCOE have been made in wave energy converter generation and control technology. have been made since the Wave Connect Project. 4. The US Department of Energy has recognized and started initial funding of the development of these improvements. 5. California energy consumers and the California environment will be major beneficiaries of cost-effective, utility-scale wave energy conversion. 6. It is recommended that the encouragement, support and funding of Ocean Wave Energy Conversion technology development, testing and deployment should be a significant part of the California Energy Commission/EPIC planning and investment for California's zero-carbon future.	Staff note several challenges that will need to be given consideration when evaluating possible R&D investment, including accessibility of potential, competing coastal uses, potential environmental impacts, and cost competitiveness relative to alternatives.
City of Richmond	Expansion of EPIC Funds to Contra Costa County	All of our awards are made through competitive solicitations. We welcome applications from those in Contra Costa

Transportation Department	EPIC funding has been made available throughout parts of the Bay Area and it would be helpful to include local government agencies within Contra Costa the opportunity to participate.	County, including local government agencies. For some solicitations, local government agencies may be in a better position to participate as a demonstration or test site for its buildings, rather than as a prime.
SunSpec Alliance	Requesting CEC participation of match for DE-FOA-0002206. This FOA total is $65M; individual awards vary between $3 to $7 million; requires 30% cost share. SunSpec is in the process of submitting the connected communities concept paper. Appreciate any contact details of the Commissioner's office to pursue a support letter with match participation.	Once the interim initiatives are approved by the CPUC, we can release our federal cost share solicitation. Until then, we do not have the ability to provide match funds for federal grants.
Schneider Electric	• Across the board all EPIC grant programs should be focused on scaling new technology as an outcome. This can be done with two additional additions to the criteria used to solicit proposals. • [a] Specifically have a set aside in grant opportunities for a pool of money for the design/engineering for critical facilities to find what critical functions they have in common that would allow plug and play deployment across multiple facilities or installations. • [b] Create scale by inviting new business models like Energy as a Service (EaaS) and other emerging business models to	a. There are other state programs looking at critical facilities and employing commercially available technologies to control critical functions. There does not appear to be any technology research needed. We can look into this further in the full EPIC 4 Plan to see whether there are any research gaps to be addressed. b. We are open to this suggestion. In fact, we have had funded several grants in the

	aggregate multiple deployments of a given technology. Designing for what is actual critical load in an exigent situation would focus on what is uniform and necessary to accomplish a critical purpose. EaaS would allow more rapid deployment with technology and capital risk sharing in private partnerships or public private partnerships. • [c] Focus EPIC grants on outcomes or systems but not technology silos. If the grant outcome is taking capacity, providing capacity or ancillary services or incorporating environmental goals to an electric distribution system operator or customer application focus less on specific technologies and more on delivering specific outcomes. The more coordinated DERs are as a system behind metered interconnection or coupling with a utility, the more they will be able to create the most efficient, economical and decarbonized transaction and extend that optimization to utility ratepayers for mutual benefit. The most optimized transaction is where energy supply and demand meet at the same location. That most optimized point will be the value that drives the grid of the future first. What technology needs are tools like tariffs and rate schedules that are outcome based to work with. Having grants that focus on specific technologies like EV to grid, load following appliance to grid, battery storage to grid misses the technology advancement and	industrial, agriculture, and demand response areas where the recipient was offering a service-like program. An example is a project in which LightApp (now Zira) signed up industrial customers for its energy management services. Over 100 industrial customers participated in the pilot and about 40% continued after the CEC EPIC grant ended. c. Several of our initiatives (e.g., 1, 2, and 3) are not necessarily tied to a specific technology and include integration of energy efficiency and controls. Our recent Flexible Load Research Hub solicitation resulted in a recommended award for a project focused on systems of end use and control technologies. The project measures outcomes at the meter (i.e., the supply/demand interface) precisely for the purpose of enabling customer integration of behind-the-meter resources and response to real-time grid operational and

	optimization that Microgrids, Home Energy Management systems and Building Energy Management systems will provide. These systems will become as ubiquitous as circuit breakers in the future. Individual technologies will be managed by these platforms as part of a two-way communication ecosystem between distribution utility and customers. The initial target of EPIC grants should be specifically in the top 200 hours of peak demand and hosting capacity and ancillary services between substations and customer coupling/interconnection should be the focus of EPIC grants. • [d] SE applauds the CEC planning to escalate equity engagement for the full EPIC 4 Investment Plan. SE believes access to clean energy is a right and encourages the CEC to robustly pursue greater equity in a new social contract that advancing technologies provide. SE encourages scoring in grant applications where equity in technology savings and deployment are shared in a new social contract in rate classes. SE believes that enough savings exist in balancing at the circuit level in initially the top 200 hours of peak demand and hosting capacity and ancillary services between distribution substations and customer coupling/interconnection to create a new paradigm of social contract in rate classes. The current paradigm is that cross a subsidization of individual choices of	supply needs. One of the goals of that research is to demonstrate (to utilities, regulators, and system operators) the operational capabilities of flexible load modifying resources so they can ascertain the value of providing rate structures and programs that promote decarbonization and reduce infrastructure, procurement, and customer costs. d. We appreciate the comments and recommend discussing this matter with CPUC staff since tariff structures and creating new rate classes are beyond the scope of the EPIC Program. e. We appreciate the comments and will consider them in the development of the EPIC 4 initiatives. We recommend discussing with the CPUC and others the potential for sharing savings in retail transactions.

	ratepayers happens between ratepayers in rate classes often with the most disadvantaged subsidizing the most affluent. [e] More consultation is needed before grants are released on business models overseen in State sovereignty in retail market jurisdiction that rewards customer interaction with the distribution utilities on the tenants of; • Avoided capital expenditures on distribution system • Meeting collective environmental goals of California • Sharing savings of efficiency of retail transactions with ratepayers generally, participants directly and extends technology to challenged demographic groups to create a circular economy of mutual benefit in rate classes.	