California Energy Commission

FINAL STAFF REPORT

THE ELECTRIC PROGRAM INVESTMENT CHARGE:

PROPOSED 2015-2017 TRIENNIAL INVESTMENT PLAN

CALIFORNIA
ENERGY COMMISSION

Edmund G. Brown Jr., Governor

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CALIFORNIA ENERGY COMMISSION

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ABSTRACT

The California Energy Commission staff has prepared this staff final proposed triennial investment plan (2015-2017) for the Electric Program Investment Charge Program in response to the California Public Utilities Commission Decision 12-05-037, as modified. This proposed plan is consistent with California Public Utilities Commission Decision 13-11-025. This continues implementation of the requirements established by Senate Bill 96 (Committee on Budget and Fiscal Review, Statutes of 2013). The California Public Utilities Commission Decision 12-05-037 established the Electric Program Investment Charge Program to fund electric public interest investments for the benefit of electricity ratepayers of Pacific Gas and Electric Company, Southern California Edison Company and San Diego Gas & Electric Company.

In Decision 12-05-037, the California Public Utilities Commission approved a total of $162 million annually beginning January 1, 2013, and continuing through December 31, 2020, unless otherwise ordered or adjusted in the future by the California Public Utilities Commission. The California Public Utilities Commission shall adjust the total collection amount on January 1, 2015, and January 1, 2018, commensurate with the average change in the Consumer Price Index, as specified. The California Energy Commission is administering 80 percent of the approved Electric Program Investment Charge funds.

Staff developed this second staff draft proposed Electric Program Investment Charge Investment Plan through an open and transparent process that involved public workshops and consultation with key stakeholder groups. Input from these stakeholders is reflected in the recommended funding initiatives.

The California Public Utilities Commission will conduct a formal proceeding, starting in May 2014, to consider this proposed plan with anticipated adoption in December 2014. The investor-owned utilities are developing their own investment plans to fund technology development and deployment initiatives. The California Energy Commission is working to coordinate its Electric Program Investment Charge Investment Plan with the plans of the investor-owned utilities.

Keywords: California Energy Commission, Electric Program Investment Charge, applied research and development, technology demonstration and deployment, market support, market facilitation, clean energy technologies, renewable energy, guiding principles, electricity value chain, energy innovation pipeline, energy efficiency, smart grid, clean generation

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As the eighth largest economy in the world, California consumes almost $100 billion worth of energy annually. To support this vibrant economy and make the state's electricity supply affordable, adequate, safe and reliable, investments must be made in clean energy. Since 1996, California ratepayers have invested in innovative clean energy technologies and resources, diversifying the state's energy supplies and using these supplies more efficiently. Because of these investments, California ratepayers have reaped the benefits of pioneering research and development (R&D).

Leveraging Ratepayer Dollars

Since 1996, the Energy Commission has invested $884 million for innovative and clean energy R&D, leveraging these funds to attract more than $1.4 billion in match funds. States with clean energy research funding programs like EPIC attract four times as much clean technology venture capital per capita as states without such programs.

Although California leads the nation in energy efficiency, more investments in energy innovation and creativity are critical to achieving the state's aggressive climate and energy goals. For more than three decades, the California Energy Commission (Energy Commission) has administered successful R&D programs that have driven innovation and advanced science to benefit ratepayers, making their energy choices safer, more reliable and less costly.

In 2011, the Electric Program Investment Charge (EPIC) Program was created by the California Public Utilities Commission (CPUC) in Decision 12-05-037 to support innovation investments in clean technologies and strategies to improve the state's electricity systems and continue to benefit ratepayers. The ratepayers from three of California's major investor-owned electric utilities – Pacific Gas and Electric Company (PG&E), Southern California Edison Company (SCE) and San Diego Gas & Electric Company (SDG&E) – fund the program. The Energy Commission administers 80 percent ($162 million annually) of the approved EPIC funds, and 20 percent is administered by PG&E, SCE and SDG&E. The CPUC provides program oversight and approved the Energy Commission and the three utilities' first triennial EPIC investment plans in November 2013. The CPUC will conduct public proceedings every three years to review each administrator's proposed EPIC investment plan. This *2015-2017 Electric Program Investment Charge Program Investment Plan (2015-2017 EPIC Investment Plan)* is the second plan to be reviewed by the CPUC, with an anticipated decision in December 2014.

2015-2017 Electric Program Investment Charge (EPIC) – Second Triennial Investment Plan

EPIC Guiding Principles

All EPIC-funded innovations share a common, fundamental goal: providing more reliable, lower-cost, safer electricity to IOU ratepayers. The *Electric Program Investment Charge Proposed 2015-2017 Investment Plan* was developed through a public process with extensive stakeholder input based on these guiding principles:

- Providing benefits to ratepayers;
- Achieving greenhouse gas emissions mitigation and adaptation in the electricity sector at the lowest possible costs;
- Supporting the Loading Order;
- Advancing low-emission vehicles and transportation;
- Supporting economic development;
- Using ratepayer funds efficiently.

This *2015-2017 EPIC Investment Plan* presents the Energy Commission's proposed strategy for administering the three-year total of $388.8 million, which includes $38.88 million for administrative costs and $349.92 million for program awards. The *2015-2017 EPIC Investment Plan* proposes strategic objectives and initiatives for Energy Commission administration of EPIC funds collected from 2015 to 2017 for applied research and development, technology demonstration and deployment, and market facilitation (Table E-1). The *2015-2017 EPIC Investment Plan* also applies ratepayer benefits as the mandatory principle to guide investment decisions. The four EPIC administrators work together to coordinate development of proposed investment plans and avoid duplication.

Applied Research and Development includes activities to support pre-commercial technologies and approaches at applied lab-level or pilot-level stages.

Technology Demonstration and Deployment involves installation and operation of pre-commercial technologies or strategies at a scale that will reflect actual operating, performance, and financial characteristics and risks.

Market Facilitation focuses on a range of activities, such as commercialization assistance, local government regulatory assistance and streamlining, market analysis, and program evaluation to support deployment and expand access to clean energy technology and strategies.

The *2015-2017 EPIC Investment Plan* also proposes the option of using EPIC funds for the New Solar Home Program, a market support program.

Table E-1: California Energy Commission EPIC Funding by Program Element 2015-2017 (million)

Funding Element	Total
Applied Research and Development	$151.63
Technology Demonstration and Deployment	$145.02
Market Facilitation	$53.26
New Solar Homes Partnership (Market Support)	*
Program Administration	$38.88
Grand Total**	**$388.8**

*Up to $130 million.

**Any additional funds that may be allocated to the Energy Commission as a result of any CPI adjustment will be used to increase the budget proportionally across all areas.

Source: California Energy Commission

The *2015-2017 EPIC Investment Plan* is organized by the three specific funding areas with proposed initiatives grouped under strategic objectives. Through the *2015-2017 EPIC Investment Plan*, the Energy Commission intends to issue solicitations in all strategic objectives. Proposed initiatives identified in the *2015-2017 EPIC Investment Plan* represent the full scope of possible awards.

Applied Research and Development – Strategic Objectives

- Improve energy efficiency technologies and strategies in California's building, industrial, agriculture, and water sectors.
- Enable cost-effective demand response for California IOU electricity customers.
- Develop innovative solutions to increase the market penetration of distributed renewable and advanced generation.
- Improve power plant performance, reduce cost, and accelerate market acceptance of existing and emerging utility-scale renewable energy generation systems.
- Reduce the environmental and public health impacts of electricity generation and make the electricity system less vulnerable to climate impacts.
- Advance the use of smart inverters as a tool to manage areas with high penetrations of PV.
- Develop advanced distribution modeling tools for the future smart grid.
- Advance customer systems to coordinate with utility communication systems.
- Advance electric vehicle infrastructure to provide electricity system benefits.
- Advance the early development of breakthrough energy concepts.
- Provide federal cost share for applied research awards.

Technology Demonstration and Deployment – Strategic Objectives

- Overcome barriers to emerging energy efficiency and demand side management solutions through demonstrations in new and existing buildings.
- Demonstrate and evaluate biomass-to-energy conversion systems, enabling tools, and deployment strategies.
- Take microgrids to the next level: maximize the value to customers.
- Demonstrate advanced energy storage interconnection systems to lower costs, facilitate market and improve grid reliability.
- Expand smart charging and vehicle-to-grid power transfer for electric vehicles.
- Provide federal cost share for technology demonstration and deployment awards.

Market Facilitation – Strategic Objectives

- Foster the development of the most promising energy technologies into successful businesses.
- Facilitate inclusion of emerging clean energy technologies into large-scale procurement processes.
- Accelerate the deployment of energy technologies in investor-owned utility territories through innovative local planning and permitting approaches.
- Inform investments and decision-making through market and technical analysis.

Evaluating EPIC investments over time is critical to the Program's success. To evaluate ratepayer benefits, the Energy Commission will use a program-wide approach integrated into solicitation planning, solicitation and agreement development, project management, and project closeout. Metrics to assess the program include job creation, economic and environmental benefits, barriers or issues that were overcome, effectiveness of information dissemination, adopting technologies, strategies, or research data by other entities, and financial support from other entities for research funded through the Program.

Once adopted by the Energy Commission, the *2015-2017 EPIC Investment Plan* will be submitted to the CPUC by May 1, 2014 for consideration along with the investment plans of the three investor-owned utilities. The CPUC's schedule anticipates considering the plans for approval in December 2014. In early 2017, the Energy Commission staff plans to hold scoping workshops for the third triennial Investment Plan covering the 2018-2020 funding cycle. The Energy Commission will continue to file annual reports to the California Public Utilities Commission every February and to the Legislature each April through 2020.

Innovative Technology Powers California

California leads the nation in energy efficiency innovation, renewable energy technologies, greenhouse gas reduction goals, and forward-thinking energy policies. Achieving the goals of

these aggressive energy policies and meeting the energy demands of Californians requires creating advanced energy markets and helping to bring new energy efficient products and technologies on line. Research and demonstration are the foundation for these innovative technologies. As Severin Borenstein notes in a March 2014 blog article posted by The Breakthrough Institute, *In Defense of Picking Winners*, public funding for innovation accelerates development and adoption of breakthroughs by investing in promising ideas and disseminating information widely. Success and value is created from winning solutions as well as lessons learned. The Energy Commission's investment of EPIC funds will provide pathways that allow new approaches to benefit California's ratepayers while building our clean energy future. Investments in innovative technologies through the EPIC program will continue to save ratepayers money and leverage their dollars, reduce energy demand, increase energy reliability and security, protect energy resources, environment and public health, and provide a better California quality of life.

CHAPTER 1:
Introduction and Overview

One in eight Americans lives in the Golden State. With nearly 38 million residents, California spends almost $100 billion each year on energy – electricity to power its homes, businesses and industry; natural gas for generating electricity, heating homes and powering industrial processes; and petroleum for transportation. The state's economic vitality and social well-being depends upon affordable, safe, and reliable energy that requires investments in clean technology. For more than three decades, California ratepayers have invested in clean energy resources and technologies, adopting policies to diversify its energy supplies and using these supplies more effectively and efficiently. And because of these investments, California ratepayers have reaped the benefits of pioneering research and development (R&D), using less electricity per person than any other state due to aggressive energy efficiency standards, having more renewable energy resources available than many countries, and owning the largest fleet of hybrid and clean-fueled vehicles on the road. However, energy innovation requires more investments, and although California investor-owned utility ratepayers cannot carry the entire burden of innovation investments for a clean energy future, their role is critical in helping California to meet its energy goals.

By 2020, California has committed to generating a third of its electricity from renewable resources, replacing 20 percent of the petroleum used for transportation with sustainable fuels, and rolling back greenhouse gas emissions to 1990

Investing in innovation is one of the most important pathways toward achieving California's clean energy future. Making the leap to meet aggressive climate and energy goals at the lowest possible cost for ratepayers will require investments in creativity and innovation – the core qualities of an energy research program. Energy research is an investment that yields significant benefits, lays the foundation for enormous savings into the future, promotes customer choice, and leads to jobs.

Since 1996, the California Energy Commission has administered several R&D programs that have driven innovation and advanced science to benefit ratepayers, making their energy choices safer, more reliable and less costly. The Electric Program Investment Charge (EPIC) Program supports these types of innovation investments in clean technologies and strategies to improve the state's electricity systems that continue to benefit ratepayers.

EPIC: California's Investment in the 21st Century Electric Grid

Innovation is the bridge that empowers California to move from the unsustainable status quo to a clean energy future. The EPIC Program is the foundation for that innovation. The EPIC Program creates new energy solutions, fostering regional innovation and bringing ideas to the marketplace. EPIC consolidates the R&D initiatives of the three largest investor-owned utility (IOU) service areas into an aggregate program, ensuring no duplication in spending and helps achieve state energy policies. With this funding, the Energy Commission is undertaking an energy pipeline approach, creating new energy solutions, fostering regional innovation, and bringing clean energy ideas to the marketplace for the benefit of California IOU ratepayers.

Electric Program Investment Charge

Created by the California Public Utilities Commission (CPUC) (Decision 12-05-037),[1] EPIC is a comprehensive R&D program for benefits to the investor-owned utilities ratepayer. EPIC and the Investment Plans were developed through an open public process. EPIC guidance and authorization were provided through CPUC decisions and a number of legislative bills, including: Senate Bill 1018 (Committee on Budget and Fiscal Review, Chapter 39, Statutes of 2012), which established the EPIC fund; Assembly Bill 110 (Blumenfeld, Chapter 20, Statutes of 2013), authorizing the Energy Commission to use ratepayer funds; and Senate Bill 96 (Committee on Budget and Fiscal Review, Chapter 356, Statutes of 2013), directing the Energy Commission to award funds through competitive bidding.

The California Public Utilities Commission (CPUC) (Decision 12-05-037) established the EPIC Program to invest funds from electricity ratepayers for clean technologies in three areas: applied research and development, technology demonstration and deployment, and market facilitation and support. The ratepayers from three of California's major IOUs – Pacific Gas and Electric Company (PG&E), Southern California Edison Company (SCE) and San Diego Gas & Electric Company (SDG&E) – fund the program. The Energy Commission administers 80 percent of the approved EPIC funds ($162 million annually), and PG&E, SCE and SDG&E administer the remaining 20 percent of the funds. The CPUC provides program oversight and approved the *2012-2014 EPIC Investment Plan* for EPIC expenditures from the Energy Commission and the three utilities in November 2013. The CPUC will conduct public proceedings every three years to review each administrator's proposed EPIC investment plan.

The *2015-2017 EPIC Investment Plan* presents the Energy Commission's proposed strategy for administering the three-year amount of $388.8 million.[1] This amount includes $38.88 million for

1 Adjusted on January 1, 2015 to commensurate with the average change in the Consumer Price Index for Urban Wage Earners and Clerical Workers for the third quarter for the previous three years. California Public Utilities Commission, Decision Addressing Applications of the California Energy Commission,

administrative costs and $349.92 million for program awards. The *2015-2017 EPIC Investment Plan* proposes strategic objectives and initiatives for Energy-Commission administration of EPIC funds collected from 2015 to 2017 for applied research and development, technology demonstration and deployment, and market facilitation. The *2015-2017 EPIC Investment Plan* also applies ratepayer benefits as the mandatory principle to guide investment decisions. The four EPIC administrators work together to coordinate development of proposed investment plans and avoid duplication.

A Transparent Public Process

Energy Commission staff developed the draft *2015-2017 EPIC Investment Plan* in an open public process with input and guidance from Energy Commission Chair Robert B. Weisenmiller as the lead commissioner on research, development, and demonstration (RD&D) issues.

Energy Commission staff held public workshops on February 7, 2014 and March 17, 2014 in Sacramento and March 21, 2014, in Southern California to solicit input from experts, stakeholders, and the public on developing the *2015-2017 EPIC Investment Plan*. Staff considered input from these workshops and comments submitted to the 12-EPIC-01 docket while developing the *2015-2017 EPIC Investment Plan.*

Proposed Initiatives Advance Energy Policy Goals

The draft-proposed funding initiatives for the *2015-2017 EPIC Investment Plan* are based on Senate Bill 96 and other clean energy statutes and policies; current knowledge and expertise of state-of-the-art technologies; existing RD&D efforts including barriers and gaps; key factors that drive clean energy development; and numerous stakeholder comments. Incorporated into these proposed funding initiatives are adherence and consistency with the EPIC Program areas as defined and directed by the CPUC; specific guiding principles; the electricity value chain; and policy and other ratepayer benefits.

Pacific Gas and Electric Company, San Diego Gas & Electric Company and Southern California Edison Company for Approval of their Triennial Investment Plans for the Electric Program Investment Charge Program for the Years 2012 Through 2014, Application 12-11-001, Application 12-11-002, Application 12-11-003, and Application 12-11-004, as consolidated, ordering paragraph 3, http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M081/K773/81773445.PDF.

As required by Senate Bill 96, this *2015-2017 EPIC Investment Plan* identifies initiatives to benefit electricity ratepayers and lead to technological advancement and breakthroughs. The *2015-2017 EPIC Investment Plan* aims to help achieve the state's statutory energy goals by investing in a strategically focused portfolio of projects designed to address the most significant technological barriers and challenges facing clean energy. Proposed initiatives include the specific priorities for EPIC established in Senate Bill 96: energy storage, renewable energy and its integration into the electrical grid, energy efficiency, integration of electric vehicles into the electrical grid, and accurately forecasting the availability of renewable energy for integration into the grid.

Vision that Drives EPIC Investments

California's future electricity system will consider near-zero-net energy buildings, highly efficient businesses, low-carbon generation, sustainable bioenergy systems, more localized generation, and the electrification of transportation. These will be supported by a highly flexible and robust distribution and transmission infrastructure.

The *2015-2017 EPIC Investment Plan* reflects the following:

1. The entire *2015-2017 EPIC Investment Plan* embodies ratepayer benefits, from selection of funded initiatives to criteria for project selection, as well as incorporates the other requirements from the CPUC's EPIC decisions and the Legislature's EPIC statutes.
2. The *2015-2017 EPIC Investment Plan* invests in achieving California's clean energy goals and benefits, reflecting the state's energy priorities as directed in the "loading order." The *2015-2017 EPIC Investment Plan* portfolio emphasizes meeting greenhouse gas (GHG) emission reductions; all cost-effective energy efficiency; 33 percent renewables; transforming and electrifying the transportation sector; and a "smart grid" that can promote this transformation.[2]
3. The priorities of the *2015-2017 EPIC Investment Plan* will accelerate "homegrown" technology innovation, creating the tools and products required to reach these goals.
4. The project selection process:
    a. Selects the most promising technology solutions that do not duplicate other ongoing public or private research activities.
    b. Helps reduce administrative costs.
    c. Maximizes in-state investments.

2 The Energy Commission's vision of the smart grid is the thoughtful integration of intelligent technologies and innovative services that produce a more efficient, sustainable, economic, and secure electrical supply for California communities. Energy Commission website: http://www.energy.ca.gov/research/integration/smart_grid.html.

5. The *2015-2017 EPIC Investment Plan* builds on lessons learned from the Energy Commission's programs and work underway to implement the Energy Commission's *2012-2014 EPIC Investment Plan*. The proposed *2015-2017 EPIC Investment Plan*'s design is to meet today's priorities and respond to guidance in the CPUC EPIC decisions and requirements set by the Legislature.

Chapter 2 discusses the directives of the EPIC Program, including the guiding principle of providing benefits to California's electric ratepayers and several complementary benefits. The funding levels for each program research area are outlined, along with a discussion of the technology areas targeted for investment, the policy justifications for investments in energy RD&D, and the energy innovation pipeline.

Chapters 3, 4, and 5 describe how the planned investments for EPIC funds collected in the 2015-2017 timeframe relate to demand-side management, generation, market design, grid operations, transmission, and distribution. Chapter 3 describes proposed strategic investment objectives in applied research and development. The objectives address gaps in the funding needed to help innovative energy technologies and approaches succeed. The chapter focuses on targeted investments in energy efficiency and demand response (DR), clean generation, smart grid enabling clean energy, and cross-cutting technologies that span two or more of these areas. Each objective includes a number of key funding initiatives that will address the gaps in applied R&D funding for each technology area.

Chapter 4 maps out proposed strategic investment objectives in technology demonstration and deployment with a focus on providing key bridge funding to scale up efficiency, renewables, and clean transportation in a real-world electricity system environment.

Chapter 5 addresses funding for the market facilitation program area to help fill gaps in marketing for clean energy technologies, including services to assist entrepreneurs and ease the procurement of clean energy by government agencies, universities, builders, and commercial enterprises. Also, Chapter 5 includes proposed initiatives to assist local regulatory and permit streamlining efforts for clean energy and initiatives to analyze market trends, develop an information clearinghouse for clean energy, and evaluate programs.

Chapter 6 identifies a need for funding for the New Solar Homes Partnership (NSHP), which provides financial incentives for installing eligible solar energy systems on new homes as part of the California Solar Initiative (CSI).

Chapter 7 discusses program administration including the following key elements of the *2015-2017 EPIC Investment Plan* identified by the CPUC and Senate Bill 96:

- The amount of funding to be devoted to each program area.
- Policy justification for the proposed funding allocation.

- The type of funding mechanisms (such as grants and contracts) to be used for each investment area.
- Competitive bid as the preferred method to solicit project applications and award EPIC program funds.
- Tracking actual overhead and administrative costs by program administrators and individual grant and contract recipients.
- Project eligibility and selection criteria.
- Per project funding limits, including match funding requirements.
- Metrics for measuring benefits and success, including whether the project resulted in any technological advancement or breakthrough to overcome barriers to achieving the state's statutory energy goals.
- Treatment of intellectual property rights.

Chapter 8 addresses the methods for assessing the Program's benefits and success based on project and technology type, energy use sector, the project funded, and where it is in the energy innovation pipeline. Each phase of program development incorporates these measurements of benefits and success, including solicitation planning, project agreement development, project management, and project closeout.

CHAPTER 2:
Innovation for a Clean Electricity Future

Energy Innovation Is Vital

California's economic strength and social well-being depend on affordable, safe and reliable energy. Today the energy people use and the ways they use it are rapidly changing. Innovation is the bridge that empowers California to move from the unsustainable status quo to its clean energy future. Innovation drives investments, has created billions of dollars in energy savings for California ratepayers, and supports the creation of new businesses and thousands of jobs in California. The state must continue to advance ways to use energy more effectively and efficiently and maximize innovative technologies to improve energy reliability, affordability, and safety to benefit all California ratepayers.

EPIC Program Mission
Through EPIC, the Energy Commission will fill critical funding gaps within the energy innovation pipeline to advance technologies, tools, and strategies that provide California's IOU ratepayers with clean, affordable, and reliable electricity and help enable the 21st century power grid.

The Energy Commission administers research and development (R&D) programs that are nationally recognized for driving innovation and advancing energy science and technology in energy efficiency, renewable and advanced clean electricity generation, energy-related environmental protection, energy transmission and distribution (T&D), and transportation. Since 1996, the Energy Commission has invested $884 million for energy R&D, leveraging this investment to attract more than $1.4 billion in match funds. Energy innovation investments also create savings: an estimated $10 billion in ratepayer savings will result from just 19 past Energy Commission efficiency R&D projects whose public results led to upgrades in California's efficiency codes. This is a return on investment of $446 for every $1 invested in the projects. To continue advancing energy science and technology in similarly positive and enduring ways, the CPUC created the EPIC Program in 2011. EPIC invests in improvements to California's electricity systems and is administered by the Energy Commission and California's three large investor-owned utilities (IOUs): Pacific Gas and Electric Company (PG&E), Southern California Edison Company (SCE), and San Diego Gas & Electric Company (SDG&E). All EPIC-funded innovations share a common, fundamental goal: providing more reliable, lower-cost, safer electricity to IOU ratepayers. EPIC will take an energy pipeline approach to creating new energy solutions, fostering regional innovation and bringing clean energy ideas to the marketplace to benefit California IOU ratepayers.

Guiding Principles

The mandatory guiding principle of EPIC is to invest in clean energy technologies and approaches that provide benefits to electricity ratepayers by promoting greater reliability, lower costs, and increased safety. In addition, EPIC adopts the following complementary principles:

- Societal benefits.
- Greenhouse gas (GHG) emissions reduction and adaptation in the electricity sector at the lowest possible cost.
- The energy loading order.
- Low-emission vehicles/transportation.
- Economic development.
- Efficient use of ratepayer money.

Also, EPIC considers the principles conveyed in Public Utilities Code Sections 740.1 and 8360 – which govern utility expenditures in the areas of research, development, and demonstration (RD&D) and smart grid – to serve as guidance. Section 740.1 states that in evaluating RD&D projects, consideration will be given to:[3]

- Projects that provide a reasonable likelihood of ratepayer benefits.
- Minimizing projects with a low probability of success.
- Projects consistent with the utility corporation's resource plan.
- Projects that do not duplicate previous or current research by other electrical or gas corporations or research organizations.
- Projects that support one or more of the following objectives:
    - Environmental improvement.
    - Public and employee safety.
    - Conservation by efficient resource use or by reducing or shifting system load.
    - Developing new resources and processes, particularly renewable resources and processes that further energy supply technologies.
    - Improve operating efficiency and reliability or otherwise reduce operating costs.

3 Public Utilities Code § 740.1: http://www.leginfo.ca.gov/cgi-bin/displaycode?section=puc&group=00001-01000&file=727-758.

Section 8360 outlines the requirements for the state's electrical T&D system to maintain safe, reliable, efficient, and secure electrical service to meet future growth in demand and achieve the following:[4]

- Increased use of cost-effective digital information and control technology to improve reliability, security, and efficiency of the electric grid.
- Dynamic optimization of grid operations and resources, including appropriate consideration for asset management and use of related grid operations and resources, with cost-effective full cybersecurity.
- Deployment and integration of cost-effective distributed resources and generation, including renewable resources.
- Development and incorporation of cost-effective demand response (DR), demand-side resources, and energy-efficient resources.
- Deployment of cost-effective smart technologies, including real-time, automated, and interactive technologies that improve the physical operation of appliances and consumer devices for metering, communications concerning grid operations and status, and distribution automation.
- Integration of cost-effective "smart" appliances and consumer devices.
- Deployment and integration of cost-effective advanced electricity storage and peak-shaving technologies, including plug-in electric and hybrid electric vehicles, and thermal-storage air conditioning.
- Provide consumers with timely information and control options.
- Develop standards for communication and interoperability of appliances and equipment connected to the electric grid, including the infrastructure serving the grid.
- Identification and lowering of unreasonable or unnecessary barriers to adoption of smart grid technologies, practices, and services.

EPIC Investment Strategy and the Electric System Value Chain

California energy policy frames a vision for its electricity future that includes an aggressive transition from fossil generation to renewable sources, highly efficient homes and businesses, and electrification of portions of the transportation system. The role of the Energy

4 Public Utilities Code § 8360, http://www.leginfo.ca.gov/cgi-bin/displaycode?section=puc&group=08001-09000&file=8360-8369.

Commission's EPIC investments is to provide the tools, technologies, and market assistance that accelerate achievement of this vision in IOU service territories at a reasonable cost and without sacrificing safety and reliability. To accomplish this, Energy Commission staff proposes strategic improvements to help bridge gaps along the electric system value chain.

The CPUC Phase 2 decision requires all EPIC investments to be linked to the different elements of the electricity "value chain," which consists of grid operations/market design, generation, transmission, distribution, and demand-side management. Similar to the guiding principles, each initiative in Chapters 3, 4, and 5 includes a matrix and is correlated to the electric system value chain.

Homes and businesses require high-quality and cost-effective efficiency products and services. Renewable generation and electric transportation must be seamlessly integrated and connected into the electric grid at all levels, ranging from small-scale home applications to large central-station power plants. The Energy Commission's *Integrated Energy Policy Report* (*IEPR*) and ongoing analysis at the California Independent System Operator (California ISO), the CPUC, the United States Department of Energy (U.S. DOE), and the United States Environmental Protection Agency (U.S. EPA) have identified key challenges to achieving this clean energy vision for California's IOU service territories. Each of the initiatives described in Chapters 3-5 addresses an important barrier and investment gap.

Vision for 2030 and Beyond: What EPIC Seeks to Accomplish

A vision for 2030 and beyond underlies the strategic objectives and initiatives defined in this *2015-2017 EPIC Investment Plan*. The vision aligns the proposed research, demonstration, and deployment activities with the state's energy policies and aligns with the major elements of the IOUs visions. The successful implementation of the initiatives proposed in this *2015-2017 EPIC Investment Plan* will help bring a clean energy future closer, advancing the solutions that will improve both the larger electricity grid and the immediate aspects of Californians' daily lives.

The electric grid was designed as a one-way system, with centralized plants burning cheap, abundant fossil fuels to send power out to users via low-tech transmission lines. In the past, renewable energy was not a significant part of the grid, advanced energy storage technologies were not used, and few electric vehicles (EVs) existed. The vision for the future of California's electricity system is based on the state's "loading order," a guiding policy that puts energy efficiency and demand response as top energy resource priorities. Next, the loading order calls for renewable resources and distributed generation. Maximizing these "preferred resources" becomes even more important to achieve goals to reduce greenhouse gas emissions and maintain system reliability at the least cost to the ratepayer and the environment. This overarching vision drives all of the Energy Commission's investments of EPIC funds.

The Vision for the Electricity System: Clean, Smart, Efficient, and Resilient

In coordination with other investments and efforts, the success of the innovations described in this *2015-2017 EPIC Investment Plan* could help transform California's electricity grid. Its generation sources, transmission and distribution networks, and the management of these resources will all be improved. With continued advances to reduce costs, by 2030 the grid may use more renewable energy and that energy could cost less than today's fossil fuel generation. Utility-scale solar photovoltaic (PV) and wind may become the lowest-cost options for electricity generation. A January 2014 study by E3: Energy and Environmental Economics explored the operational challenges, potential solutions, costs, and greenhouse gas impacts of achieving a 40 percent or 50 percent RPS by 2030, including scenarios with high levels of wind and solar energy. The study suggests that curtailment of renewable generation or other solutions to address over-generation must be available to maintain reliable operation of California's electricity system.[5]

New thermal generation facilities could be more flexible and efficient, produce fewer emissions, and use less water than those facilities currently operating. Advancements to thermal generation, including geothermal, natural gas, and solar thermal, could increase the operational flexibility and ramping capability of the grid to support the integration of high penetrations of intermittent PV and wind. Electricity grid operators and managers may use advanced technologies and improved tools to see grid activity and prevent issues that compromise electricity service. Generators and grid operators could have increased ability to forecast renewable generation, permitting integration of intermittent renewable resources at the lowest possible economic and environmental costs. Smart environmental planning and up-front assessments could help locate generation in the most environmentally benign areas.

As a whole, these technological improvements could help change the very nature of the grid. The 2030 grid may begin to evolve into a decentralized network of microgrids connected as smart, responsive "local energy networks," working together, yet independent and self-sufficient when necessary. Regional integration will be critical to smooth out renewable variability. In addition to incorporating higher levels of renewables, the 2030 grid may have to contend with more frequent extreme weather events and cyber-security threats. Electric system operators could more effectively use preferred resources such as demand response and distributed generation to meet energy demand and maintain reliability. Smart devices, real-time, and near-real-time communication, combined with automated controls, could help manage increased complexity, and improve the overall efficiency of the electricity system, and allow greater consumer choice in energy services. The electricity sector may be more prepared to adapt to climate change effects through strategies that predict water shortfalls, increased energy demand from extreme temperatures, and built-in protections to energy infrastructure.

5 E3: Energy and Environmental Economics. January 2014. *Investigating a Higher Renewables Portfolio Standard in California*. Executive Summary.
https://ethree.com/documents/E3_Final_RPS_Report_2014_01_06_ExecutiveSummary.pdf.

What This Vision Means for California's Residents, Industries, and Resources

The transformation supported by Energy Commission investments under EPIC will affect more than just the structural landscape of California's broader electricity system; it will also bring measurable benefits and improvements to the immediate aspects of Californian's daily lives: the buildings they live and work in, the companies and industries they work for and that drive the economy, the transportation systems they use, and the resources they need to sustainably prosper.

Clean, low-cost energy for communities. Near-term requirements and goals in state laws and policies for clean energy set the stage for this investment plan. For example, Assembly Bill 1109 (Statutes of 2007), requires reduced average statewide electrical energy consumption by 2018 for indoor residential lighting by not less than 50 percent and for indoor commercial and outdoor lighting by not less than 25 percent compared to 2007 levels. The 2013 Title 24 standards for new buildings are expected to use 25 percent less energy for lighting, heating, cooling, ventilation, and water heating than the 2008 standards. Also, California has a policy goal of achieving zero-net-energy (ZNE) building standards by 2020 for low-rise residential buildings and by 2030 for commercial buildings. Governor Brown's Executive Order B-18-12 calls for all new state buildings and major renovations that begin design after 2025 to be constructed as zero-net-energy facilities. For existing buildings, Assembly Bill 758 (Skinner, Chapter 470, Statutes 2009) requires the Energy Commission, in collaboration with the California Public Utilities Commission and stakeholders, to develop a comprehensive program to achieve greater energy efficiency in the state's existing buildings. In addition, Assembly Bill 758 will require building rating disclosures and mandatory energy retrofits. Technologies that reduce electricity demand for lighting, heating and cooling, and other building energy uses may lower payback periods to the point that these solutions are widely adopted.

California's Renewables Portfolio Standard requires 33 percent of retail sales to be met with eligible renewable energy by 2020. To reduce uncertainty regarding environmental mitigation costs for large-scale renewable energy in southeastern California, Executive Order S-14-08 mandated the formation of the Renewable Energy Action Team (REAT) to develop the Desert Renewable Energy Conservation Plan (DRECP), a major component of California's renewable energy planning efforts. The REAT agencies include the California Energy Commission, California Department of Fish and Wildlife, U.S. Bureau of Land Management, and U.S. Fish and Wildlife Service. The DRECP, when completed, is expected to further these objectives and accelerate the processing of renewable projects in the Mojave and Colorado deserts of California. Senate Bill 43 (Wolk, Chapter 413, Statutes of 2013) established a community renewables program to facilitate development of eligible renewable energy resource projects located close to the source of demand. Looking out to 2030, low-cost community renewable energy facilities, such as solar, could provide widespread opportunities for renters, small businesses, and low-income households to adopt renewables. Expanded implementation of best practices may accelerate clean energy upgrades developments.

Regional integration and microgrids could help tie together variability in electricity loads and resources to maintain system reliability. The CPUC smart grid proceeding, Rulemaking 08-12-009, is considering policies for California investor-owned electric utilities to develop a smarter electric grid in the state, including policies, standards, and protocols to guide the development of a smart grid system and facilitate integration of new technologies such as distributed generation, storage, demand-side technologies, and electric vehicles. In addition, the U.S. Department of Navy (DON) supports the use of microgrids: "To improve energy security, DON must evolve beyond simply providing emergency generators for individual buildings to being able to provide reliable, sustained power to designated substations with the capability to match sources to critical loads. As microgrids and smart grids are developed, [renewable energy] RE can be integrated along with other generation sources to provide diversified power as necessary to the installation's critical assets."[6]

Clean energy for businesses to flourish. In the clean electricity system of the future, California's businesses and job creators may be able to significantly lower their energy costs, improving their competiveness and ability to offer better services to customers. Achieving the 2030 goal of ZNE for new commercial buildings poses a difficult challenge. Emerging renewables – such as PV-integrated windows and energy harvesting technologies that supply power to electronics, appliances, and machines –may help to achieve this goal. Office buildings, restaurants, shopping centers, restaurants, and other commercial businesses in IOU service territories may be encouraged to make greater use of technologies such as advanced daylighting and efficient lighting and waste heat conversion technologies. Businesses like restaurants and hotels may be able to convert their food waste to electricity and heat on-site with more affordable and cleaner conversion technologies. This 2030 vision could provide a living laboratory that attracts the best and brightest clean energy entrepreneurs, creating the infrastructure and environment that allows next-generation innovators to successfully develop new technologies and businesses to further transform the electricity system.

Improved electricity quality, reliability, and security for California's industries. Innovative technologies and procurement mechanisms may help large institutional and industrial facilities, such as ports, military bases, manufacturing facilities, and business parks, to adopt more cost-effective efficiency measures and onsite renewables for daily operations. Future automated demand response (Auto DR)[7] capabilities could allow customers to pre-program facilities to respond automatically to incentives and other applicable tariffs, conserve energy, reduce energy bills, and provide services to the grid. Near-term milestones for demand response include the CPUC demand response rulemaking 13-09-011 to develop a competitive procurement mechanism for supply-side demand response resources, defined reliable and flexible demand

6 http://www.secnav.navy.mil/eie/ASN%20EIE%20Policy/DASN_EnergyStratPlan_Finalv3.pdf.

7 Automated demand-response systems use Internet-based electricity pricing and demand-response signals to initiate preprogrammed control strategies that provide fully automated management of building energy use.

response that meets system resource planning and operational requirements, and take other steps to advance demand response in California.

Facility managers could transition vehicle fleets to plug-in electric vehicles to reduce fueling costs, meet stringent air quality standards, and receive payment for using EV batteries to help provide reliability services for the electricity system. In 2012, Governor Brown signed an executive order laying the foundation to support 1.5 million zero-emission vehicles by 2025. In February 2014, the California ISO published the *California Vehicle-Grid Integration (VGI) Roadmap: Enabling vehicle-based grid services*, focusing on next steps needed to establish the value and business case for VGI, develop enabling policy, and support enabling technology development. Proceedings underway affecting VGI include the CPUC's electric vehicle proceedings and their smart grid proceeding. The Energy Commission, with assistance from the National Renewable Energy Laboratories, will develop a statewide plug-in electric vehicle infrastructure plan to provide guidance on state level policy, high-priority locations for infrastructure, consideration of interregional corridors, and guidance to local communities and regions as they plan for plug-in electric vehicles.

Demand for greater reliability and power quality could also drive facilities to install microgrid control systems combined with onsite renewables, combined heat and power (CHP), and storage, allowing them to operate independently from the larger grid and maintain critical operations during short-term grid outages. In compliance with Assembly Bill 2514 (Skinner), CPUC Decision 13-10-040 in Rulemaking 10-12-007 specified energy storage procurement targets for transmission, distribution, and customer points of interconnection totaling 200 megawatts (MW) for 2014, 270 MW for 2016, 365 MW for 2018, and 490 MW for 2020. Also, the Governor has set a goal of 12,000 MW of localized renewable generation available close to load by 2020 and 6,500 MW of combined heat and power by 2030. The Assembly Bill 32 Scoping Plan includes a reduction goal of 6.7 million metric tons (MMT) of carbon dioxide (CO_2) from CHP resources. Technologies that cleanly and efficiently convert natural gas to onsite electricity generation could provide backup generation to ensure critical loads can be maintained for extended periods without high-polluting diesel generators.

Economically and environmentally sustainable agricultural and forest operations. Advances in bioenergy technologies could enable agricultural operations to use a greater proportion of waste for lower-cost, local, clean electricity generation, reducing waste treatment and disposal costs. Fuel choices may be more diverse and more sustainably harvested, reducing harm to the environment and vulnerable communities. Expanding clean bioenergy in agricultural and forestry industry areas could foster job creation and investment in rural communities. Advances in bioenergy could also reduce waste streams, air pollution, and associated negative health impacts.

Cheaper, more efficient, and more integrated electric vehicles. Vehicle-to-grid and battery reuse strategies could improve the operation and efficiency of the electric grid and provide revenues to EV owners, reducing the upfront purchase costs of plug-in EVs and making electric vehicles more economically viable alternative for ratepayers.

More choices and convenience for ratepayers. The technologies and solutions funded by EPIC could help transform future ratepayers' ability to choose and control energy solutions. Ratepayers could select from a variety of home area networks to better manage home energy use. Customers may have access to a wider variety of renewable energy options, including "plug-and-play" distributed generation technologies designed to streamline installation and interconnection. To help achieve additional energy savings, while maintaining comfort, integrated controls could provide building occupants with instant feedback on energy use and cost, and correlate energy use patterns with occupant behavior to determine the best way to minimize energy use. To fully implement the vision, these solutions and technologies must be deployed at a scale and in a manner that reaches all sectors, including traditional hard-to-reach sectors, such as affordable housing and small business.

The investments made in the *2015-2017 EPIC Investment Plan* will connect, integrate, and further build on the progress made in the first investment period. Through coordination among EPIC administrators and stakeholders, EPIC investments can help align present and planned actions with the envisioned clean energy future to provide ratepayers with valuable energy choices while creating a more robust, reliable, safe, and secure electric grid that operates efficiently by optimizing assets and lowering costs.

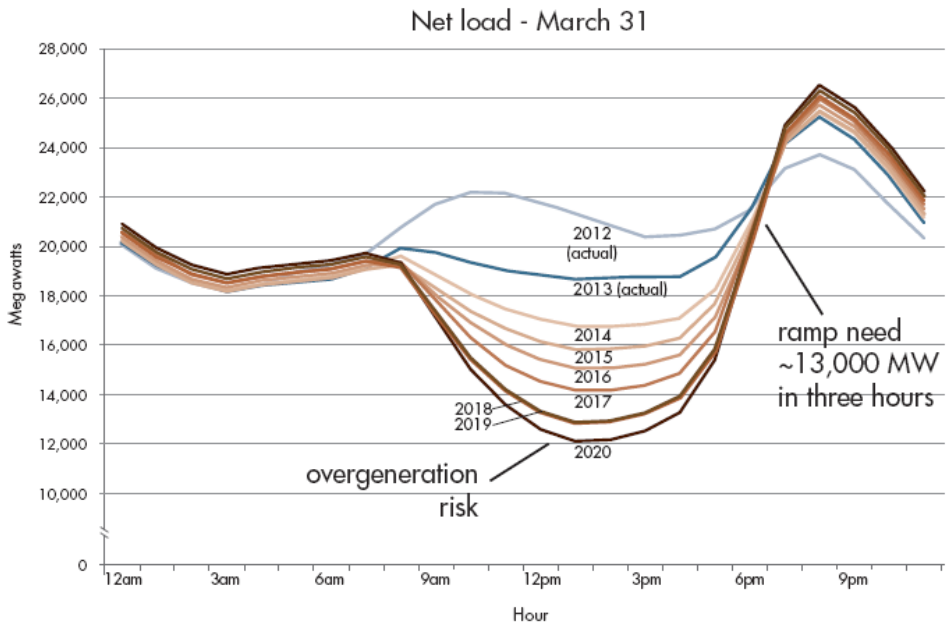
Foresight and Planning Resources Guiding This Vision

Developing and advancing the most beneficial technologies and solutions to bring this future closer for California are complex tasks, but the vision described in this *2015-2017 EPIC Investment Plan* is based on the most informed forecasts. Energy Commission-funded innovations have been building decision makers' capabilities to approach the task by providing real-world operational data about emerging solutions and by building predictive forecasting tools.

Researchers at the University of California, Berkeley and Lawrence Berkeley National Laboratory created one of these models. The planning model, known as SWITCH, can simulate the evolution of myriad combinations of technological, economic, and policy factors between now and 2050 to create long-term energy scenarios.[8] SWITCH results indicate that a range of aggressive actions will allow California to achieve sweeping GHG reductions by 2050; the model also shows that investments in efficiency and renewables are necessary under all scenarios to achieve GHG targets. The results also indicate California must make early investments in new technologies, such as aggressive demand response, to avoid significantly higher costs in the long term.

8 For more information about SWITCH, see page 64 of the *Public Interest Energy Research 2012 Annual Report*. California Energy Commission, 2013. http://www.energy.ca.gov/research/annual_reports.html

Figure 1: The Duck Chart



The Duck Chart is a net load curve that illustrates the demand for conventional generation and renewable over-generation risk during a typical spring day in California. As seen during the afternoon, the belly of the duck shows over-generation of solar power, and around 4 PM, the system requires a steep on ramp of conventional generation to replace the loss of solar power as the sun sets.

Source: California Independent System Operator. 2013. "What the Duck Curve Tells Us about Managing a Green Grid." http://www.caiso.com/Documents/FlexibleResourcesHelpRenewables_FastFacts.pdf.

Another important forecasting tool that demonstrates the importance of the improvements made through EPIC funds is the "duck chart" (Figure 1) developed by the California ISO. The California ISO modeled future scenarios of net load curves – curves that show the difference between forecasted load and expected electricity production from variable generation resources to highlight the changing conditions renewables bring to the grid. The net curves demonstrate how real-time electricity net demand may change as policy initiatives are realized between now and 2020. The duck chart illustrates the anticipated pattern and need for flexible resources, flexible ramping, over-generation mitigation, and automated frequency response to meet net load shifting in the green grid. There is considerable uncertainty in forecasting hourly load profiles and intermittent resource profiles years into the future. As a result, this analysis illustrates an issue that planners must address, but the precise results are uncertain, particularly for the out years.

EPIC Investment Areas and Funding

The CPUC's approach to investments in clean energy research recognizes many market-driven scientific and financial barriers by allocating funding to three interconnected stages of development. The *2015-2017 EPIC Investment Plan* presents the Energy Commission's proposed strategy for administering the three-year amount of $388.8 million.[9] This amount includes $38.88 million for administrative costs and $349.92 million for program awards (Table 1).

- **Applied Research and Development** ($151.63 million; three-year funding to the Energy Commission): These activities support pre-commercial technologies and approaches designed to solve specific problems in the electricity sector, including activities that address environmental and public health impacts of electricity-related activities, support building codes and appliance standards, and clean transportation with a linkage to electricity sector ratepayer benefits.
- **Technology Demonstration and Deployment** ($145.02 million; three-year funding to the Energy Commission and $86.6 million of three-year funding to the three large investor-owned utilities [IOUs]): Technology, demonstration and deployment (TD&D) is the installation and operation of pre-commercial technologies or strategies at a large-enough scale and in conditions that reflect anticipated actual operating environments allowing an appraisal of the operational and performance characteristics , and the financial risks of the project.
- **Market Facilitation** ($53.26 million; three-year funding to the Energy Commission): Projects in Market Facilitation are a range of activities that include program tracking, market research, education and outreach, regulatory assistance and streamlining, and workforce development to support clean energy technology and strategy deployment. The Phase 2 decision further clarifies that this category should not necessarily be limited to renewables but may also include any other clean energy technologies and/or strategies.

A fourth area, **Market Support**, was not specifically allocated funding in the decision by the CPUC; however, the New Solar Homes Partnership (NSHP) fits within the definition of activities that support commercially viable technologies that require public support to meet economies of scale and be competitive with other technologies. The CPUC can allow EPIC

9 Adjusted on January 1, 2015 to commensurate with the average change in the Consumer Price Index for Urban Wage Earners and Clerical Workers for the third quarter for the previous three years. California Public Utilities Commission, Decision Addressing Applications of the California Energy Commission, Pacific Gas and Electric Company, San Diego Gas & Electric Company and Southern California Edison Company for Approval of their Triennial Investment Plans for the Electric Program Investment Charge Program for the Years 2012 Through 2014, Application 12-11-001, Application 12-11-002, Application 12-11-003, and Application 12-11-004, as consolidated, ordering paragraph 3, http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M081/K773/81773445.PDF.

funding for Market Support, including funding for NSHP incentives. At this time, the Energy Commission would like to propose keeping all options open for NSHP funding, including combining different funding sources, provided that total funding does not exceed the $400 million cap for NSHP under Senate Bill 1.

Table 1: California Energy Commission EPIC Funding by Program Element 2015-2017 (million)

Funding Element	Total
Applied Research and Development	$151.63
Technology Demonstration and Deployment	$145.02
Market Facilitation	$53.26
Program Administration	$38.88
Sub Total	**$388.8**
New Solar Homes Partnership	*
Total**	**$388.8**

*Up to $130 million.

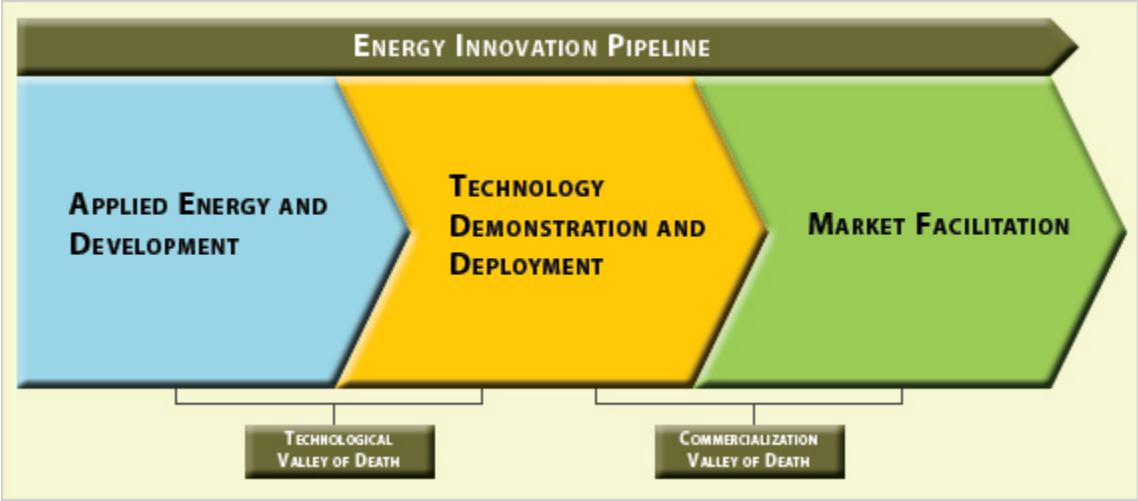
**Any additional funds that may be allocated to the Energy Commission as a result of any CPI adjustment will be used to increase the budget proportionally across all areas

Source: California Energy Commission

Energy Innovation Pipeline

Ensuring a reliable, safe, clean, and diverse electricity system remains one of the most important elements toward securing California's economic and environmental energy security. For more than three decades, California has endeavored to expand and diversify its energy sources from traditional fossil fuel sources. As a result, these efforts are embedded in state energy policy; however, major barriers remain, including higher costs of new technologies. Private sector investments in early-stage, untested technologies often present financing risks for profit-minded business models. The process for new technologies from early- to market-stage adoption requires several steps known as the **energy innovation pipeline** (Figure 2).

Figure 2: Energy Innovation Pipeline



Source: California Energy Commission

The earliest phase of the energy innovation pipeline is basic or fundamental research. This expansion of knowledge is without a predefined commercial application or specific invention. Basic research lays the foundation for applied science. There is no obvious commercial value to the discoveries resulting from basic research.[10] The EPIC Program excludes basic research because this category is typically supported by national labs and research universities. The next phases of the energy innovation pipeline consist of early feasibility, such as lab or field research, bench- and pilot-scale testing, and full-scale demonstration and deployment. The latter two steps also require monitoring and validation studies to provide proven assurances to be fully embraced by private markets. Promising innovations often languish unless supported by public investments. Within the energy innovation pipeline, two critical stages of financing gaps have been recognized – the bridge to move beyond the applied research stage (for example, from lab to pilot-scale) and the bridge between demonstration and commercialization. Jenkins and Mansur (2011) describe these two economic barriers as the "Technology Valley of Death" and the "Commercialization Valley of Death" and they consider these the greatest barriers to innovative energy prototypes and innovative entrepreneurs entering the market place.[11]

In his 2006 article in *Innovations*, John P. Holdren of Harvard University outlined the acute need for investment and deployment on new energy technologies.[12] Holdren also acknowledged that

10 http://www.lbl.gov/Education/ELSI/research-main.html.

11 Jenkins, J., & Mansur, S. (2011). *Bridging the Clean Energy Valleys of Death: Helping American Entrepreneurs Meet the Nation's Energy Innovation Imperative*. Breakthrough Institute. Retrieved from http://thebreakthrough.org/blog/Valleys_of_Death.pdf.

12 http://www.policyinnovations.org/ideas/policy_library/data/energy_innovation.

private sector investments in research, development, and deployment are inadequate because corporate environments tend to rely on short-term and high rates of return, which R&D is not likely to provide.

Within the energy innovation pipeline there are critical funding gaps not adequately addressed by the private sector due to market barriers. Private venture capital firms, while accustomed to making risky speculative investments on new technologies, avoid investing in early-stage technologies and instead opt to invest when a technology is only a few years from production.[13] Private funding is also rarely enough to fund energy technologies. Unlike software and other large technology industries, demonstrating and assessing pre-commercial energy technologies often require prohibitively large amounts of money over many years.

There are numerous examples of Energy Commission research during the past 16 years that have returned significant ratepayer benefits; however, most likely would not have received initial private sector funding including:

- SunPower and the company it absorbed, PowerLight. Total sales of SunPower systems through the California Solar Initiative (CSI) in IOU territories amount to 339 MW and generate 560 million kilowatt-hour (kWh) of electricity a year, generating $2.1 billion in sales revenues. By supporting tracker technology and residential market streamlining, Energy Commission funding directly contributed to 210 MW of these CSI supported sales, generating 350 million kWh per year of electricity and $1.35 billion in revenues. Adding in the utility solar ranches, Energy Commission RD&D grants directly contributed to the installation of 1,040 MW of SunPower solar panels, generating 2.46 million kWh a year. SunPower and its partners' operations are directly sustaining 4,055 California jobs in addition to 800 construction jobs created in school installations each year, and 1,350 temporary utility-scale construction jobs.
- The Energy Commission funded Winesecrets' demonstration of a low-energy tartrate removal system for wineries in 2002 called the Selective Tartrate Removal System (STARS). Today, STARS units process 5 million gallons of wine a year in California, saving 4 million kWh of electricity and 1 million gallons of water, as well as reducing waste sodium hydroxide, sulfuric acid, and salt in the effluent water. In addition, this process prevents 38,000 gallons of wine from being lost due to tartrate removal, and more than 12,000 therms of natural gas are saved because there is no need to warm wine back up for bottle labeling.[14] Thanks to the STARS process, wineries are improving their net earnings by controlling when they release their inventory rather than having to wait through the weeks-long cold

13 Weiss, C., & Bonvillian, W. (2009). *Structuring an Energy Technology Revolution.* Cambridge Mass.: MIT Press. p. 20.

14 When wine undergoes cold stabilization, condensation from the cold temperatures builds up on the bottle, creating a challenge when adhering labels. After cold stabilization, many wineries have to warm wine bottles back up to near room temperature for labels to adhere properly.

stabilization process. They are also saving on cold stabilization operational costs. All told, California winemakers are saving $1.5 million a year above STARS rental or purchase and operation costs independent of any utility incentives they *may receive.*[15] *STARS machines in North Americ*a are processing around 9 million gallons of wine a year, preventing nearly 3,000 metric tons of carbon dioxide equivalent greenhouse gas emissions per year.

- The development of automated demand response (AutoDR) and open automated demand response (Open AutoDR) at the Demand Response Research Center. The use of AutoDR and Open AutoDR is already avoiding 260 MW of peak load in California annually. The annual net benefits (savings minus technology costs) of these technologies in California are projected to increase from $16.5 million in 2012 to between $39 million and $118 million by 2020. Without Energy Commission leadership and funding, AutoDR development and dissemination would likely have been delayed around five years, perhaps longer, had it come to market at all. This is in part because product and market research and testing, as well as policy support, were needed. Also, the lack of a standardized communications protocol would have slowed development, raised customer costs, and limited customers' ability to change vendors.

The Energy Commission will focus EPIC investments on addressing conditions in which private investment is either unlikely to be invested at all or, if invested, would be inadequate to resolve barriers promptly. The Energy Commission will target projects where publicly available data can reduce the cost of clean energy technologies to the ratepayers.

Developing and Prioritizing Proposed Funding Initiatives

The Energy Commission *2015-2017 EPIC Investment Plan* outlines a series of strategic objectives and proposed funding initiatives that incorporate the CPUC's EPIC decision's defined program areas, guiding principles, electricity value chain, policy, and other ratepayer benefits. The strategic objectives and initiatives are based on current knowledge of state-of-the-art technologies and information, existing RD&D efforts, known barriers and knowledge gaps, and key factors driving clean energy development. Energy Commission staff developed the following framework to develop and prioritize the funding initiatives in this *2015-2017 EPIC Investment Plan*:

1. What are the policy goals, barriers to achieve them, and scale of the gaps?
2. What are funding opportunities to address these barriers?
3. Do the barriers require public funding to achieve these opportunities?
4. How big are the potential benefits, and at what cost?

15 This calculation assumes they borrow money at a rate of 8.75 percent.

5. Do the opportunities address needs unique to California?
6. Is the portfolio balanced in terms of risk, time frame, and the benefits to the residential, commercial, and industrial ratepayer sectors?

The proposed *2015-2017 EPIC Investment Plan* selects high priority issues that must be addressed within the next few years. However, the *2015-2017 EPIC Investment Plan* does not propose initiatives in order of their importance. In developing and selecting the proposed funding initiatives, Energy Commission staff leveraged numerous resources including:

- **Energy Commission research roadmaps.** Research roadmaps are expert- and stakeholder-driven documents that provide strategic guidance on prioritizing funding initiatives. These roadmaps summarize current research, data gaps, connections to state policy, potential impact by cost, urgency and timeliness of outcomes, and potential partnerships with other funding entities. As part of the *2015-2017 EPIC Investment Plan* development process, the Energy Commission used the numerous research roadmaps as well as U.S. DOE roadmaps to identify gaps and funding opportunities. For example, the gaps analysis in the *Plug-in Hybrid Electric Vehicle Research Roadmap* (CEC-500-2010-039) found an abundance of basic chemical and battery formatting research conducted by battery manufacturers but minimal research into the second use of batteries after the primary vehicle application.

  To reduce program implementation costs, the Energy Commission will build on, review, and update existing research roadmaps.[16, 17, 18] Also, when necessary, the Energy Commission will undertake new research roadmaps to further refine initiatives and funding priorities. Recognizing that funding decisions can be dynamic due to market, economic, and political changes, these roadmaps are also dynamic and will require periodic refinements or updates.

- **Institutional knowledge of Energy Commission staff.** For more than three decades, the Energy Commission's extensive experience and expertise in administering programs has advanced clean energy technologies. Staff experts routinely conduct literature reviews, participate in state agency and utility collaborations, manage various RD&D projects, attend Web forums, participate in technical/program advisory committees, and perform other activities and duties to stay informed about current issues and technologies. In addition, through the planning and management of past and current funding programs, Energy Commission staff have developed and sustained strategic, neutral partnerships with experts

16 *PIER Industrial, Agricultural, and Water Energy Efficiency Program RD&D Targets: Consolidated Roadmap* (http://www.energy.ca.gov/2011publications/CEC-500-2011-035/CEC-500-2011-035.pdf).

17 *Public Research on Advanced Generation Roadmap* (http://www.energy.ca.gov/2012publications/CEC-500-2012-079/CEC-500-2012-079.pdf).

18 *California Utility Vision and Roadmap for the Smart Grid of 2020* (http://www.energy.ca.gov/2011publications/CEC-500-2011-034/CEC-500-2011-034.pdf).

in industry, academia, government, and nongovernmental organizations, helping to avoid duplicative efforts, leverage investments, and build upon previous successful projects to ensure that the best technologies move forward. These partnerships have included enlisting businesses, utilities, researchers, advocacy groups, and institutions to provide input into various public planning processes and forums, serve on project technical advisory committees, and review project deliverables.

- **Expertise of many stakeholders provided comments during the *2015-2017 EPIC Investment Plan* proceeding.** California is home to many of the world's leading experts, companies, and institutions in the clean energy sector. To ensure the *2015-2017 EPIC Investment Plan* leveraged the expertise of these stakeholders in an open forum, the Energy Commission conducted several one-day public workshops to solicit input on potential investment areas (Table 2). In addition to numerous oral comments provided at the workshops, the Energy Commission received more than 100 sets of written comments. The input and comments were used to shape and develop the proposed funding initiatives released to the public on March 21, 2014, and used to further refine and prioritize the funding initiatives for the staff final *2015-2017 EPIC Investment Plan*.

Table 2: Stakeholder Workshop Schedule

Stakeholder Activity	Date and Location
Energy Commission Scoping Workshop	**February 7, 2014 in Sacramento**
Northern California Public Workshop to receive comments on staff draft *2015-2017 EPIC Investment Plan* initiatives	**March 17, 2014 in Sacramento**
Southern California Public workshop to receive comments on staff draft *2015-2017 EPIC Investment Plan* initiatives	**March 21, 2014 in Westminster**
Staff Final *2015-2017 EPIC Investment Plan* Posted	**April 9, 2014**

Source: California Energy Commission

Along with the guiding principles of the decision, Energy Commission staff considered the following additional factors and criteria in developing and prioritizing proposed funding initiatives.

- **Policy Drivers.** California is at the forefront of energy policy and has developed some of the most aggressive clean energy goals in the world. Over the past several years, the state has developed policy and planning documents to identify barriers, challenges, and strategies to

achieve these goals. Energy Commission staff reviewed these documents to identify key policy drivers and barriers that were addressed to provide electric ratepayer benefits encompassed in state energy policy goals. These policy and planning documents include but were not limited to:

- *Assembly Bill 32 Climate Change Scoping Plan*
- *AB 2514 Energy Storage Systems*
- *2013 Zero Emission Vehicle (ZEV) Action Plan*
- *2012 Bioenergy Action Plan*
- *Clean Energy Jobs Plan*
- Various *Integrated Energy Policy Reports* (*IEPR*)
- *California Energy Efficiency Strategic Plan* (*CEESP*)

- **Transformational Potential**. To ensure efficient use of ratepayer funds, it is important that the *2015-2017 EPIC Investment Plan* prioritize technologies and strategies with the potential for significant market penetration in California, relative to business as usual as well as the potential to provide significant ratepayer benefits as described in the CPUC's EPIC decision. Energy Commission staff reviewed existing market and technology assessments, *IEPR* forecasts, and past research results to identify technologies and strategies that have the potential for large-scale deployment and adoption in California. For example, a study by ICF International, Inc (CEC-500-2009-094-F) estimates California has more than 15,000 MW of additional CHP capacity, but under base case conditions, only about 3,000 MW will penetrate the market over the next 20 years.
- **Investment Scope.** There are a number of technologies that could provide ratepayer benefits but are beyond what EPIC investments are capable of funding. For example, emerging utility-scale renewable demonstration projects typically cost hundreds of millions of dollars. Energy Commission staff has determined that projects of this size would not be an efficient use of ratepayer funds.

Reducing Duplication with IOU EPIC Investment Plans.

The CPUC's EPIC decision requires the four administrators to file coordinated triennial investment plans. Throughout the investment plan process, Energy Commission staff worked collaboratively with the other three administrators (PG&E, SCE, and SDG&E), conducting conference calls, participating in each other's public workshops, and meeting periodically to coordinate investment plans and ensure funding initiatives were complementary and not duplicative.

For some topics, there are industry gaps that offer such high potential for achieving ratepayer benefits that coordinated efforts from all the administrators is warranted. Coordination helps to capture benefits for IOU ratepayers. For example, information sharing and coordinated planning of EPIC-funded microgrid activities will provide ratepayer benefits and help achieve California's renewable goals, while increasing reliability and lowering costs.

Another common area is technology demonstrations of energy storage. Coordination across the administrators will help to develop consistent approaches to evaluation, measurement and verification of the results. Examples of initiatives related to energy storage proposed for 2015-2017 EPIC funding include, the SCE storage objective "Optimized Control of Multiple Storage Systems," PG&E's objective "Evaluating Storage on the Distribution Grid," and the Energy Commission's S15 *Demonstrating Advanced Energy Storage Interconnection Systems to Lower Costs, Facilitate Market and Improve Grid Reliability.*

In furtherance of the guiding principles and goals of the EPIC Program as set out by the CPUC, and in order to maximize the benefits of the program to electric utility ratepayers, the EPIC administrators have agreed to pursue the following principles for cooperating and collaborating for EPIC funded projects:

- **Information Sharing and Coordinated Planning.** The EPIC Administrators will work together to address common goals, consistent with the State's energy and environmental policies and the guiding principles for energy RD&D as stated in the CPUC's EPIC Phase 2 decision. To this end, the EPIC Administrators will share information regarding their EPIC investment plans, programs and projects as much as practicable in order to maximize the efficient use of the funds and facilitate the dissemination of the results of the program efforts for the benefit of electric utility ratepayers.
- **Leveraging Funding and Avoiding Duplication of Projects.** To the extent legally permissible, the EPIC administrators will work together to avoid unnecessary duplication of efforts, consistent with Public Utilities Code 740.1, and to leverage the EPIC funding for the benefit of electric utility ratepayers.
- **Coordinated Input and Advice from Stakeholders.** The EPIC administrators will continue working together to schedule, solicit, and respond to comments and advice from stakeholders on their respective proposed and on-going EPIC Plans and programs.

To benefit from coordination among EPIC administrators and ensure fairness for all bidders in competitive solicitations, IOUs may not submit bids to those solicitations they help to develop. Similarly, state agencies, universities, and other stakeholders that provide input on the development of a solicitation are precluded from submitting bids in that solicitation, unless the input is provided through a public forum (such as a workshop, webinar, or staff survey) in which other entities have the same opportunity to provide input.

- **Focus on California Unique Environmental Challenges.** It is also crucial that EPIC be non-duplicative and focus on California's uniqueness. The research requirements in California

are often different from those pursued by the federal government. The federal government typically spends far more research dollars on developing new technologies and materials to lower the component costs of the new or emerging technologies. Given this focus by the federal government, California can best use state funds addressing technology integration and demonstrations closer to the end application. For example, over the last decade, the U.S. DOE has spent billions on reducing the material and manufacturing costs of renewable technologies and research efforts in California focused on renewable integration, reducing barriers to expanding renewables on the grid, and demonstrating grid-scale and customer renewable technologies. However, in California, DR is critical to the management of the high peak load on the grid, so California has invested heavily in implementing new DR technologies, policies, and automation. At the same time, the federal government has focused the majority of its efforts on national policy, rates, and tariffs rather than technology development or demonstration. In critical areas such as energy storage, microgrids, or distributed renewables, California often is a leader in fielding and demonstrating these technologies, and can work actively with the federal government to jointly fund future efforts that are valuable to both missions. In some of these cases, California can be the test bed for the entire country. In other cases, the state has unique attributes such as a hot dry climate, so building and residential energy efficiency technologies that work well in California are not effective in the humid, moist areas of the North, East, and South.

Due to the increased penetrations of intermittent renewables and the demand for more to come on-line given the aggressive 33 percent Renewables Portfolio Standard (RPS), California must be at the forefront of addressing renewable integration. Further, California has some of the most polluted air basins in the country and that, coupled with some of the most progressive and forward-thinking state and local air quality management organizations in the nation, is leading to electrification of the state's transportation fleet to help meet strict air quality requirements. System integration issues due to a high number of electrical vehicles will also be an issue that California must explore. Lastly, policy goals in California push for a more distributed electricity supply chain, which will strain the state's aging T&D grids. Integration of a distributed electricity supply will present unique challenges to California that RD&D dollars should target. Under EPIC, the Energy Commission will continue its approach of ensuring that California leverages federal funds to the maximum extent possible while avoiding duplication of work being done by other entities, federal or otherwise.

California's Energy Policy

Embedded in the directives outlined above, including the guiding principles, is the expectation that California will achieve the state's clean energy policy goals, while promoting greater reliability, lower costs, and increased safety. California continues to lead the nation in promoting clean energy goals, such as those directed at reducing GHG emissions and ensuring an aggressive portfolio of efficient and renewable energy sources. The Energy Commission's EPIC Program used California's clean energy goals to guide the development of strategic objectives outlined in this *2015-2017 EPIC Investment Plan*, including the following policy drivers.

Senate Bill 96

Senate Bill 96 (Committee on Budget and Fiscal Review, Statutes of 2013) adds Public Resources Code section 25711.5, subparagraph (a), which directs the Energy Commission, in administering EPIC to develop and implement the program, to award EPIC funds for projects that will benefit electricity ratepayers and lead to technological advancement and breakthroughs to overcome the barriers that prevent the achievement of the state's statutory energy goals and that result in a portfolio of projects that is strategically focused and sufficiently narrow to make advancement on the most significant technological challenges that shall include, but not be limited to, energy storage, renewable energy and its integration into the electrical grid, energy efficiency, integration of EVs into the electrical grid, and accurately forecasting the availability of renewable energy for integration into the grid.

Assembly Bill 32, Executive Order S-3-05, and Executive Order B-16-2012

The California Global Warming Solutions Act of 2006 (Assembly Bill 32 [Núñez, Chapter 488, Statutes of 2006]) requires the state to reduce GHG emissions to at or below 1990 levels by 2020. Executive Order S-3-05 established a goal to reduce GHG emissions to 80 percent below 1990 levels by 2050. In Executive Order B-16-2012, Governor Brown established a target for 2050 to reduce GHG emissions from the transportation sector to 80 percent below 1990 levels.[19]

Assembly Bill 2514 and CPUC Decision 13-10-40

Assembly Bill 2514 (Skinner, Chapter 469, Statutes of 2010) required the CPUC to open a proceeding by March 1, 2012, to determine appropriate energy storage procurement targets by October 1, 2013, if any, for each load-serving entity in California. In October 2013, the CPUC issued Decision 13-10-040 and established the energy storage procurement target of 1,325 MW for investor-owned utilities (IOUs) to procure viable and cost-effective energy storage systems by December 31, 2020, and operational no later than the end of 2024. The IOUs are required to meet specific procurement targets during each biennial procurement period beginning 2014. On March 1, 2014, the CPUC received the IOU applications for authorization to procure energy storage systems during the 2014 Biennial Procurement Period pursuant to Decision 13-10-040.

19 http://gov.ca.gov/news.php?id=17472

The Loading Order

Since 2003, California's energy policy has defined a loading order of resource additions to meet the state's growing electricity needs: first, energy efficiency and DR; second, renewable energy and DG; and third, clean fossil-fueled sources and infrastructure improvements. This strategy has had the benefit of reducing carbon dioxide emissions and diversifying California's sources of energy.

Energy Efficiency

The CPUC's *Energy Efficiency Strategic Plan* and the Energy Commission's *Integrated Energy Policy Report* set ZNE goals for new homes by 2020 and new commercial buildings by 2030.[20] The California Air Resources Board's *Climate Change Scoping Plan* sets a target of 32,000 gigawatt-hours (GWh) of reduced energy consumption from energy efficiency improvements by 2020.[21]

Renewables Portfolio Standard

California's aggressive Renewables Portfolio Standard (RPS) requires all electricity retailers, including IOUs, to serve 33 percent of their retail sales with renewable energy procurement. The RPS is mandated under Public Resources Code 399.11.[22]

Transmission and Distribution

Senate Bill 17 (Padilla, Chapter 327, Statutes of 2009) mandates implementing and planning a smart grid, defined as an electric grid using computers and communications to gather, distribute, and act on information about the behavior of suppliers and consumers to improve efficiency, reliability, economics, and sustainability of electricity services.

To implement the RPS successfully, it will be necessary to upgrade existing transmission facilities and build new ones to connect remote, large-scale generation to load centers. Proactively assessing environmental and land-use challenges will greatly aid permitting to upgrade existing lines and build new ones to help meet the policy goals.

Transportation

Senate Bill 626 (Kehoe, Chapter 355, Statutes of 2009) codified Public Utilities Code Section 740.2, which directs the CPUC to adopt rules to evaluate policies and develop infrastructure

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20 California Public Utilities Commission, *California Energy Efficiency Strategic Plan, January 2011* http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/eesp/.

21 California Air Resources Board, *Climate Change Scoping Plan,* http://www.arb.ca.gov/cc/scopingplan/document/adopted_scoping_plan.pdf.

22 The RPS was enacted by Senate Bill 1078 (Sher, Chapter 516, Statutes of 2002) and subsequently modified by Senate Bill 107 (Simitian, Chapter 464, Statutes of 2006). In 2011, the RPS goal was increased to 33 percent by 2020 under Senate Bill x1-2 (Simitian, Chapter 1, Statutes of 2011).

sufficient to overcome barriers to the widespread deployment and use of plug-in hybrid and EVs.

Governor Brown's Executive Order B-16-2012 establishes expectations for agencies to expedite the rapid commercialization of ZEVs. The order was issued on March 23, 2012, directing California to "encourage the development and success of zero-emission vehicles to protect the environment, stimulate economic growth and improve the quality of life in the State." The Governor's Executive Order sets a long-term target of reaching 1.5 million ZEVs on California's roadways by 2025. The *2013 ZEV Action Plan*, released in February 2013, follows on the Governor's Executive Order by identifying specific strategies and actions that state agencies will take to meet the Executive Order.

Governor Brown's *Clean Energy Jobs Plan*

By 2020, California should produce 20,000 new MW of renewable electricity, accelerate development of energy storage capacity, and strengthen energy efficiency measures. This includes installing 8,000 MW of renewable central station capacity and 12,000 MW of renewable distributed generation (DG). The plan also calls for adding 6,500 MW of combined heat and power (CHP) systems over the next 20 years.[23]

Integrated Energy Policy Report

Senate Bill 1389 (Bowen and Sher, Chapter 568, Statutes of 2002) requires the Energy Commission to: "[C]onduct assessments and forecasts of all aspects of energy industry supply, production, transportation, delivery and distribution, demand, and prices. The Energy Commission shall use these assessments and forecasts to develop energy policies that conserve resources, protect the environment, ensure energy reliability, enhance the state's economy, and protect public health and safety." (Public Resources Code Section 25301[a]).

The *2013 Integrated Energy Policy Report* addressed, among other things, the development of energy efficiency, demand response, renewable electricity, DG, and CHP in California and recommended policies to foster the development of these areas.

Energy efficiency continues to be California's top priority for meeting new electricity needs and a key strategy for creating jobs and reducing GHG emissions from the electricity sector. The central policies that aim to increase energy efficiency in the state include achieving all cost-effective energy efficiency, reducing energy use in existing buildings, and making all new residential construction in California ZNE by 2020 and all new commercial construction ZNE by 2030.[24]

As part of the *2013 Integrated Energy Policy Report* proceeding, the Energy Commission issued the *Renewable Power in California: Status and Issues* report, which discussed challenges to

23 Governor Brown's Clean Energy Jobs Plan, http://gov.ca.gov/docs/Clean_Energy_Plan.pdf.

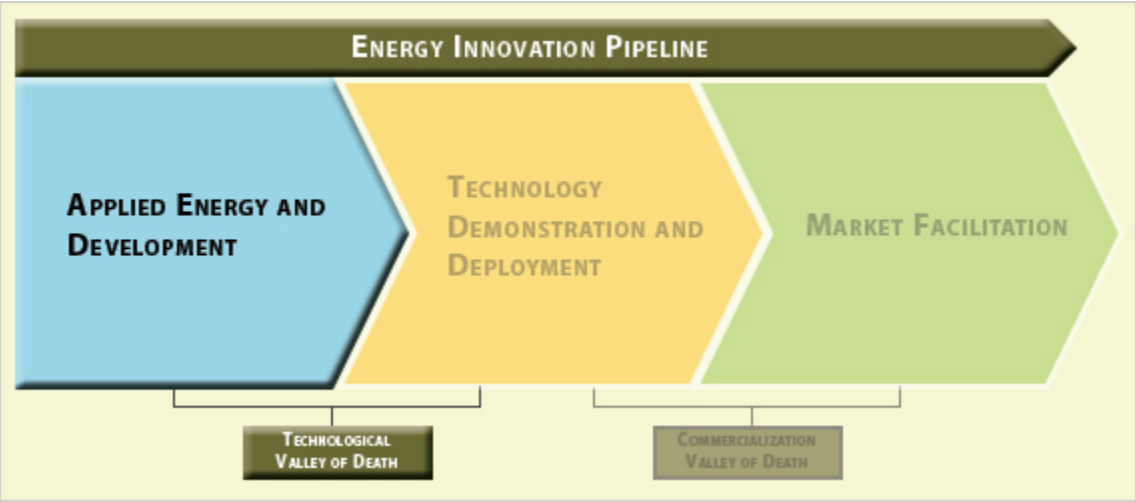
24 California Energy Commission, *2011 Integrated Energy Policy Report*, http://www.energy.ca.gov/2011publications/CEC-100-2011-001/CEC-100-2011-001-CMF.pdf .

developing renewables and achieving the goals in Governor Brown's *Clean Energy Jobs Plan*. The report identified five high-level strategies: prioritize geographic areas for development; evaluate costs and benefits of renewable projects; minimize interconnection costs and time; promote incentives for projects that create in-state benefits; and promote and coordinate existing financing and incentive programs for critical stages in the renewable development continuum. These strategies are the foundation for a more detailed Renewable Action Plan being developed as part of the *2012 Integrated Energy Policy Report Update.* The update will also include a summary of a recent assessment of CHP technical and market potential.

The *2013 IEPR* also emphasized the expanding role of Demand Response in meeting the state's energy goals. Traditional DR programs have focused primarily on reliability and peak load reduction; however, the rapid increase in renewable resources is increasing the need for flexible, fast-response resources to balance variation in solar and wind resource output as well as mitigating evolving changes in net load. The central recommendations related to R&D are to "Advance fast-response demand response," "Improve forecasting techniques and methodologies", and "advance demand response market outreach." According to the *2013 IEPR*, "Demand response represents an important low-carbon option for load-balancing services to integrate the even higher levels of renewable resources that will be necessary to meet California's long-term (2050) greenhouse gas emission reduction goals."[25]

25 California Energy Commission, *2013 Integrated Energy Policy Report*, pg. 58, http://www.energy.ca.gov/2013publications/CEC-100-2013-001/CEC-100-2013-001-CMF.pdf

CHAPTER 3:
Applied Research and Development



Source: California Energy Commission

Through the Applied Research and Development program area, the Energy Commission will address gaps in the funding needed to help innovative energy technologies and approaches bridge the "Technological Valley of Death." For this three-year *2015-2017 EPIC Investment Plan*, the Energy Commission will provide $151.63 million for applied research and development (R&D) funding for development of new technologies, methods, and approaches from early bench-scale up to pilot-scale prototype demonstration. This will include activities that address environmental and public health impacts of electricity-related activities, support building and appliance standards, and promote clean transportation. Each strategic objective below outlines a set of initiatives focused on a particular area of proposed research.

Table 3: Proposed Strategic Objectives for the Applied Research and Development Program Area

Funding Area
Energy Efficiency and Demand Response
S1 Strategic Objective: Improve Energy Efficiency Technologies and Strategies in California's Building, Industrial, Agriculture, and Water Sectors.
S2 Strategic Objective: Enable Cost-Effective Demand Response for California IOU Electricity Customers.
Clean Generation
S3 Strategic Objective: Develop Innovative Solutions to Increase the Market Penetration of Distributed Renewable and Advanced Generation.
S4 Strategic Objective: Improve Power Plant Performance, Reduce Cost, and Accelerate Market Acceptance of Existing and Emerging Utility-Scale Renewable Energy Generation Systems.
S5 Strategic Objective: Reduce the Environmental and Public Health Impacts of Electricity Generation and Make the Electricity System Less Vulnerable to Climate Impacts.
Smart Grid Enabling Clean Energy
S6 Strategic Objective: Advance the Use of Smart Inverters as a Tool to Manage Areas with High Penetrations of PV.
S7 Strategic Objective: Develop Advanced Distribution Modeling Tools for the Future Smart Grid.
S8 Strategic Objective: Advance Customer Systems to Coordinate with Utility Communication Systems.
S9 Strategic Objective: Advance Electric Vehicle Infrastructure to Provide Electricity System Benefits.
Cross-Cutting
S10 Strategic Objective: Advance the Early Development of Breakthrough Energy Concepts.
S11 Strategic Objective: Provide Federal Cost Share for Applied Research Awards.
Applied Research and Development Program Area Total

Source: California Energy Commission

The Energy Commission developed the proposed initiatives for the *Applied Research and Development Program Area* by Strategic Objective provided in Table based on the priorities defined in the CPUC EPIC decision and Senate Bill 96. For S11, *Provide Cost Share for Applied Research Awards,* up to 10 percent of the funding allocated for the applied R&D strategic objectives can be applied to providing cost share for these types of competitive federal awards.

Through this *2015-2017 EPIC Investment Plan*, the Energy Commission intends to issue solicitations in all strategic objectives. Proposed initiatives identified in this *2015-2017 EPIC Investment Plan* represent the full scope of possible awards. The Energy Commission may not issue solicitations or make awards in every initiative area if funding is inadequate, there is a lack of qualified applicants, or further analysis of market conditions indicates that an initiative is not currently a high priority or it is already adequately funded by other entities.

The following section describes each strategic objective under applied R&D and its associated proposed funding initiatives**.**

Energy Efficiency and Demand Response

S1 Strategic Objective: Improve Energy Efficiency Technologies and Strategies in California's Building, Industrial, Agriculture, and Water Sectors.

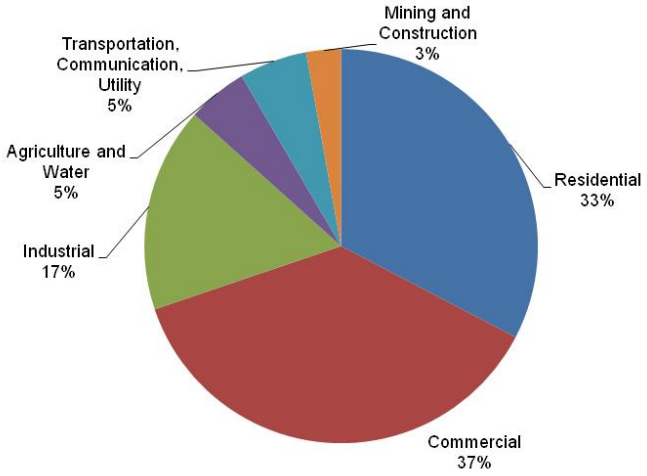
Table 4: Ratepayer Benefits Summary for Strategic Objective 1

	Promote Greater Reliability	Lower Costs	Increased Safety	Societal Benefits	GHG emissions mitigation and adaptation	Lower emission vehicles/ transportation	Economic Development	Public Utilities Code Section 740.1	Public Utilities Code Section 8360
S1.1 Advance Efficient Solutions for Lower Energy Buildings.		X		X	X		X	X	
S1.2 Develop Model Designs and Strategies for Cost-Effective Zero Net Energy Homes and Buildings.	X	X	X		X		X	X	
S1.3 Apply Advanced Social Science Research Methods to Improve Adoption of Next Generation Energy Efficiency Solutions.	X	X		X	X		X	X	
S1.4 Develop And Evaluate Strategies to Improve Indoor Air Quality in Energy-Efficient Buildings.	X	X	X	X	X			X	
S1.5 Develop and Test Advanced Industrial, Agricultural, Water and Demand Response Technologies and Strategies to Reduce Energy Use and Costs.	X	X		X	X		X	X	
S1.6 Advance Strategies to Reduce California Buildings' Impact on the Water-Energy Nexus.	X	X		X	X		X	X	

Source: California Energy Commission

Barriers and Challenges: Energy efficiency is a primary strategy for reducing the state's energy use and costs, as well as greenhouse gas (GHG) emissions. Electricity used in California homes, commercial buildings, industrial, and agricultural processes, and in water and wastewater activities, consumes nearly 256 billion kilowatt-hours (kWh)/year.[26] As shown in Figure 3, the commercial and residential sectors together used 70 percent of electricity consumed in California IOU service territories in 2011. Achieving reductions in these sectors to meet state policy goals will require advances in new technologies, strategies and tools beyond what is currently commercially available. Process operations associated with the industrial, agriculture and water sectors used about 20 percent of the electricity consumed in IOU service territories and face economic and environmental challenges that require efficiency improvements.

Figure 3: 2011 Electricity Use by Sector in California Investor-Owned Utility Service Areas



Source: California Energy Commission

Though significant progress has been made in some areas, there is still a need to look for ways to reduce the cost of these technologies, to provide verification that the actual benefits will accrue to electric ratepayers, and to look for ways to best integrate and apply these technologies in the most cost effective manner. All of these will be crucial to achieving the state's zero-net energy (ZNE) building goals and to maximizing efficiency in existing buildings.

The following are examples of specific barriers and challenges associated with the building, industrial, agriculture and water sectors:

26 http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_4_b

- Lighting offers significant opportunities for energy savings and peak demand reductions but additional research is needed to test and verify performance of new systems to realize the full potential of new products that promise more efficient lighting.
- Heating, ventilation, and air conditioning (HVAC) and refrigeration systems are among the largest consumers of electricity. Continued research is needed to advance HVAC technologies and controls and to improve their performance and cost effectiveness and to move them closer to wide scale deployment and commercialization.
- Building envelope systems and components, such as windows, roofing, insulation at the roof plane and walls, and building manufacturing practices all impact heating and cooling energy use. While many new advances show promise, research is needed to monitor and verify energy and cost saving benefits and to assess long-term durability.
- Energy use in the residential and commercial sectors in California for plug loads is one of the fastest growing energy loads. Current estimates indicate that plug-loads are contributing about 15-20 percent of residential and 10-15 percent of commercial electrical use and could nearly double by 2030.[27] Recent estimates by the United States Department of Energy (U.S. DOE) have put residential plug-load, without intervention, at 40 percent by 2035. At that pace, plug-load energy use would prevent achievement of the state's ZNE building goals.[28]
- Existing building retrofits have occurred haphazardly. Utility rebate programs have focused on specific energy technologies rather than whole-building approaches and participation in those programs has been limited. Whole-building energy audit programs typically target specific sectors or organizations with a desire to upgrade or renovate. Often, energy renovations require a champion to push for improvements and to identify energy and non-energy benefits. Split incentives can deter any energy improvements since building owners often do not pay utility bills or reap the benefits from retrofits.
- Existing California K-12 school buildings are aging, but most districts lack the technical knowledge and funding to identify solutions to their indoor environmental quality (IEQ) issues and implement the needed energy efficiency upgrades.
- Though there is increased interest in ZNE building design, there is still limited research and information available regarding the best approaches for meeting the ZNE goals for different building sectors and types by climate zones. As a result, very few designers, builders, or contractors have the expertise or experience to construct ZNE buildings cost-effectively.

27 U.S. DOE Annual Energy Outlook, 2008.

28 Brown, Rittleman, Parker & Homan, *Appliances, Lighting, Electronics, and Miscellaneous Equipment Electricity Use in New Homes*. 2006.

- Opportunities to improve the energy use characteristics of new devices and buildings have begun to approach regulatory and engineering limits. Now, attention needs to focus on the large variation in consumption levels between households and between similar commercial buildings.
- As buildings become more energy efficient and approach ZNE, attention must also focus on ensuring adequate indoor air quality in these buildings.
- The industrial, agriculture and water sectors are risk averse regarding new, unproven technologies and lack the resources to analyze and evaluate technologies at either bench or facility scale. However, these sectors are major energy consumers and producers of GHGs.
- Improvements are needed to reduce energy waste associated with the treatment, delivery and conveyance of water throughout the state. Water related uses (by water agencies and end-users) comprise the largest electricity demand sector in California, consuming nearly 20 percent of California's electricity (or roughly 48 billion kWh/year). Peak electricity demand by water agencies and end-users is estimated to be about 9,000 megawatts (MW).[29] Water deliveries to buildings and industrial facilities are often treated, pumped and used within the facility and then disposed. The state's dire water situation further highlights the need for new strategies, technologies, and tools to optimize water/wastewater processes and develop technologies and techniques to maximize water conservation in homes, businesses and industries.

Investments in *2012-2014 EPIC Investment Plan* addressing barriers and challenges: The *2012-2014 EPIC Investment Plan* addressed the major energy using systems associated with buildings. The Energy Commission will release solicitations in fiscal year 2014 and 2015 in the areas of advanced lighting, HVAC, building envelope, plug-loads, indoor air quality, and strategies to achieve ZNE buildings and energy retrofits in existing buildings. The focus will be on advancing technologies and addressing data gaps that hinder large-scale demonstrations or prevent achievement of California's policy goals for energy efficiency. Consumer behavioral research will be integrated into the analysis to gauge potential acceptance of energy efficiency technologies by consumers, including building owners, occupants, engineers, designers, and installers. In the *2012-2014 EPIC Investment Plan*, the strategy was to lay the foundation for future deployment and large-scale technology demonstrations.

Some building technology areas will be funded through the solicitations from the *2012-2014 EPIC Investment Plan*. Based on the strength of purposes and the scope of selected technologies,

29 Wang, Warren. (Navigant Consulting, Inc.). 2011. *PIER Industrial, Agricultural, and Water Energy Efficiency Program RD&D Targets: Consolidated Roadmap*. California Energy Commission. Publication Number: CEC-500-2011-035.

it may be necessary to emphasize some areas more or less in future solicitations from this *2015-2017 EPIC Investment Plan*. Anticipating this need, the *2015-2017 EPIC Investment Plan* will continue to support research funding for new technologies and strategies for energy efficiency, address data gaps to help inform future building and appliance energy efficiency code changes, strategies for ZNE buildings, and maximize energy efficiency in existing buildings.

New areas to be included in the second *2015-2017 EPIC Investment Plan* include research initiatives to advance energy efficiency technologies for the industrial, agriculture and water sectors to reduce energy use and cost. This research will be coordinated with the California Air Resources Board and others. There is also an initiative to advance strategies and technology pilots to increase end-use water efficiency in buildings.

S1.1 Proposed Funding Initiative: Advance Efficient Solutions for Lower Energy Buildings.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	Full-scale Demo	Early Deployment	Market Facilitation	Grid Operations / Market Design	Generation	Transmission / Distribution	Demand – side Management
X							X

Source: California Energy Commission

The purpose of this initiative is to develop and test new and advanced technologies and strategies to improve energy efficiency and performance of major energy using systems. This initiative will support technologies to reduce cost, expand acceptance of energy efficiency measures and help to inform future codes and standards. This initiative will also support research on five components of energy efficiency: lighting, HVAC, building envelope, plug-load, and retrofit strategies for existing buildings.

1. **Lighting: develop and test next generation lighting systems and components**

Purpose: Research in this area focuses on the development, implementation and strategies to advance next generation lighting technologies, controls, and systems to provide improved energy efficiency and customer satisfaction. Examples of potential research topics in this area include the following:

- Develop and test advanced lighting technologies, controls, and integrated systems that achieve improved performance (for example, lighting quality, energy savings, reliability,

commissioning), minimize installation costs, reduce energy costs, and meet customers' operational needs.

- Evaluate lighting control systems to compensate for installer inexperience, improve performance, and reduce installed costs.
- Conduct lab, bench-scale, and pilot programs to estimate energy savings and customer/occupant satisfaction; identify and test technologies that are candidates for utility incentive programs; and inform future updates to building and appliance energy efficiency standards.
- Engage local experts and other stakeholders through public workshops to identify research priorities and needs associated with lighting-related R&D to provide cost-effective energy efficiency benefits to California ratepayers.

Stakeholders: Electric ratepayers who own and operate or occupy buildings and facilities, equipment manufacturers, lighting designers/consultants, CPUC Lighting Action Plan working group, U.S. DOE, local governments, Regional Energy Networks, researchers (for example, academia, national labs) and IOUs.

Background: Lighting offers significant opportunities for energy savings and peak demand reductions. Many new products that promise more efficient light sources, including light emitting diodes (LEDs), are entering the market, but additional work is still needed to realize the full potential of these light sources. Increased interest, awareness, and emphasis on energy efficiency combined with rapid technological advances in LEDs and lighting controls systems could transform the lighting industry. This, in turn, would create opportunities for faster acceptance of new technologies and systems that could accelerate reductions in energy consumption and GHG emissions.

This initiative will complement past and current lighting research in support of the following state goals for lighting: reduce average statewide electrical energy consumption by 2018 for indoor residential lighting by not less than 50 percent and for indoor commercial and outdoor lighting by not less than 25 percent compared to 2007 levels (AB 1109, Statutes of 2007).

2. HVAC: develop and test innovative HVAC systems

Purpose: Research in this area focuses on improving the energy efficiency of commercially available HVAC systems, developing innovative approaches or techniques to maximize the efficient use of energy in HVAC systems, and conducting pilot testing for candidate HVAC technologies and controls. Examples of potential research areas include the following:

- Improve the energy efficiency and cost-effectiveness of existing HVAC systems, such as use of fault detection, diagnostic tools and test protocols, commissioning, plug-and-play

emerging energy management systems, and of HVAC sensors and controls for small and medium sized commercial buildings. Fault detection and diagnostic tools provide equipment operators with information on whether HVAC equipment and related systems are operating efficiently.

- Test emerging HVAC and refrigeration systems, such as refrigeration improvements; reverse osmosis/absorption cycles, solid state cooling, high efficiency chillers adsorption, Stirling-cycle air conditioners, air, ground source, and miniaturized heat pumps, refrigerant-free technologies, radiant cooling, and innovative ways to incorporate HVAC systems into building structures.
- Optimize integration of HVAC and refrigeration systems used in grocery stores, in food services, and similar applications.
- Develop night- or pre-cooling strategies to minimize or eliminate the need for mechanical cooling.
- Develop simulation models and performance modeling rule sets to promote utility incentives and compliance credit for innovative HVAC systems; test protocols to detect refrigerant issues (for example, leakage, contamination, flow restrictions), and develop appropriate design guides. Performance modeling rule sets establish design guidelines on how to properly model energy use in buildings.
- Develop approaches and techniques to scale power and equipment sizing to the task needed (for example, HVAC energy consumption to cool a limited number of occupants in an office building during a weekend).
- Engage local experts and other stakeholders through public workshops to identify research priorities and needs for HVAC and refrigeration-related R&D that will provide additional cost-effective energy efficiency benefits to California ratepayers.

This initiative will be coordinated with other ongoing CPUC/IOU activities/studies. Coordination will ensure that the research and work scope will a) benefit and inform CPUC/IOU efficiency policy and b) remain consistent with energy, monitoring and verification frameworks and standards, and the *California Energy Efficiency Strategic Plan*'s *HVAC Action Plan*.[30] Moreover, this initiative will coordinate with basic research conducted by the U.S. DOE and provide pilot testing in California for promising technologies.

Stakeholders: Electric ratepayers who own and operate buildings, HVAC equipment manufacturers, distributors, contractors, engineers, building designers, academia, researchers, government entities, utilities, local governments, Regional Energy Networks.

30 *HVAC Action Plan*, http://www.cpuc.ca.gov/NR/rdonlyres/25B56CBE-7B79-41BC-B1C0-AE147F423B19/0/HVACActionPlan.pdf.

Background: HVAC and refrigeration systems are among the largest consumers of electricity in residential and commercial buildings, which makes them primary targets for reducing energy consumption. The CPUC is targeting reductions in HVAC energy consumption in its IOU energy efficiency portfolio, and these reductions are a component of utility incentive programs.[31, 32] The IOUs, HVAC designers and contractors, and regulators also need better and simpler simulation tools to help design and evaluate high efficiency systems. These tools can also help justify incentive levels and indicate the amount of credit appropriate for compliance tools associated with energy efficiency standards.

Past research focused on advanced evaporative air conditioners, radiant floor cooling, under-floor air-distribution systems, fault detection and diagnostics, and design approaches to reduce the installation cost of advanced systems. For instance, research to evaluate the benefits of radiant cooling systems resulted in the adoption of this technology by several Wal-Mart stores located in hot, dry climates. A ceiling-mounted radiant cooling system for homes showed promise for reducing cooling cost. A demonstration of the use of wireless sensors for fault detection and diagnostics for HVAC, lighting, and refrigeration systems identified substantial potential for commercial buildings with central energy management systems. Additional work is required to assess the potential to integrate them with other HVAC systems such as thermal energy storage or demand response (DR), and to provide standardization and validation of energy and other benefits. This initiative will further develop and test advanced HVAC technologies and controls to improve their performance and cost-effectiveness, and to move them closer to deployment and commercialization.

Areas to be investigated in this initiative were identified through public workshops, internal deliberative discussions with the Energy Commission's Building and Appliance Energy Efficiency rulemaking staff, the U.S. DOE's building efficiency research staff, and public comments.[33]

3. Building envelope: develop and test next generation systems

Purpose: Research in this area focuses on improving building envelope performance, systems, materials, and components and developing or modifying existing simulation tools. The goal of this initiative is to ease the entry of the new technologies and strategies into the market and to inform future building energy efficiency standards. Potential research areas include the following:

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31 http://www.energy.ca.gov/2011_energypolicy/documents/2011-07-20_workshop/presentations/Cathy_Fogel_Current_Public_Goods_EE_Program_for_Existing_Buildings.pdf.

32 http://www.calmac.org/events/EE_and_MEO_2103-14_decision_166830.pdf.

33 August 2011 workshop: www.energy.ca.gov/research/notices/2011-08-31_workshop/presentations
February 2012 workshop: www.energy.ca.gov/research/notices/2012-02-23_workshop/presentations
and comments on the EPIC plan: www.energy.ca.gov/research/epic/documents/2012-09-27_workshop/comments

- Identify improvements that can increase the energy efficiency of building envelope systems, materials, and components for existing and new buildings. Examples include assessing and reducing air infiltration rates; improving insulation technology; more advanced construction methods; solar reflective walls; roofs and other surfaces; self cleaning roofs; and advanced windows and fenestrations. This task will be accomplished by using research and product developments discovered during assessments and targeting other ongoing complementary research.
- Evaluate new materials and components of building envelopes for durability and energy performance. For example, evaluating the use of roof deck insulation for new and existing construction, improved insulation materials similar to structurally integrated panel systems, insulation with high R-value[34] per inch (for example, R-8 per inch or greater), and advanced framing methods.
- Assess the most effective ways to measure the performance and address regulatory requirements associated with fire, moisture, structure, and earthquakes to ensure new building envelope systems, materials, and components meet safety standards. Promote techniques that achieve high performance, including manufacturing processes and installation techniques.
- Develop and implement pilot programs for candidate technologies to meet the operational needs of building occupants, owners, designers, installers and other decision makers.
- Engage local experts and other stakeholders through public workshops to identify research priorities and needs associated with envelope-related R&D with the following goals:
    - Provide cost-effective energy savings benefits to California ratepayers in the form of lower energy bills and healthier, more durable, and more comfortable residential and commercial buildings.
    - Help inform future building efficiency standards, especially in the areas of ZNE buildings and building retrofits.

Stakeholders: General contractors, home performance contractors, Home Energy Rating System raters, the construction industry, the building materials industry, IOUs, local code enforcement agencies, regulatory agencies, building designers, engineers, local governments, Regional Energy Networks.

Background: Research has been conducted to make buildings more efficient by promoting new envelope systems and other building components that are efficient, durable, and cost-effective.

34 A measure of resistance to the flow of heat through a given thickness of a material (as insulation) with higher numbers indicating better insulating properties.

The results from past research were the basis for the initiatives in this section. Examples of past research include:

- Fenestration: Lawrence Berkeley National Laboratory's Windows and Facades Test Bed Facility has looked at innovative ways to cut energy use in windows and window treatments, resulting in the development of improved modeling and simulation tools. New types of windows that dramatically reduce infiltration are used in passive houses in Europe, but the high cost of these windows is a market barrier in the United States. Benefit assessments of these windows and development of cost-saving manufacturing approaches are needed to ease market entry.[35] Windows often allow water to leak into the interiors of walls, potentially leading to mold growth. Window improvements that eliminate this source of leakage need development and independent validation to enhance building durability and ensure that these products perform as claimed. [36] Further research is required to develop robust models to assess daylight discomfort glare and enable improved automated controls.[37] Interior shade products can reduce cooling loads and improve thermal comfort but are not as effective as exterior systems. Additional research is needed to promote integrated designs and create demand for high efficiency buildings.[38]
- Roofing and building envelope: Past research has resulted in the development of innovative "cool roof" materials. New roofing materials include coatings that increase reflectivity and emissivity, keeping structures cooler during hot, sunny summer months. Efforts are underway to more effectively integrate solar photovoltaic (PV) cells into roofing materials.[39] Other envelope improvements, such as insulation at the roof plane and sealed attics, are being tested and need rigorous validation. Retrofit technologies, such as techniques for sealing existing building envelopes with adhesive mist, show great promise, but research is needed to monitor and verify energy and cost saving benefits.
- Building manufacturing: Improvements in manufacturing processes, such as in-shop manufacturing and quality control for entire wall sections, can reduce waste and construction defects that typically plague site-built structures. Research on the improvement of roof and wall insulation in manufactured housing is underway. Additional research is needed to assess these new building techniques, materials, and components to determine

35 http://buildings.lbl.gov/

36 http://www.energy.ca.gov/2007publications/CEC-500-2007-036/CEC-500-2007-036.PDF

37 *High Performance Building Façade Solutions*: http://gaia.lbl.gov/btech/papers/4583.pdf

38 Ibid

39 http://heatisland.lbl.gov/coolscience/cool-science-cool-roofs

technical and economic feasibility and to provide accurate information to designers, engineers, and standards developers.

4. Plug-load efficiency research

Purpose: Research in this area focuses on advancing the development and deployment of more efficient consumer devices, consumer electronics and the electronic infrastructure that supports the communication of these devices. Potential research includes the following:

- Improve and develop efficiency improvements to existing and future consumer and plug-load devices, including research to develop and test low cost components, low cost energy reporting technologies, and integration and commissioning of smart controls via an integrator or network.
- Address consumer behavioral patterns for equipment use and potential acceptance of new technologies and operating strategies.
- Develop and implement pilot programs, assessments, test procedure development of candidate devices and technologies to inform future energy efficiency codes and standards, as applicable.
- Develop competition mechanism for one or more plug-load/consumer devices to encourage the market to go well beyond incremental existing efficiencies. For instance, a minimum energy using goal/target could be established for selected plug-load devices, and applicants could submit equipment designs/standards that would meet or exceed this target. The best designs could be selected (by a panel of experts in the field). The funds would be for prototype development and testing.
- Engage local experts and other stakeholders through public workshops to identify research priorities and needs associated with plug-load-related R&D with the goal of providing cost-effective energy savings benefits for California ratepayers.

UC Irvine-California Plug-Load Research Center (CalPlug), national laboratories, and others will complement and coordinate with past and current research.

Stakeholders: Electric ratepayers who own and operate plug-load devices, consumer/business equipment manufacturers and industry, engineers, electronic component designers, building designers, developers, contractors and consultants, academia, governmental agencies, utilities, national labs and researchers, standard-setting groups, local governments, Regional Energy Networks.

Background: Plug-load devices such as computers, televisions, and cell phones contain internal or external AC-DC power supplies. Energy use in the residential and commercial sectors in California for plug-loads is one of the fastest growing energy loads. For instance, the average

house that contained only four or five plug-load devices 20 years ago now has as many as 50.[40] Current estimates indicate that plug-loads are contributing about 15-20 percent of residential and 10-15 percent of commercial electricity use and suggest this could nearly double by 2030.[41] Recent estimates by the U.S. DOE have put residential plug-load, without intervention, at 40 percent by 2035. At this pace, plug-load energy use will prevent achievement of the state's ZNE building goals.[42]

Past research focused on set-top boxes (STBs), computer enabling rates, component power display, external power supplies, office electronics, battery chargers, flat-screen televisions, home stereo/audio systems, 24/7 kiosks (for example, ATMs), multi-media computers, and high performance and ultra efficient hybrid computers. The Energy Commission's plug-load research to date has been very successful and is projected to result in estimated savings of $9 billion between 2005 and 2025 through adoption of three Title 20 Standards for televisions, external power supplies and battery chargers.[43]

This initiative investigated areas identified through public workshops, internal deliberative discussions with the Energy Commission's Building and Appliance Energy Efficiency rulemaking staff, and public comments received on the *2015-2017 EPIC Investment Plan*.

5. Existing building energy efficiency retrofit strategies

Purpose: Research in this area focuses on development of new approaches and strategies for cost-effective energy efficiency retrofits in existing residential and commercial buildings. Proposed research includes the following:

- Identify and pilot innovative advanced approaches, strategies, and technologies to bring energy saving solutions to the following sectors: low-income, market-rate residential builders/owners, the multifamily market, commercial builders, and institutional facilities (for example, K-12 schools). Technologies and approaches can include single technology or integration of multiple technologies to capture opportunities for improving energy

40 http://viewer.epaperflip.com/Viewer.aspx?docid=bfddb00c-6c9a-4169-befe-a06101208516#?page=16.

41 U.S. DOE Annual Energy Outlook, 2008.

42 Brown, Rittleman, Parker & Homan, *Appliances, Lighting, Electronics, and Miscellaneous Equipment Electricity Use in New Homes*. 2006.

43 Battery charger: www.energy.ca.gov/appliances/battery_chargers/documents/2010-10-11_workshop/2010-10-11_Battery_Charger_Title_20_CASE_Report_v2-2-2.pdf.
Televisions: www.energy.ca.gov/appliances/2008rulemaking/documents/2008-04-01_workshop/2008-04-04_Pacific_Gas_+_Electric_Televisions_CASE_study.pdf.
External power supply: www.energy.ca.gov/appliances/2004rulemaking/documents/case_studies/CASE_Power_Supplies.pdf.

efficiency and IEQ at various points of a building owner's decision-making process to upgrade equipment or buildings. Technologies can include advanced HVAC, lighting, building envelope, plug-load efficiency strategies, equipment controls, building commissioning and other energy using systems.

- Evaluate and test simple, low cost audit tools or diagnostic approaches that can estimate actual energy use in existing buildings and/or individual devices, determine the impacts of various advanced energy efficiency measures, recommend building improvements, generate performance and cost/benefit data and information of the energy use by devise with specific recommendations or options for the consumer and decision maker to save energy.

This initiative will coordinate with ongoing activities and studies by the CPUC, IOUs, and the Energy Commission related to Proposition 39 (2012), Senate Bill 73 (Committee on Budget and Fiscal Review, Chapter 29, Statues of 2013), and Assembly Bill 758 (Skinner, Chapter 470, Statutes of 2009).

Stakeholders: Electric ratepayers who own and operate buildings and facilities, equipment manufacturers, engineers, building designers, developers, contractors and consultants, academia, local education agencies, state, federal, and local government agencies, utilities, national labs, Regional Energy Networks.

Background: Existing building retrofits have occurred haphazardly. Utility rebate programs have focused on specific energy technologies rather than whole-building approaches and participation in those programs is limited. Whole-building energy audit programs typically target specific sectors or to organizations with a desire to upgrade or renovate. Often, energy renovations require a champion to push for improvements and identify energy and non-energy benefits (for example, improved employee, or student performance). Split incentives can deter any energy improvements since building owners often do not pay utility bills or reap the benefits from retrofits.

Existing California K-12 schools are aging, but have lacked technical knowledge and funding to identify and implement the needed energy efficiency upgrades and solutions to their IEQ issues. The California Clean Energy Jobs Act (Proposition 39) and Senate Bill 73 provide energy efficiency upgrade and clean energy job creation funding to local education agencies to reduce classroom energy consumption and improve IEQ. Research resulting from this initiative will complement these activities.

S1.2 Proposed Funding Initiative: Develop Model Designs and Strategies for Cost-Effective Zero Net Energy Homes and Buildings.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	Full-scale Demo	Early Deployment	Market Facilitation	Grid Operations / Market Design	Generation	Transmission / Distribution	Demand – side Management
X							X

Source: California Energy Commission

Purpose: To overcome the multiple barriers of cost effective designs, technologies, and acceptance, this initiative will develop an integrated building design approach to meet ZNE building goals and achieve a high acceptance among consumers and builders, while maintaining costs similar to standard construction. Potential topics include the following:

- Develop and test standard prescriptive design packages for ZNE residential, multifamily and commercial buildings in various climate zones. Design packages should be easy to implement, provide reliable energy savings, allow construction at costs comparable to standard construction, and achieve high consumer acceptance.
- Develop a design optimization competition for prospective developers to design ZNE residential, multifamily/low income, or commercial buildings/ centers that incorporate a set of prescriptive energy efficiency and self generation measures. The goal is to apply the design in large-scale deployment in the technology demonstration phase. Large-scale deployment can include multi-building demonstrations (for example, subdivision, business park). Potential areas of emphasis could include development of standard designs that are able to meet minimum performance and construction quality goals including building commissioning; designs likely to be replicable in multiple climate zones; are cost effective (for example, cost comparable to standard construction); are capable of large-scale or subdivision/community scale deployment; and have high potential for customer (for example, owner, builder, installer) acceptance and market demand.

Furthermore, behavioral elements and motivations for owners/occupants to transition to ZNE will be assessed, including the customer's value proposition.

Stakeholders: Electric ratepayers who plan to build ZNE buildings, equipment manufacturers, engineers, building designers, developers, contractors and consultants, academia, governmental agencies, utilities, CPUC ZNE working groups, and national labs.

Background: Though there is increased interest in ZNE building design, there is still limited research and information available regarding the best approaches for meeting the ZNE goals for different building sectors and types by climate zones. As a result, very few designers, builders, or contractors have the expertise or experience to construct ZNE buildings cost-effectively.

The *California Energy Efficiency Strategic Plan*[44] and the Energy Commission's *Integrated Energy Policy Report (IEPR)*[45] have established ZNE goals for residential and commercial new construction. The goals include all new residential and commercial construction to be ZNE by 2020 and 2030, respectively. In addition, the CPUC has completed two studies with Pacific Gas and Electric Company (PG&E) that establish a framework for ZNE research that identifies technical potential, performs market assessments of drivers and barriers, identifies research needs, and provides a roadmap for new construction.[46, 47] This initiative will build on these reports and other current research to achieve California's ZNE goals in all building types and multiple climate zones.

S1.3 Proposed Funding Initiative: Apply Advanced Social Science Research Methods to Improve Adoption of Next Generation Energy Efficiency Solutions.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	Full-scale Demo	Early Deployment	Market Facilitation	Grid Operations / Market Design	Generation	Transmission / Distribution	Demand – side Management
X							X

Source: California Energy Commission

Purpose: This initiative focuses on improving the understanding of consumer activities associated with energy consumption to identify strategies that: 1) improve and adapt devices to maximize efficiency based on real world applications; 2) identify opportunities for savings due to behavioral changes; and 3) communicate with, motivate, and reward consumers for their

44 *California Energy Efficiency Strategic Plan*, January 2011 Update, p. 11.

45 *2011 Integrated Energy Policy Report*, p. 8.

46 *The Road to ZNE – Mapping Pathways to ZNE Buildings in California*; Heschong Mahone Group, Inc, CALMAC Study ID: PGE0327.01, December 20, 2013.

47 *The Technical Feasibility of Zero Net Energy Buildings in California*, ARUP, Job number 219664, December 31, 2013.

efforts. The main goals are to determine: 1) how people will respond to and engage with new building designs and systems; 2) how people will adapt their lifestyles to new technological opportunities associated with ZNE buildings; and 3) how people will best respond to opportunities to retrofit existing buildings. The research needed to achieve these goals must be as innovative and "next-generation" as the technologies being developed in parallel. Potential research areas include:

- ZNE New Buildings: Apply social science methods, including on-site observations, interviews, integrated data collection, and critical analysis to the task of understanding the development and real world operation of new ZNE buildings. This will involve collecting information on the changing roles, responsibilities, perspectives, and activities of planners, building officials, developers, construction workers—and ultimately building owners and occupants. The research will provide insights in real world operation of ZNE buildings that would help in maximizing regulatory, developer and customer adoption of this strategy.
- Retrofit Buildings: Apply social science methods, including on-site observations, interviews, integrated data collection, and critical analysis to the task of understanding retrofit strategies for existing buildings. For a viable retrofit marketplace to develop, building owners must believe such retrofits are important enough to justify their attention and their investment. Concurrently, research into best practices for contractors and comparative analysis of emerging contractor business models must be used to identify and promote viable contractor business models that align with the fundamental policy goal of being able to diagnose building inefficiency and providing customers reasonable options for fixing those problems.
- Consumer acceptance: Address the fundamental issue of consumer acceptance and adoption of emerging technology by exploring ways in which the technology R&D process—particularly as funded through public investment—could include social science research components that anticipate end-user needs, expectations, understanding and capabilities.

Stakeholders: California ratepayers, building owners, the (new) construction industry, retrofit contractors/HVAC contractors/plumbers, emerging technology developers, utilities, academia, national labs, and other governmental agencies.

Background: As opportunities to improve the energy use characteristics of new devices and buildings have begun to approach regulatory and engineering limits, attention is turning to the large variation in consumption levels observed between households and between similar commercial buildings, even when considering engineering and demographic factors. Historically, "behavior" research and efficiency programs have reflected a "rational choice" framing of the problem and solution opportunities—to disappointing effect. From a "rational choice" perspective, the behavior that matters takes place within an economic transaction, such as the purchase of devices or the purchase of energy to fuel those devices. The external measure

of savings opportunities has been couched in terms of "potential", particularly "economic potential"—a constructed estimate of the difference between current consumption levels and the levels that would be observed if all cost-effective energy efficiency improvements had been made–a difference that has been termed the "Efficiency Gap."[48] Consequently, most programs have been designed to reduce first costs (rebates), to offset the higher cost of more efficient devices or to provide information on the value of future savings so consumers can make better choices. Much of the "behavioral" research in the energy efficiency literature, particularly in the sub-field of program evaluation, focuses on addressing and correcting these sub-optimal transactions by improving information delivery, identifying and overcoming "market barriers", simplifying the process of providing subsidies (for example, reducing "transaction costs"), and providing cost-savings information for consumers—essentially teaching them how to make "rational" choices (for example, EnergyGuide labels, by their presence, shows that one should consider operating costs along with purchase price). Alternatively, this institute seeks insights or consumer preferences so that technologies developed will meet their needs and increase adoption rates.

To help address these problems there is a growing reliance on the use of academic disciplines with other frameworks for understanding and explaining human behavior. Psychology, sociology, anthropology and sub-disciplines (for example, economic sociology, social anthropology) and applied offshoots (for example, marketing, program evaluation) have contributed to advances in theoretical framings, data collection methods, and analytical approaches for energy efficiency. Three collections of research literature, conference presentations, and evaluation research represented the history of these efforts.[49, 50, 51] More recently, work funded through the Public Interest Energy Research (PIER) program and the CPUC has sought to document behavior research efforts and organize the application of multiple methods and theoretical frameworks to future research, program development, and evaluation of energy efficiency. [52, 53, 54] This initiative will build on these reports and other

48 Hirst, E., & Brown, M. (1990). *Closing the efficiency gap: barriers to the efficient use of energy. Resources, Conservation and Recycling*, 3(4), 267-281.

49 The "Human Dimensions" and "Human Behavior" panels in The Proceedings of the semi-annual ACEEE Summer Study on Energy Efficiency in Buildings: http://www.aceee.org/proceedings

50 The Proceedings of the annual Behavior, Energy and Climate Change Conference: http://peec.stanford.edu/events/2007/becc/index.php

51 Evaluation research reports for the California IOU Efficiency programs: www.calmac.org

52 Lutzenhiser, L., L. Cesafsky, H. Chappells, M. Gossard, D. Moran, J. Peters, M. Spahic, P. Stern, E. Simmons, and H. Wilhite. 2009. *Behavioral Assumptions Underlying California Residential Sector Energy Efficiency Programs*. Portland State University, Center for Urban Studies, Portland, OR. Report to the California Institute for Energy and Environment and the California Public Utilities Commission. Berkeley: California Institute for Energy and Environment

current research, including research to complement CPUC and Energy commission proceedings on access to large data sets for analysis, including data sets for IOU energy efficiency program.

S1.4 Proposed Funding Initiative: Develop and Evaluate Strategies to Improve Indoor Air Quality in Energy-Efficient Buildings.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	Full-scale Demo	Early Deployment	Market Facilitation	Grid Operations / Market Design	Generation	Transmission / Distribution	Demand – side Management
X							X

Source: California Energy Commission

Purpose: This initiative focuses on filling in the data gaps needed to characterize and evaluate indoor air quality in low-energy and ZNE building and developing strategies to ensure adequate indoor air quality in these buildings.

Data gaps include:

- Collect and analyze data on building characteristics that affect indoor air quality for low-energy or ZNE buildings.
- Identify and quantify sources of indoor pollutants and developing approaches to reduce the pollutants.
- Investigate occupant and operator habits, what influences those habits and the effects of those habits on IEQ.
- Identify, develop and demonstrate metrics for tracking and comparing IEQ in buildings.

Stakeholders: Electric ratepayers who own and operate buildings, buildings designers, builders, governmental agencies, and utilities.

Background: The Energy Commission is required to set standards for energy efficiency for both new and existing buildings and for new appliances.[55] It must consider indoor air quality

53 Vine, E., M. Sullivan, L. Lutzenhiser, C. Blumstein, and B. Miller. 2014. *Experimentation and the Evaluation of Energy Efficiency Programs*. Energy Efficiency (in press)

54 http://www.calmac.org/publications/Residential_Behavior_White_Paper_5-31-13_FINAL.pdf

55 AB 758, Chapter 470, Statutes of 2009.PRC Sec. 381.2 and 385.2. http://www.energy.ca.gov/ab758/.

impacts in setting these energy efficiency standards.[56] Further, the Energy Commission must comply with the California Environmental Quality Act (CEQA) by considering potential impacts of such standards on human health and safety and by reducing any significant adverse impacts.[57] Climate change legislation, policy, and California's AB 32 Global Warming Solutions Act of 2006[58] are some of the main drivers for more efficient buildings. The *AB 32 Scoping Plan* identified green buildings with increased energy efficiency as a major target for reducing GHG emissions in.[59, 60]

The Energy Commission has funded several landmark studies of IEQ and related factors in California, such as studies related to:

- New residential buildings, small and medium commercial buildings, pollutant emissions from office equipment.
- Building HVAC and air leakage that are pertinent to IEQ.
- Retrofits of low-income apartments, exposures from unvented combustion appliances, and healthy ZNE buildings.
- Guiding future research through development of an IEQ Research Roadmap 2012-2030: Energy-Related Priorities.

The California Air Resources Board (ARB) sponsors research on indoor air quality covering topics such as indoor and personal exposure, indoor-outdoor relationships, and toxic air contaminants. The U.S. Environmental Protection Agency (U.S. EPA) Indoor Air Quality research focuses on improving techniques to measure and model emissions of indoor chemical contaminants in structures such as schools, office buildings, and homes. The U.S. EPA program also investigates a variety of approaches to address mold problems in residences and office buildings. The U.S. DOE's indoor air quality R&D focuses on developing new ventilation strategies that simultaneously improve indoor air quality and reduce the energy impact of increased ventilation.

56 AB 4655 (Tanner; PRC 25402.8).

57 CEQA. PRC Sec. 21000 et seq. http://ceres.ca.gov/ceqa/.

58 Assembly Bill 32 (Nuñez), Chapter 488, Statutes of 2006

59 ARB. 2008. *Climate Change Scoping Plan*. See Final version, 5/11/09, pp. 57 et seq. and Vol. 1, Appendix C, pp. C-138 et seq. http://www.arb.ca.gov/cc/scopingplan/document/scopingplandocument.htm.

60 ARB. 2011. Green Building Strategy. http://www.arb.ca.gov/cc/greenbuildings/greenbuildings.htm.

S1.5 Proposed Funding Initiative: Develop and Test Advanced Industrial, Agricultural, Water, and Demand Response Technologies and Strategies to Reduce Energy Use And Costs.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	**Full-scale Demo**	**Early Deployment**	**Market Facilitation**	**Grid Operations / Market Design**	**Generation**	**Transmission / Distribution**	**Demand – side Management**
X				**X**			**X**

Source: California Energy Commission

Purpose: This initiative will develop, validate and document energy saving technologies, including water-energy nexus improvements, which are in the research and early development stages in industrial, agricultural, water or wastewater plant settings. The objective is to develop and test innovative technologies and develop the technical proof of concept performance data needed to make these technologies eligible to participate in future demonstration or deployment programs. Examples of research include:

- Industrial and agricultural:
    - Energy efficiency process improvements for energy intensive industries (for example, glass, pharmaceuticals, petroleum, advanced metals, coatings, manufacturing and fabrication processes, data centers).
    - Development of technologies that substitute or materially change the underlying process (for example, development of lower weight cement mix, substitutions for electrically intensive materials such as aluminum).
- Water or wastewater sectors: Evaluate and fill data gaps in the following areas:
    - Continue investments in advanced membrane filtration technologies microfiltration, ultra-filtration, nano-filtration, reverse and forward osmosis membranes, and ozone and ultraviolet light disinfection/oxidation technologies.
    - Collect data from new and existing facilities to develop reliable estimates of savings potential and costs of alternative water disinfection systems.
    - Evaluate existing installations of water reuse technologies at both centralized regional facilities and at individual industrial sites to better understand the potential of water reuse to save water and energy in California.
    - Identify potential efficiencies in moving water in water treatment facilities and in transport and distribution systems (for example, pumps, efficient canal technologies,

water recycling technologies, desalination technologies, leak detection tools, process improvements).

- Workshops and stakeholder meetings: Identify research priorities and needs to achieve reductions in electric energy use in the industrial, agriculture and water end use sectors by engaging experts and other stakeholder through workshops or technical advisory meetings.

Stakeholders: Electric ratepayers who own and operate industrial, agricultural and water facilities, equipment manufacturers, engineers, contractors and consultants, academia, governmental agencies, utilities, national labs and ARB.

Background: The private sector, for the most part, does not conduct basic applied research and is risk averse regarding new, unproven technologies, often lacking the resources to analyze and evaluate various technologies either at bench scale or at facility scale. Typically, the private sector offers funding only after a successful field demonstration. Over the past five years, the Energy Commission's IAW research program has funded many demonstration projects to prove their efficacy and cost effectiveness. In the *2012-2014 EPIC Investment Plan*, the emphasis was on large-scale deployment of technologies. The emphasis of the *2015-2017 EPIC Investment Plan* will be applied research that will help support demonstrations in future Investment Plans.

In addition, the Energy Commission held multiple stakeholder workshops to identify specific research needs and emerging technologies ready for demonstration at a commercial/industrial scale. The IOUs are stakeholders and their input has been received through participation in the Emerging Technology Coordinating Council, the Emerging Technologies Summit events, and other venues.

This initiative will coordinate with utilities, the ARB and others on their respective programs affecting the industrial, agriculture and water sectors. For instance, ARB is working with the largest industrial customers to identify cost effective energy efficiency improvements to reduce greenhouse gas emissions.

S1.6 Proposed Funding Initiative: Advance Strategies to Reduce the Impact of California Buildings on the Water-Energy Nexus.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	Full-scale Demo	Early Deployment	Market Facilitation	Grid Operations / Market Design	Generation	Transmission / Distribution	Demand – side Management
X							X

Source: California Energy Commission

Purpose: This initiative will conduct research to improve and develop cost-effective techniques, technologies, and methods to promote water and energy efficiency in residential and commercial buildings. The research seeks solutions that lead to improving California's water conservation and efficiency, focusing on ratepayer benefits. The research will help achieve the goal of potentially saving Californians 30 percent of their current urban water use with cost-effective water-saving solutions. [61] Potential research areas:

- Increase end-use water efficiency: Develop and test water efficient fixtures (for example, shower heads, faucets, toilets) and plumbing to verify energy/water savings; develop cost effective methods for leak detection in buildings and test potential cost effective remedies; develop and test advanced technologies such as improved moisture sensors and controls for integration of landscape irrigation; identify barriers and recommend mitigation measures and solutions; and develop best practices guides to reducing water and energy use for residential and commercial building owners/operators.
- Use of gray and storm water: Develop and test strategies and technologies to encourage gray water reuse in residential and commercial building applications; investigate the feasibility of storm water capture (for example, on building/community scale) in conjunction with ZNE buildings/communities; and determine potential barriers and recommend mitigation measures and solutions.
- Use of smart water meters and controls: Evaluate the feasibility of developing smart water metering systems linked to electricity rate schedules to assess the potential of reducing water and energy use.

This initiative will coordinate with ongoing activities and studies by the CPUC, IOUs, other governmental agencies, and the Energy Commission's Efficiency Division.

61 http://www.pacinst.org/wp-content/uploads/sites/21/2013/02/waste_not_want_not_full_report3.pdf.

Stakeholders: Ratepayers, owner/operators of buildings, homeowners, water equipment manufacturers, engineers, researchers, cities, counties, special districts, governmental regulatory agencies, building designers, academia, and utilities.

Background: In a state where literally every drop of water counts, using water wisely has become a way of life for most Californians. The governor recently issued a proclamation encouraging Californian's to reduce water usage by 20 percent is an example.[62] Shrinking water supplies and a growing population are worsening the effects of a multi-year drought. Court decisions and new regulations have resulted in the reduction of water deliveries from the Sacramento-San Joaquin River Delta by about 20 to 30 percent. In some areas of the state, its ecosystems and quality of underground and surface waters are deteriorating. Water efficiency research is needed to provide integrated, reliable, sustainable, and secure water resources and management systems for public health, economy, and ecosystems.[63] The California Water Plan Update 2013 reinforces the need for the state to take a lead role in investing in innovation actions that can include process improvements, data, tools and water technology research and development.[64]

The Department of Water Resources estimates that the population will grow to 45 million by 2020. With an increasing population, climate change, and a multi-year drought, the state must take action to promote water efficiency to preserve its limited water supply. Landscape irrigation uses a significant amount of water. An estimate of residential water use statewide for 2005 is 5.9 million acre feet, of which an estimated 3.2 million acre-feet is outdoor water use. [65] There is considerable potential for water savings through irrigation system improvements and behavioral change. Using existing technology and management techniques will save substantial amounts of water. Further innovation of irrigation equipment and improved management methods present important opportunities to conserve and maintain the state's water supply. Proper system design, correct installation and consistent maintenance of efficient irrigation systems combined with the selection of climate appropriate and water efficient plants are key components of landscape water use efficiency. [66]

"*Waste Not, Want Not: The Potential for Urban Water Conservation in California*," in preparation for three years, is the first report to look comprehensively at residential, commercial, institutional, and industrial water use in the state – and then evaluate the potential for reducing those uses

62 http://gov.ca.gov/news.php?id=18368

63 http://www.acwa.com/content/conservation/californias-water-using-water-wisely.

64 http://www.waterplan.water.ca.gov/docs/cwpu2013/2013-prd/Vol1_Ch02_ImperativeToInvest_PubReviewDraft_Final_PDFed_wo_JW.pdf

65 One acre-foot = 43,560 cubic feet = 325,851 gallons (the volume of water that would cover the area of an acre one foot.

66 http://www.water.ca.gov/wateruseefficiency/docs/LandscapOrdinanceReport_to_Leg-4-22-2011.pdf

through conservation and efficiency.[67] The bad news: California's urban sector uses a third more water than it needs to satisfy demand. In this study, the Pacific Institute quantifies the potential for water conservation and efficiency improvements in California's urban sector. California's urban sector uses around 20 percent of the state's water to meet commercial, industrial, institutional, and residential needs. The best way to save is to reduce waste in the system by using proper pricing and economics, educating the public, and improving water efficiency and conservation efforts.

S2 Strategic Objective: Enable Cost-Effective Demand Response for California IOU Electricity Customers.

Table 5: Ratepayer Benefits Summary for Strategic Objective 2

	Promote Greater Reliability	Lower Costs	Increased Safety	Societal Benefits	GHG emissions mitigation and adaptation	Lower emission vehicles/ transportation	Economic Development	Public Utilities Code Section 740.1	Public Utilities Code Section 8360
S2.1 Develop and Test Demand Response Technologies to Assess Performance, Increase Reliability and Improve Forecasting Techniques.	X	X		X	X				

Source: California Energy Commission

Barriers and Challenges: According to the *2013 IEPR*,[68] DR shares the top slot with energy efficiency in California's loading order of preferred resources to satisfy current and future electricity demand. DR – essentially reducing electricity use or shifting it to another period – provides many benefits including a more efficient electric system with lower overall system costs, reduced need for new power plants and transmission infrastructure, and more control by customers over their electric bills. DR is a flexible resource that can play a variety of roles in the electric system. DR can also help integrate the renewable resources needed to meet California's 33 percent by 2020 Renewables Portfolio Standard (RPS). Importantly, DR can reduce net load

67 http://www.pacinst.org/wp-content/uploads/sites/21/2013/02/waste_not_want_not_full_report3.pdf

68 http://www.energy.ca.gov/2013publications/CEC-100-2013-001/CEC-100-2013-001-CMF.pdf

swings in either direction by strategically increasing load (for example, to accommodate plentiful wind supply in early morning) or reducing it (for example, during a summer afternoon upward ramp). DR represents an important low-carbon option for balancing load to integrate higher levels of renewable energy resources that will be necessary to meet California's long-term (2050) GHG emission reduction goals.

Customer participation opportunities are limited—both in California Independent System Operator (California ISO) markets and through utility programs. The limited choices reflect a system where load reductions—individual or aggregated—are largely expected to behave like the generation resources they are intended to replace.

While communication, automation, and end-use control technologies have been rapidly evolving—along with other microelectronic, telecommunication and Internet-based technologies—the institutional frameworks for using those advances have not been able to keep up. DR from large numbers of small loads is still largely seen as unproven rather than ready for implementation on a large-scale. The potential utility of diverse, distributed DR for fast response, flexibility, locational dispatch, and low customer opportunity cost must be considered in light of reduced "visibility" to system operators and probabilistic estimates of performance that vary by time, temperature and other factors. While the basic technology has been proven, there remains substantial need for building operational experience and empirical evidence that supports the case for adapting energy markets and designing programs that displace traditional generation resources with DR.

While these challenges have organizational and regulatory components—all in the context of institutional inertia in the face of disruptive technological change--there are underlying technology, application and customer awareness barriers that need to be addressed through research.

Investments in the *2012-2014 EPIC Investment Plan* addressing barriers and challenges: The first Investment Plan had several initiatives focused on tools and strategies to increase customer participation in existing and developing load reduction programs and California ISO markets. The main emphasis was to identify customer choices for participating in California ISO markets, grid services, ancillary service markets, microgrids or enhancement of DR activities. The Energy Commission will release solicitations in fiscal year 2014 and 2015 that will focus on these areas. It is uncertain how many of these areas will be funded.

The *2012-2014 EPIC Investment Plan* focuses on R&D that helps organize and operationalize DR for existing market and program opportunities. The *2015-2017 EPIC Investment Plan* will focus on developing and testing (Chapter 3) and demonstrating (Chapter 4) DR technology and operational capabilities in the following areas: a) building performance datasets needed for DR to compete with generation as a resource, b) providing the technical and operational data to support new programs and market products that take advantage of DR characteristics, and c) developing the capability to forecast DR performance.

S2.1 Proposed Funding Initiative: Develop and Test Demand Response Technologies to Assess Performance, Increase Reliability and Improve Forecasting Techniques.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	Full-scale Demo	Early Deployment	Market Facilitation	Grid Operations / Market Design	Generation	Transmission / Distribution	Demand – side Management
X				X			X

Source: California Energy Commission

Purpose: This initiative will focus on increasing the potential for DR to displace fossil fuel generation while maintaining grid reliability and integrating intermittent and highly variable renewable resources. This will be done by developing and testing DR technologies to assess and evaluate performance as well as collecting and evaluating performance data from different programs to increase reliability of impact estimates and improve forecasting techniques. Potential research areas include the following:

- Develop, test and advance DR technologies: Building on the technology development research under the *2012-2014 EPIC Investment Plan*, this initiative will develop the ability to combine end-use DR technology—switches, control logic and communications—with management systems. The purpose is to develop and test load reduction capabilities for all hours of the year, evaluate the most effective use of different end use technologies and participating customers, and provide an empirical basis for DR participation following a traditional "least cost dispatch" model. This can include:
  - Identifying opportunities to operate equipment or alter processes to provide load reduction on demand, such as fast response and duration-limited load reductions that assist system operators in integrating intermittent, variable renewable energy generation and maintaining power quality across the grid.
  - Characterizing the load reduction capabilities of DR systems by end use, availability, opportunity cost, and customer type.
  - Refining benchmarking and simulation tools and analysis platforms for DR strategies.
- Develop hardware and software systems that facilitate use of DR—and DR combined with onsite storage and/or distributed generation (DG)—as a reliable substitute for fossil generation resources. These systems should provide control and performance monitoring capabilities sufficient to replace fossil generation in providing ancillary services to the system operator.

- Assemble and evaluate performance data: Build a sufficient database of DR performance data to be able to make reliable estimates of performance from different end uses and customer types under different conditions, such as:
    - Develop specifications for a data repository and parameters necessary to make reliable estimates of DR performance while considering customer privacy, data security and transparency and access needed to complete the evaluation.
    - Develop and test a prototype platform for the data repository.
    - Evaluate the economic and other benefits to electric ratepayers.
    - Improve DR Forecasting: Use the growing DR performance database to improve DR forecasting techniques. Potential areas of investigation include identification of parameters for modeling improvement.
    - Develop modeling tools, data management, and communication systems that provide a sufficient level of performance transparency to system operators to document the real time performance effects.
- Evaluate and demonstrate the extent to which (1) new technologies can enable more devices within residential and/or commercial buildings to participate in DR programs and deliver cost-effective, reliable savings and (2) the extent to which strategies that provide the consumer control (as opposed to direct or remote appliance control) can deliver cost-effective reliable savings.

Stakeholders: Ratepayers with DR, storage, plug-in electric vehicles (PEVs) or other distributed energy resources; grid operators; utilities; electronics manufacturers; Home Automation Network providers; third party DR aggregators.

Background: Policies designed to reduce GHG emissions will increase renewable energy generation and increase electricity consumption, such as electrification of the transportation sector. The latter increases are due to substituting electricity for fossil fuels in transportation and increasing electricity used for water heating, home heating and other end uses in areas where natural gas has been available. As more renewable energy generation is added to the grid, resources with intermittent and variable output will create new operational and procurement challenges for system operators and load-serving entities. In addition, these shifts in demand and supply balance have the potential to alter the historical relationship among the consumer, the utility, and the system operator. Instead of demand being treated as a "given" and supply being expected to meet that demand (with the system operator required to operate in the background to maintain reliability), consumers and suppliers act in both roles, increasing the number of active participants and expanding the role of the system operator. These changes can be managed; however, there are risks—particularly with regard to costs—of achieving sub-

optimal results without sufficient attention and oversight by regulatory authorities to protect ratepayer interests.

DR, along with DG and storage, is critical in balancing renewable intermittency. The extent of DR participation by consumers will ultimately have a strong effect on consumer costs. Prior research has demonstrated that large numbers of small loads have the ability to provide a dependable, dispatchable, flexible, fast (in response time) resource for system operators at a very low opportunity cost compared to existing DR resources. Currently, the majority of DR participating in California comes through programs designed for large industrial and commercial customers. Much of the load subject to DR dispatch carries a higher opportunity cost in reduced output or occupant inconvenience or discomfort, and is compensated at a level intended to offset those costs. Further R&D is required to realize the savings opportunities possible due to participation by large numbers of small loads. In order to expand market opportunities for small users it will be necessary to develop communications technologies, low-cost automation technologies, dependable and end-user-friendly control strategies and performance measurement strategies. These efforts should provide sufficient information to system operators that the value provided to the grid can be characterized and monetized appropriately.

Clean Generation

S3 Strategic Objective: Develop Innovative Solutions to Increase the Market Penetration of Distributed Renewable and Advanced Generation.

Table 6: Ratepayer Benefits Summary for Strategic Objective 3

	Promote Greater Reliability	Lower Costs	Increased Safety	Societal Benefits	GHG emissions mitigation and adaptation	Lower emission vehicles/ transportation	Economic Development	Public Utilities Code Section 740.1	Public Utilities Code Section 8360
S3.1 Efficient, Sustainable and Lower-Cost Bioenergy: Innovations to Improve Biomass-to-Energy Systems in California.	x	x		x	x		x	x	x
S3.2 Develop Integrated and Hybrid Photovoltaic Technologies and Strategies to Reduce Costs and Advance Zero-Net Energy Buildings.	x	x		x	x		x	x	x
S3.3 Generate Electricity While Moving Water: Developing Solutions to Expand California's Use of In-Conduit Hydrokinetic Power.	x	x		x	x		x	x	x
S3.4 Advance Breakthroughs in Renewable Energy Technologies to Dramatically Increase Efficiencies Reduce Costs, and Enable Additional Renewable Resources.	x	x		x	x		x	x	x
S3.5 Develop Piezoelectric-Based Systems for Harvesting Energy to Maximize Efficient Use of Emerging Energy Sources in California.	x	x		x	x		x	x	x

Source: California Energy Commission

Barriers and Challenges: Distributed renewable energy generation refers localized power generation from renewable resources that are typically close to electricity loads and smaller in scale than traditional central power plants. Such generation reduces the demand for transmission and distribution (T&D) infrastructure and large-scale centralized power generation. Despite the significant increase in distributed energy resources, mainly rooftop PV, over the past several years, DG still accounts for only a small fraction of California's total electricity generation. However, the expansion of these resources is a key goal under Governor Brown's *Clean Energy Jobs Plan*, which calls for adding 12,000 MW of distributed renewables by

2020. Much of the energy generated by the 12,000 MW of distributed renewable energy is likely to be eligible for the state's 33 percent by 2020 Renewable Portfolio Standard. Depending on the technology and resource, common barriers to effective integration of large quantities of renewable DG resources may include relatively high overall cost, intermittency, and potential impacts on reliability.

Permitting processes and utility interconnection requirements also pose major challenges. These requirements can add costs and results in lengthy delays to DG projects. Efforts to streamline these processes and requirements are underway; however, additional applied R&D is needed to ensure continued improvement. For some emerging DG technologies, lack of sufficient performance data and bench and pilot scale verification complicates permitting processes and hinders the development of investor confidence needed for full market deployment of the technology. This strategic objective aims to benefit ratepayers by addressing the R&D needs of different forms of renewable and advanced DG, such as biomass, solar, small hydroelectric, and other potential resources that are currently used including possible breakthroughs that have potential for significant improvements in performance and costs.

The relative immaturity and inefficiencies of most current renewable energy technologies make it difficult to compete with classical forms of generating electricity. Some cutting-edge technologies are increasing the value proposition for renewable DG, but it may be possible to generate even greater efficiencies than currently feasible by making systems less complex and generating more power per unit of input. The marketplace needs technological breakthroughs to make these systems economical. There is a need to improve and integrate state-of-the-art technologies to promote widespread use of renewables. For example, conventional PV systems use only a small fraction of the sun's potential, and the rest is either reflected or becomes waste heat. Waste heat and/or unused mechanical energy are generated by almost every energy conversion process that could, instead, be used to augment energy supply. Also, emerging technologies may be able to use previously untapped renewable resources to augment renewable energy capacity and/or reduce demand-side load.

Investments in the *2012-2014 EPIC Investment Plan* addressing barriers and challenges: This strategic objective builds on initiatives started in the *2012-2014 EPIC Investment Plan* to address barriers and challenges related to distributed renewable energy by leveraging technical advances expected from funded projects. One of the proposed initiatives in this *2015-2017 EPIC Investment Plan* addresses barriers and challenges for small hydropower that was not included in the *2012-2014 EPIC Investment Plan*. This strategic objective also includes initiatives addressing the barriers and challenges for breakthrough energy generation sources that were not included in the *2012-2014 EPIC Investment Plan*.

S3.1 Proposed Funding Initiative: Efficient, Sustainable and Lower-Cost Bioenergy: Innovations to Improve Biomass-to-Energy Systems in California.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	Full-scale Demo	Early Deployment	Market Facilitation	Grid Operations / Market Design	Generation	Transmission / Distribution	Demand – side Management
X	X				X		X

Source: California Energy Commission

Purpose: The goal of this initiative is to advance innovative approaches that show the greatest potential to reduce biomass system costs, increase energy conversion efficiency, and improve environmental performance. This initiative will develop and demonstrate at the pilot scale early-stage innovative technologies, techniques, and deployment strategies for biomass-to-electricity generation and feedstock management, such as collection, densification, and conversion of biomass waste streams to electricity, while reducing GHG emissions and providing additional co-benefits. These co-benefits are indirect results of using biomass for electricity generation and can include prevention of catastrophic wild fires and reduction of material sent to landfills. This initiative includes applied R&D in the following areas:

- Advanced Biomass-to-Energy Conversion Technologies: Biomass conversion technologies include thermochemical and biochemical conversion technologies and approaches that can decrease production costs, increase the value of biogas, and achieve environmental compliance. Innovative, lab-proven biomass conversion technologies and approaches should continue development into next generation prototypes to verify technical potential. Promising technologies such as thermochemical gasification (which refers to the conversion of biomass at elevated temperature and at limited amounts of oxygen), anaerobic digestion and integrated gasifier combined cycle and gaseous fuel co-firing will be developed and evaluated for reliability, conversion efficiency, cost-effectiveness, and environmental performance at the pilot scale.
- Application of Conversion Technologies: This research area includes developing technologies and strategies for the sustainable use of forest residue and thinning to generate clean electricity, while reducing catastrophic fire hazards, and use of municipal waste, agricultural residue and food processing waste. The goal is to generate electricity and useful thermal energy in the form of renewable combined heat and power (CHP) from various organic waste streams to achieve cost parity with fossil-fuel power by 2020 while achieving emission requirements.
- Sustainable Biomass Harvesting, Processing, and Handling Systems: This research topic will investigate technologies and approaches to reduce the cost and environmental impacts of

collecting and transporting biomass feedstocks over greater distances, and increase the technical and economical availability of biomass feedstock throughout the state. Proposed research projects develop tools and techniques to evaluate environmental and economic impacts of proposed technology solutions. This topic will also advance research on sustainability standards for harvesting biomass to ensure that future bioenergy development is environmentally sustainable.

Stakeholders: Ratepayers in rural and urban communities, industrial and commercial food processing facilities, dairy and agricultural facilities, and wastewater treatment facilities; California Department of Food and Agriculture (CDFA); local air quality districts; ARB; California Department of Forestry and Fire Protection; biomass industry groups; California Department of Resources Recycling and Recovery; waste management industry, municipal governments and agencies, Bioenergy Associations of California, independent power producers, and the U.S. Forest Service.

Background: This initiative will address challenges identified in the *2009 IEPR*, the *2011 Bioenergy Action Plan*, [69] and the *2013 IEPR*. This initiative also leverages the biomass activities specifically identified in the *2012-2014 EPIC Investment Plan*. Unlike variable renewable energy resources, bioenergy technologies can provide reliable and renewable base load generation, meaning that electricity can be generated during scheduled times and at predetermined power levels. Some bioenergy technologies can also vary energy output based on the demand for power. Bioenergy has many benefits compared to other forms of energy generation, including displacing fossil fuel power plants with a reliable renewable resource; generating distributed energy near demand; reducing GHG emissions, providing jobs in rural communities; providing agriculture, industry, and forestry with an effective disposal option for biomass residues; and reducing wildfire severity and the use of landfills.

Biomass produced by California's commercial, agricultural, industrial, forestry, and urban sectors can be used as feedstock to generate heat and electricity out of what would otherwise be treated as waste materials. Biomass is converted to fuels and other products through one of the three processes: thermochemical, biochemical, and physicochemical. This initiative focuses on the first two types of conversion processes. Thermochemical conversion processes, such as combustion or gasification, and biochemical conversion, commonly by anaerobic digestion, are the dominant processes for biomass-to-electricity generation (also referred to as biopower) Most

69 California has adopted numerous policies to promote bioenergy, but significant barriers to its development remain. The *2011 Bioenergy Action Plan* identifies those barriers and recommends actions to address them, so that the state can meet its clean energy, waste reduction, and climate protection goals. The *2012 Bioenergy Action Plan* reflects an update to the actions in the 2011 Plan, but does not update the challenges. For more information on California's Bioenergy Action Plan, please see http://www.energy.ca.gov/bioenergy_action_plan.

solid biomass power plants convert biomass from forestry, agricultural residue (for example, prunings), and urban wood wastes to electricity in a thermochemical process. These plants use only about 5 million bone dry tons per year of biomass in California, which is a small fraction of the estimated biomass technical potential of more than 36 million bone dry tons per year. Similarly, only a small proportion of food and other organic wastes are captured as resource for biopower through anaerobic digestion. For example, only 1 percent of the manure produced from the dairy farms is used to generate electricity through anaerobic digestion. Furthermore, a major portion of the biogas produced by the anaerobic digesters and waste water treatment plants is flared.

Small reciprocating engines are the dominant technology in biogas-to-electricity systems, but they need improvements to meet state and local air emission requirements at lower cost. Air pollutant emissions control devices for this type of engine can be relatively expensive, posing a major barrier to expanding the use of reciprocating engines to generate electricity from biogas. Other generation technologies, such as microturbines and fuel cells, have lower emissions profiles but are currently more costly, more complicated to operate, and require higher quality biogas.

The U.S. DOE is funding thermochemical research projects to develop conversion and upgrading technologies; however, its focus is on enabling biorefineries to convert woody biomass efficiently into biofuels at demonstration and commercial scales.[70] The United States Department of Agriculture (USDA) is funding bioenergy with a focus on environmental and policy issues. The conversion technology research funded through this initiative will apply to biopower systems, and will leverage the research performed by other agencies. There is a need for the EPIC funding to focus on technical and economic solutions for the waste to energy issue.

Implementation of this initiative will be coordinated with other Energy Commission renewable energy commercialization activities, including those pursued under the Alternative and Renewable Fuel and Vehicle Technology Program.

70 http://www1.eere.energy.gov/biomass/thermochemical_conversion.html.

S3.2 Proposed Funding Initiative: Develop Integrated and Hybrid Photovoltaic Technologies and Strategies to Reduce Costs and Advance Zero-Net Energy Buildings.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	Full-scale Demo	Early Deployment	Market Facilitation	Grid Operations / Market Design	Generation	Transmission / Distribution	Demand – side Management
X					X		X

Source: California Energy Commission

Purpose: This initiative will develop next generation distributed PV technologies and strategies to increase overall conversion efficiencies, promote the adoption of building-integrated PV and hybrid photovoltaic/thermal systems, and reduce the total costs of PV technologies in distributed applications. This initiative will also support the development and evaluation of comprehensive approaches to reducing the cost of energy for PV, including strategies and business models to ensure that commercial PV systems are readily available and provide the functionality needed for customers and the utility grid. This initiative will include applied R&D to improve the performance and value of distributed PV systems in the following areas:

- Hybrid solar photovoltaic/thermal generation technologies: This initiative will develop and evaluate innovative PV and thermal energy generation systems to drive down the costs for distributed PV and increase overall conversion efficiencies. Facilities that need both onsite electricity generation and hot water will benefit from the higher efficiencies that these hybrid systems may provide.
- Low-cost building-integrated PV technologies and strategies to support ZNE Buildings: This initiative will analyze the technical and economic feasibility of further reducing PV costs by developing building-integrated and hybrid systems that are fully integrated into building designs, including roofing surfaces, window materials, and/or other building elements. These systems should work with other energy components within the building to advance California's ZNE buildings goals, as indicated in Strategic Objective S1.
- Strategies to reduce non-hardware costs of PV: This initiative will develop and evaluate strategies to reduce the non-hardware costs for distributed PV across the entire value chain – including manufacturing, distribution, installation, operations, and end-of-life system considerations. The Energy Commission will investigate strategies to strengthen the business case for distributed PV systems in California.

Stakeholders: Residential, commercial, and industrial facilities, building developers, California IOUs; solar industry groups.

Background: Although solar is one of California's most promising renewable resources, it is not yet cost-competitive with conventional electricity generation. Particularly over the long term, as PV subsidies expire, funding research now can continue to reduce costs (both technology and "soft" costs) and continue advancing California's PV industry. The California Solar Initiative (CSI) research, development, and demonstration (RD&D) will invest up to $50 million by 2016 pursuant to Public Utilities Code Section 2851. [71] The CSI RD&D program is funded by the electric ratepayers of California's three largest IOUs, PG&E, Southern California Edison Company (SCE), and San Diego Gas & Electric (SDG&E) as described in Decision 06-12-033.[72] Under this initiative, the Energy Commission will seek opportunities to complement the advances made by the CSI RD&D program and avoid duplicative efforts.

The CPUC's Long Term Energy Efficiency Strategic Plan established big bold initiatives to achieve residential and commercial ZNE in new construction by 2020 and 2030, respectively. ZNE buildings have been demonstrated in a limited scale in both commercial and residential buildings in California. However, the technical feasibility of ZNE buildings and communities is still in the early stages of demonstration. "Significant additional resources will be required to scale these efforts up for full-scale production at affordable prices."[73]

As California strives to meet its ZNE building goals for commercial and residential buildings, it is becoming increasingly important to identify and evaluate opportunities for cost reduction, including synergies between building materials and onsite renewable energy generation. Currently, a majority of distributed PV is installed on top of existing rooftop materials, but the opportunity exists to integrate PV into the actual roofing materials, window surfaces, and other building components to further reduce costs. While some (R&D) investment focus has previously been placed on developing these types of building integrated PV technologies, additional technology development, validation, and scale-up is needed to ease the widespread deployment of these technologies. Additional cost savings may be realized by identifying opportunities for hybrid photovoltaic/thermal technologies to provide power and heat to California's buildings.

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71 Public Utilities Code Section 2851 (c)(1) establishes a CSI R&D funding cap of $50 million. It provides in pertinent part: "In implementing the California Solar Initiative, the commission [CPUC] shall not allocate more than fifty million dollars ($50,000,000) to research, development, and demonstration that explores solar technologies and other distributed generation technologies that employ or could employ solar energy for generation or storage of electricity or to offset natural gas usage…"

72 CPUC. 2007. *The Adopted California Solar Initiative Research, Development, and Demonstration Plan*. http://www.calsolarresearch.org/images/stories/documents/csi_rdd_adopted_plan_73189.pdf.

73 *California Energy Efficiency Strategic Plan.*

A significant research effort is underway at the federal level with the U.S. DOE's SunShot Initiative, which aims to reduce the cost of solar energy 75 percent by 2020. As part of this effort, the U.S. DOE launched the Rooftop Solar Challenge to reduce non-hardware PV costs and improve market conditions for PV projects. This nationwide effort engages diverse teams of local and state governments, along with utilities, installers, nongovernmental organizations, and others, to make solar energy more accessible and affordable.[74] The SunShot initiative presents a significant opportunity for California to leverage U.S. DOE funding while maintaining the state's track record of innovation and early adoption.

In recent years, several research projects have focused on ways to advance distributed PV technologies and California's PV industry as a whole. For example, SolarTech has looked at comprehensive ways to reduce the cost of solar energy through permitting, installation, and other "soft cost" reductions. Other projects have sought to reduce costs with innovative technology designs and low-cost installation strategies. While promising advances were made in these projects, even further cost reduction opportunities are needed for the long-term viability of distributed PV in California.

S3.3 Proposed Funding Initiative: Generate Electricity While Moving Water: Developing Solutions to Expand California's Use of In-Conduit Hydrokinetic Power.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	**Full-scale Demo**	**Early Deployment**	**Market Facilitation**	**Grid Operations / Market Design**	**Generation**	**Transmission / Distribution**	**Demand – side Management**
X					**X**		

Source: California Energy Commission

Purpose: The intent of this research initiative is to develop the tools, strategies, and technologies to advance the pre-commercial development and demonstration of in-conduit hydrokinetic turbines and generators. This initiative includes pilot-scale demonstrations of pre-commercial turbines and generators, such as a demonstration of a unit within an actual conduit. This initiative will also address the development of testing protocols or procedures for evaluating this new technology and the development of criteria to facilitate the selection of the appropriate turbine or generator for specific site conditions.

74 http://www.eere.energy.gov/solarchallenge/.

Stakeholders: PG&E, SCE, state and federal agencies, water agencies, and interested stakeholders.

Background: In-conduit hydrokinetic generate electricity from the force of moving water flowing in tunnels, canals, pipelines, aqueducts and other structures without the need for a large dam or reservoir. Significant hydrokinetic generation potential exists at existing canal drops and pipeline pressure relief valves within the state. An Energy Commission study from 2006 estimated that 250 MW is available on existing open channel drops of nine feet or more.[75] Additional generation opportunities exist by replacing pressure valves in pressurized water or wastewater conveyance pipelines. Pressure-reducing valves are used in water supply systems and industry to reduce the buildup of pressure in a valve or to reduce pressure to an appropriate level for use by water system customers. Such valves can also be found at distribution points in water conduits, canals, irrigation ditches, aqueducts, and pipelines, and can be replaced with a turbine to generate electricity.

In-conduit hydropower projects often meet eligibility requirements for the state's Renewables Portfolio Standard, avoid environmental concerns associated with in-stream hydropower generation; exploit synergies with infrastructure already in place, offer all the benefits of distributed and self-generation and often requires less of a capital investment.

In-conduit electricity generation usually requires smaller turbines operating at lower pressure than conventional hydropower, different installation techniques, and different interconnection requirements. Although a host of turbine technologies have been developed for in-conduit hydropower,[76] the major barriers to greater deployment of this technology are permitting requirements, cost of interconnections, a lack of standardized testing protocols, and a lack of guidance for equipment selection.[77] California's RPS Participating Facilities[78] list identifies less than 40 in-conduit generation installations within the state; the capacity of most of these facilities is less than one MW and therefore represents a small fraction of the available generation identified in the 2006 Energy Commission study. Recent federal legislation has significantly relaxed permitting requirements, but interconnection costs remain an impediment.

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75 Navigant. 2006. *Statewide Small Hydropower Resource Assessment*. Publication CEC-500-2006-065. Prepared for California Energy Commission. June. http://www.energy.ca.gov/2006publications/CEC-500-2006-065/CEC-500-2006-065.PDF.

76 *Inventory of Current In-Conduit Small Hydroelectric Generation Technologies*. 2013. Cooperman, Aubryn and J.P. Delplanque. California Small Hydro Collaborative. August.

77 House, Lon. 2010. *Recapturing Embedded Energy in Water Systems: A White Paper on In-Conduit Generation Issues and Policies*. http://www.waterandenergyconsulting.com/recapture.pdf. Accessed February 25, 2014.

78 http://www.energy.ca.gov/portfolio/documents/list_RPS_certified.html. Accessed Feb. 25, 2014.

S3.4 Proposed Funding Initiative: Advance Breakthroughs in Renewable Energy Technologies to Dramatically Increase Efficiencies, Reduce Costs, and Enable Additional Renewable Resources.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	Full-scale Demo	Early Deployment	Market Facilitation	Grid Operations / Market Design	Generation	Transmission / Distribution	Demand – side Management
X					X		X

Source: California Energy Commission

Purpose: This initiative will develop early-stage innovative electricity generation technologies and novel applications with breakthrough potential in the commercial market to effectively take advantage of currently untapped localized resources for electricity generation. The initiative targets technology advancements that will dramatically increase energy conversion efficiencies, reduce system costs, and expand the use of potential renewable resources that are not used for electricity generation. This funding initiative will also develop novel systems, technologies and approaches to address issues on affordability, reliability, durability, and efficiency that will enable accelerated integration and deployment of renewable-based DG technologies.

The following research areas are included in this initiative:

- Novel technological solutions to enable increased deployment of clean and advanced distributed power generation. This research topic includes supporting new designs, materials, and control systems that have the potential to significantly reduce the cost, improve the durability and increase the reliability of renewable and advanced DG technology. Possible projects may include areas that address new materials and system design for turbines or fuel cells, enabling control systems to better integrate renewable DG with the grid and user requirements, for instance, to respond better to load changes or ramping requirements.
- High-efficiency waste heat conversion technologies to augment electricity generation, such as bottoming cycle. These technologies can help increase existing electricity generation by using the heat that is wasted during classical energy generation or other everyday processes, to provide a source of clean electricity.
- Nanogeneration and energy-harvesting technologies to enable devices to power themselves based on ambient electromagnetic, thermal, or mechanical energy. These technologies can help reduce plug-load demand using energy resources that are renewable, consistent with California's energy loading order.

- Thermoacoustic engines for electricity generation. These technologies can potentially convert heat into useful energy using high-pressure sound waves. This is a promising field with potentially widespread applications for energy generation and beyond.
- Biomimicry applications for enhanced electricity generation. Biomimicry is the practice of designing technologies that are inspired by nature, and has potentially widespread applications for the energy sector. Techniques used in nature may be applied to optimize existing energy systems or develop altogether new approaches to electricity generation.
- Application of advanced printing techniques for electricity generation. Some applications include printing processes for ultra low-cost PV panel manufacturing or evaluating potential applications of three-dimensional printing to reduce costs or increase values for renewable energy technology prototypes.
- Integration of multiple existing materials in a single high-efficiency renewable energy system. Potential synergies may be available within two renewable energy generators that can be hybridized to increase overall conversion efficiencies and provide other potential benefits.

Stakeholders: Energy researchers, product developers, local governments, and energy consumers.

Background: In 2012, the Energy Commission released a solicitation titled Community Scale Renewable Energy Development, Deployment and Integration. One of the solicitation's research areas was for "Breakthrough Renewable Energy Generation Technology Development."[79] This research area sought proposals to develop renewable energy technologies with breakthrough potential in the commercial energy market, and will contribute significantly towards California's 2020 renewable energy goals. Twelve research proposals were received and two received Energy Commission funding, both for advanced solar technology prototypes. This approach should be expanded to include a wider range of breakthrough energy generation technologies and applications.

The U.S. DOE's Advanced Research Projects Agency – Energy (ARPA-E) advances high-potential, high-impact energy technologies that are too early for private-sector investment. ARPA-E projects aim to develop entirely new ways to generate, store, and use energy with the potential to radically improve U.S. economic and environmental well-being. In 2013, ARPA-E signed a first-of-its kind memorandum of understanding with the Energy Commission to establish a framework for collaboration on energy research and demonstration projects. This

79 California Energy Commission solicitation number PON-12-502. *Community Scale Renewable Energy Development, Deployment, and Integration*.

initiative offers a potential opportunity to leverage this relationship to develop breakthrough renewable energy systems in California and provide significant benefits to IOU ratepayers.

S3.5 Proposed Funding Initiative: Develop Piezoelectric-Based Systems for Harvesting Energy to Maximize Efficient Use of Emerging Energy Sources in California.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	Full-scale Demo	Early Deployment	Market Facilitation	Grid Operations / Market Design	Generation	Transmission / Distribution	Demand – side Management
X					X		X

Source: California Energy Commission

Purpose: This initiative will advance electricity generation technologies and novel applications to take advantage of the developments in piezoelectric materials and the availability of existing wasted mechanical energy to expand the generation of energy from otherwise untapped resources. This includes the use of piezoelectric devices to harvest power from existing roadway surfaces, train tracks, building materials, or other underused applications to cost-effectively increase renewable energy capacity and/or reduce load. This funding initiative intends to implement recommendations from the Energy Commission's assessment of piezoelectric materials for roadway energy harvesting. Proposed projects will develop, demonstrate and evaluate the technology to quantify performance, durability, and lifetime, and develop strategies for integrating energy storage to address expected intermittency in power generation from piezoelectric devices. This initiative also includes assessments of piezoelectric system applications in other opportunity areas. Currently, there is little public data to determine technical and economic feasibilities, particularly to determine projected power output, system lifetime, durability, costs, and marketing potentials.

Stakeholders: Energy researchers, product developers, National Laboratories, local governments, and energy consumers.

Background: Unlike the PV semiconductor which generates electricity with the application of light, piezoelectric materials generate electricity with the application of stress. This material offers a wide opportunity to harvest energy where stress or vibration is generated and yet remains largely untapped. Potential sources of vibration include pedestrians, industrial machinery, or moving cars. The application of piezoelectric technology is not entirely new. For instance, it has been used in sonar and touch screen phones and has been installed and tested in

flooring in railway stations to generate energy from passing pedestrians in Japan, under some highways in Israel, and under the floor of a dance club in San Francisco.[80]

From 2011-2013, DNV KEMA conducted an Energy Commission-funded study to evaluate the potential for piezoelectric materials for harvesting energy from roadways and railways. The analysis estimated the range of the levelized cost of energy for the piezoelectric systems to be between $0.08-$0.18/kWh, although it depends strongly on traffic conditions and vehicle characteristics. The study recommended that further testing is needed to validate power output, durability, and lifetime of the proposed system, as well as the relative performance as a function of traffic volume.[81]

80 Simons, C. 2014. Cutting-Edge Technology Championed by Calif. Assemblyman Gatto Gets Strong Support in California Energy Commission Study. In http://californianewswire.com/2014/02/06/CNW18855_122448.php/cutting-edge-technology-championed-calif-assemblyman-gatto-gets-strong-support-california-energy-commission-study/.

81 Hill, Davion, Nellie Tong, (DNV KEMA). 2013. *Assessment of Piezoelectric Materials for Roadway Energy Harvesting.* California Energy Commission. Publication Number: CEC-500-2013-007.

S4 Strategic Objective: Improve Power Plant Performance, Reduce Cost, and Accelerate Market Acceptance of Existing and Emerging Utility-Scale Renewable Energy Generation Systems.

Table 7: Ratepayer Benefits Summary for Strategic Objective 4

	Promote Greater Reliability	Lower Costs	Increased Safety	Societal Benefits	GHG emissions mitigation and adaptation	Lower emission vehicles/ transportation	Economic Development	Public Utilities Code Section 740.1	Public Utilities Code Section 8360
S4.1 Boost Concentrated Solar Power by Reducing System Costs and Increasing Performance.	X	X		X	X			X	X
S4.2 Develop Innovative Tools and Strategies to Increase Predictability and Reliability of Wind and Solar Energy Generation.	X	X		X	X			X	X
S4.3 Develop Advanced Technologies and Strategies to Improve the Cost-Effectiveness of Geothermal Energy Production.	X	X		X	X			X	X
S4.4 Upgrade California's Aging Wind Turbines: Design, Cost, and Development Improvements That Meet Local Needs.	X	X		X	X			X	X

Source: California Energy Commission

Barriers and Challenges: Utility-scale clean energy generation is defined as a stand-alone generation facility that is directly connected to the grid and is 20 MW or greater in capacity. While systems as low as 10 MW have also been considered utility-scale in other utility generation policy and planning documents, the key distinction here is being stand-alone and having direct connection to T&D system. California has been aggressively pursuing increased generation of electricity from renewable resources pursuant to both Governor Brown's *Clean Energy Jobs Plan* goal of deploying 8,000 MW of large-scale renewable energy systems by 2020, and the mandated 33 percent RPS. Alternative forms of utility scale systems and technologies have been developed, deployed and commercialized for several years. However, the need to improve the cost and performance of existing systems, possibly by developing new cost-effective enabling technologies and strategies, remains a common challenge across utility-scale renewable energy systems.

This strategic objective will focus on technological needs for concentrating solar power (CSP), other solar generation, geothermal, and wind energy, with each of these systems having specific barriers and challenges. For instance, the continuing high cost of CSP projects compared to PV and conventional natural gas-fired generation sources remains a significant barrier to greater penetration of this technology. For solar PV and wind energy, reliable operation of the power system due to daily and seasonal resource variability, short-term intermittency, and relative uncertainty of generation output are major concerns. Specific technical concerns related to intermittency involve grid stability, voltage regulation, and power quality (for example, voltage rises, sags, flickers, and frequency fluctuations). These concerns only grow larger as these renewable resources continue to provide an increasing percentage of California's electricity generation portfolio, which may result in higher costs to the electricity system if not accurately forecasted. CSP and geothermal offer great potential for firming up wind and solar resource, however, continuing applied R&D is needed to address the important cost issues and to improve the flexibility of these systems.

For geothermal, exploration and development remains risky and expensive, and improving the cost and operations will require special materials and tools that can withstand very high temperatures, pressures, and corrosive brines. On the other hand, California, being an early adopter of wind generation, has a large number of older wind developments that are candidates for repowering. Wind turbines in many of these wind resource areas are past the designed useful life and their continuing operation generally results in increasing operation and maintenance costs. Repowering existing wind parks promises many improvements to generation capacity, power quality, and environmental safety and aesthetics.[82] Repowering needs to be implemented while considering other related challenges including insufficient transmission capacity, regulatory limits on tower height and spacing, existing power purchase agreements that provide attractive pricing only for the current installed capacity, and eligibility for tax incentives. Furthermore, the *2013 IEPR* states that prices for land will offset cost reductions for new wind project, thus supporting the value of repowering. Addressing these technological barriers and needs will help fill critical information gaps while protecting the environment and creating jobs. Research under this objective will continue to serve as a guiding framework for R&D on utility-scale renewable energy systems.

Investments in the *2012-2014 EPIC Investment Plan* addressing barriers and challenges: The *2012-2014 EPIC Investment Plan* contains funding initiatives focused on utility-scale renewable energy sources, specifically intermittent renewable generation, concentrating solar thermal, geothermal energy, and emerging offshore renewable technology opportunities. This strategic objective will leverage any technical advancements made as result of projects awarded under the *2012-2014 EPIC Investment Plan*, particularly in the area of solar and wind forecasting, to

82 KEMA. 2008. *A Scoping-Level Study of the Economics of Wind-Project Repowering Decisions in California*. Publication CEC-300-2008-004. Prepared for California Energy Commission. August. http://www.energy.ca.gov/2008publications/CEC-300-2008-004/CEC-300-2008-004.PDF.

increase the accuracy of solar and wind generation forecasts, and the value they provide to California IOUs and the California ISO. Research on CSP, wind repowering and geothermal technologies will address technological barriers and challenges that are not addressed in, but are leveraging the results from, the *2012-2014 EPIC Investment Plan*.

S4.1 Proposed Funding Initiative: Boost Concentrated Solar Power by Reducing System Costs and Increasing Performance.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	**Full-scale Demo**	**Early Deployment**	**Market Facilitation**	**Grid Operations / Market Design**	**Generation**	**Transmission / Distribution**	**Demand – side Management**
X					**X**		**X**

Source: California Energy Commission

Purpose: This initiative will support research to improve the performance of reflectors (mirrors) and receivers (absorbers) for CSP applications and reduce manufacturing, operation and maintenance costs. These components are used by all four major CSP technologies, which are solar tower, parabolic trough, linear Fresnel, and solar dish. These technologies can be distinguished based upon how sunlight is focused, whether receivers are fixed or mobile, and current operating temperatures.

This initiative will include research on reducing costs by improving the solar transmissivity of the mirrors, developing lighter-weight reflective surfaces, developing reflector coating to reduce maintenance, and improving reflectivity assessments to improve maintenance. Also, research to support microdefect detection, accelerated aging, and increased efficiency of absorbers to operate at higher temperatures that will allow higher radiation fluxes are included under this initiative. For linear absorbers, there is a need for the development of absorbers that can work with alternative heat transfer fluids, and coatings that can perform at high temperatures. For solar tower and dish technologies, there is a need for research on developing high temperature-resistant materials and coatings capable of reliable operation over many thermal cycles. This initiative will also address alternative receiver designs that allow solar collection to operate at higher temperatures.

Other important components of CSP plants, namely heat transfer fluids and thermal storage were addressed in a specific funding initiative in the *2012-2014 EPIC Investment Plan*.

Stakeholders: Technology developers and providers, federal, state and local agencies, academic institutions, IOUs, California ISO, and the Western Electricity Coordinating Council.

Background: CSP has the potential to play an important role in helping California achieve its renewable energy goals. Increasing the efficiency of this technology through improving component performance can help reduce the levelized cost of energy and potentially provide a range of other benefits, such as reducing the environmental footprint of these projects and promoting greater use of thermal storage with this technology. CSP technologies have different system configurations and, all use different designs of mirrors and receivers, to concentrate sunlight to heat a fluid and produce steam that drives a turbine to produce electricity.

According to the U.S. DOE's SunShot Initiative, mirrors represent 40 percent of the total system costs for CSP plants, while receivers represent another 15 percent. The SunShot Initiative seeks to reduce the levelized cost of electricity generated by CSP to $0.06 per kWh or less, without any subsidy by 2020. To achieve this ambitious goal, the initiative has set certain performance goals to reduce the cost of the collector field and reduce optical error while ensuring durability. For receivers, the SunShot Initiative has also set temperature, thermal cycling and efficiency, cost and durability goals.

To help achieve these SunShot Initiative goals, the Department of Energy awarded more than $21 million for receiver and collector R&D in 2012. Another $6.9 million was awarded this same year for receiver and thermal storage research.

NREL is undertaking research to improve measuring both the thermal and optical efficiency of new receiver tubes and the optical efficiency of parabolic trough reflector modules to reduce the delivered energy costs of these systems by 50 percent, while improving their optical efficiency and reducing heat loss. A particular focus of research is on advanced solar receiver coatings for heliostats to increase solar absorption and decrease emissivity to increase receiver efficiency. Sandia National Laboratories in collaboration with NREL is also conducting a complementary research on the topic of high-temperature solar-selective coatings for power tower receivers. This research is developing advanced coatings that meet the high-performance requirements of large central receivers.

These efforts also present a significant opportunity for California to leverage U.S. DOE funding into California while maintaining the state's track record of innovation and early adoption. EPIC funds will be used in conjunction with California's creativity, investor capital and technical knowledge to address some of the research opportunities posed by the U.S. DOE's SunShot Initiative.

S4.2 Proposed Funding Initiative: Develop Innovative Tools and Strategies to Increase Predictability and Reliability of Wind and Solar Energy Generation.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	Full-scale Demo	Early Deployment	Market Facilitation	Grid Operations / Market Design	Generation	Transmission / Distribution	Demand – side Management
X					X		X

Source: California Energy Commission

Purpose: This initiative will support research solutions to improve intermittent renewable energy integration into the state's electrical grid through developing improved forecasting and modeling tools for wind and solar generation. To enable the integration of increasing amounts of wind and solar generation into the grid, research under this initiative will develop and evaluate improved forecasting techniques and tools to inform grid operators of expected wind and solar power plant performance on minutes-ahead, hours-ahead, and days-ahead time scales. Potential research topics include the following:

- Expand and extrapolate on past renewable forecasting efforts, including investments made as a result of the *2012-2014 EPIC Investment Plan*, to result in higher accuracy, more reliable forecasts that grid operators and IOUs can use for planning and dynamic operation of the grid.
- Develop and evaluate advanced algorithms and mathematical techniques to account for the many complexities of the Earth's atmosphere, such as marine cloud layers, inversion layers, cloud type and height, and other factors, to generate increasingly accurate forecasts on each timescale.
- Develop advanced modeling techniques and real-time resource assessments to account for regional variations and California's microclimates, aggregate forecasts over larger areas to reduce intermittency, and potentially reduce the need for high-accuracy forecasts.
- Identify and implement advanced forecast evaluation metrics to ensure high-accuracy output, maximize the value provided by renewable forecasting, and ensure that IOU and California ISO needs are adequately addressed.

Stakeholders: Electric IOUs, California ISO, Forecast Providers, and the Western Electricity Coordinating Council.

Background: Research has been conducted to develop solar energy forecasting and monitoring tools for a spectrum of time scales, from minutes ahead to hours ahead to days ahead. There are several distinct forecasting techniques that each provides more accurate forecasts within certain timeframes, including total sky imagers for minutes ahead, satellite-based cloud vector analysis for hours ahead, and numerical weather prediction models for days ahead. Research is evaluating the feasibility of integrating these three tools into one seamless forecasting tool, and additional applied R&D activities will be funded by the *2012-2014 EPIC Investment Plan*. Future research should continue to build upon these efforts to support the development and implementation of high-fidelity tools that California ISO can use for grid planning.

The University of California, San Diego, has performed extensive R&D in this area, particularly using shorter-time frame forecasting techniques and predicting the onset of localized weather events such as marine layers. The National Oceanic and Atmospheric Administration recently completed a two-year project with the U.S. DOE to improve forecasts of turbine-level (or boundary layer) winds using high-resolution numerical models. Other private entities, such as Clean Power Research and AWS Truepower, have performed Energy Commission-sponsored forecasting research in collaboration with the California ISO.

The U.S. DOE SunShot Initiative and CSI RD&D program have both supported research into forecasting for solar generation. Future EPIC investments will be coordinated with these and other research programs to avoid duplication and leverage prior project results.

S4.3 Proposed Funding Initiative: Develop Advanced Technologies and Strategies to Improve the Cost-Effectiveness of Geothermal Energy Production.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	Full-scale Demo	Early Deployment	Market Facilitation	Grid Operations/ Market Design	Generation	Transmission/ Distribution	Demand – side Management
X					X		

Source: California Energy Commission

Purpose: This initiative will support research on strategies that will help existing geothermal facilities maintain capacity and productivity and improve system efficiency. It will also support research on improvements to geothermal resource characterization and development tools and analytical techniques to help reduce costs and risks associated with geothermal exploration and development. Research activities may address temperature tolerant tools and electronics to

improve geothermal subsurface operations, improved drill string components and materials, advanced drilling technologies that may reduce bit wear or demand less water, and advanced steering and monitoring while drilling mechanisms. Maintaining reservoir productivity is also a priority, so the initiative will research refinements to the techniques and modeling tools needed to quantify production and injection impacts on geothermal reservoirs. Alternative working fluids for geothermal plants or for injection in hot dry rock environments may also be addressed.

To improve power plant efficiency, the initiative will address research towards performance-enhancing materials and component designs for improved resistance to stress, corrosion, scaling in turbine components, plant piping, pumps and valves, advanced control systems, and improved cooling technology. Research will also include advanced materials development and plant system models leading to better tolerance, reduced wear, and improved ability to ramp up or down rapidly on demand in flexible mode.

Stakeholders: Utilities, ratepayers, geothermal energy developers and operators, resource exploration and characterization companies, the U.S. DOE, and geothermal industry groups.

Background: California has vast amounts of known and producing geothermal resources that offer significant opportunities to expand the presence and role of geothermal in the state's renewable resource mix. Some of California's most promising known resource areas remain underexploited or underexplored, and some may still be undiscovered. However, geothermal exploration and development remains a risky, lengthy, and very expensive process, contributing as much as 50 percent of the capital costs of new geothermal power production. The drilling and completion of even one geothermal well can cost as much as $10 million, and the risks of an unproductive or marginally useful well are high. Developments in modern technologies such as surface, satellite, and airborne remote sensing exploration technologies and subsurface remote sensing technologies, coupled with improvements in materials, tools, and drilling technologies may hold the greatest potential for reducing production costs and for developing new or expanded geothermal resources.

Newer geothermal plants have the potential to be operated in flexible mode as well as provide baseload generation, and can be designed with advanced control systems that allow the plant to operate in either mode given the appropriate technological development and operational data. Furthermore, newer binary power plants are able to use moderate and lower temperature resources which were formerly impossible or uneconomic to exploit for electricity production. Applied R&D is needed to take advantage of these potentials for greater efficiency, lower operation and maintenance costs, and improved ability to exploit lower quality resources and respond to changing grid needs. There are also opportunities in managing brine and in cost-effective recovery of valuable co-products while addressing environmental concerns related to emissions and water use.

The U.S. DOE's Geothermal Technologies program conducts in-house research on exploration, characterization, and development tools for enhanced geothermal systems, including high-temperature tools and sensors, advanced drilling systems for enhanced geothermal systems, resource characterization and validation studies, and research on geothermal water use. EPIC geothermal research can use and build upon these federally supported research efforts to help improve and support California-specific geothermal research.

The Energy Commission also supports geothermal development and research through its Geothermal Resource Development Account (GRDA) program. EPIC's focus on applied research complements the GRDA program.

S4.4 Proposed Funding Initiative: Upgrade California's Aging Wind Turbines: Design, Cost, and Development Improvements That Meet Local Needs.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	**Full-scale Demo**	**Early Deployment**	**Market Facilitation**	**Grid Operations / Market Design**	**Generation**	**Transmission / Distribution**	**Demand – side Management**
X					**X**		

Source: California Energy Commission

Purpose: This initiative will develop technologies and strategies that address the challenges to repowering California's wind resources, leading to improved system performance while taking into consideration the regulatory and social barriers to wind repowering. The focus will be to:

- Develop alternative wind generation approaches that address common barriers to repowering. This may include changes to turbine design, deployment and spacing strategies, tower or foundation design, and others.
- Develop cost-reduction strategies related to the removal of old equipment, such as site restoration or foundation removal.
- Develop economic models and tools to assist operators/developers in making informed repowering decisions.
- Design and develop simulation tools for predicting the effects of various policy options on developers' repowering decisions to optimize repowering opportunities in accordance with local constraints.

Stakeholders: Electric ratepayers, wind plant owners/operators/developers, utilities, transmission operators, land owners, equipment manufacturers, researchers, and academia.

Background: California was one of the first locations for utility-scale wind development with some existing equipment currently in operation dating back to the early 1980s. Much of this development occurred in the better wind resource areas of the state, including Altamont Pass, Solano, Tehachapi Pass and San Gorgonio Pass. Utility-scale wind turbine technology has evolved over the last few decades from machines of several tens of kilowatts to multi-megawatt machines today, resulting in fewer turbines being needed to generate equivalent electricity. Moreover, modern turbines are more efficient at converting wind energy into electricity and feature sophisticated control technologies enhancing their contribution to the grid.

Because wind turbines are generally designed for a useful life of about 20 years and, like any other machinery, experience increasing operation and maintenance cost as they age, much of California's best wind resource acreage is occupied by an aged fleet of relatively inefficient turbines and are candidates for repowering. Repowering, which refers to the replacement of obsolete wind turbines with modern technology, provides a primary incentives of producing more revenue from electricity and ancillary benefits per acre per year.

The U.S. DOE Office of Energy Efficiency and Renewable Energy's Wind program funds research on wind resources and technology improvements. In recent years, the Office of Energy Efficiency and Renewable Energy's efforts have included forecasting, wind tower designs, varying hub heights, turbine drive trains, supply chain issues, turbine wear, blade erosion, and other topics to support the advancement of wind development. Announced upcoming opportunities for 2014 include research on forecasting improvements for projects in complex terrains, and taller hub heights for accessing higher elevation wind resources and lower energy costs. EPIC wind research can use and build upon these federally supported research efforts to help improve and support California-specific wind research.

S5 Strategic Objective: Reduce the Environmental and Public Health Impacts of Electricity Generation and Make the Electricity System Less Vulnerable to Climate Impacts.

Table 8: Ratepayer Benefits Summary for Strategic Objective 5

	Promote Greater Reliability	Lower Costs	Increased Safety	Societal Benefits	GHG emissions mitigation and adaptation	Lower emission vehicles/transportation	Economic Development	Public Utilities Code Section 740.1	Public Utilities Code Section 8360
S5.1 Implement Roadmap to Address Public Health Effects From Energy Technologies.			X	X					
S5.2 Develop Environmental Tools and Information for Future Renewable Energy Conservation Plans.		X	X	X			X		
S5.3 Improve Science for Water Management in Power Generation: Hydropower Forecasting and Alternative Sources of Cooling Water.	X		X	X					
S5.4 Provide Tools and Information for Regional Climate Change Adaptation Measures for the Electricity Sector.	X		X	X	X		X		
S5.5 Provide Small Grants to Solicit Innovative Energy-Related Environmental Research Concepts.	X	X	X	X	X		X		

Source: California Energy Commission

Barriers and Challenges: California's energy system is evolving with unprecedented speed toward a variety of near-term and long-term goals. These changes introduce new technologies and deploy energy infrastructure into new geographic areas, potentially modifying the types and magnitudes of impacts on environmental and public health from those that have been studied in the past and through the *2012-2014 EPIC Investment Plan*. Deploying clean energy technology depends upon assessment of impacts on air quality and public health, terrestrial species and habitats, and aquatic resources, based on the best-available science, which is lacking in many cases because of the novelty of the circumstances. Critical knowledge gaps can create barriers both to permitting of new facilities and acceptance of new technology by the public, investors, and other key stakeholders. Recent research has shown that over the next few decades the existing electricity system will become highly vulnerable to climate change and extreme events, both through increased peak demand and lower generation and delivery to

end-users. A rapidly evolving electricity system offers the opportunity to reduce vulnerability, but the pathways to a more resilient system need to be explored in greater detail. Work in this strategic objective will be performed in IOU territories.

Investments in the *2012-2014 EPIC Investment Plan* addressing barriers and challenges: The *2012-2014 EPIC Investment Plan* also contained funding initiatives addressing the barriers and challenges related to air quality and public health, terrestrial species and habitats, aquatic resources, and climate change. Specific research areas have been identified to implement the spirit of the *2012-2014 EPIC Investment Plan*, which provides opportunity to leverage more specific research initiatives for the *2015-2017 EPIC Investment Plan*. For example, in some cases, the first investment period will only be able to partially address the research needs in a given area (for example, environmental consequences of long-term energy scenarios, probabilistic hydrologic forecasts, and indoor air quality implications of renewables), and the early results of the first sets of projects will inform initiatives in the second investment period. In the public health area, the first investment period will cover development of a roadmap of research while this investment period will fund priority projects identified in the roadmap.

S5.1 Proposed Funding Initiative: Implement Roadmap to Address Public Health Effects From Energy Technologies.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	Full-scale Demo	Early Deployment	Market Facilitation	Grid Operations / Market Design	Generation	Transmission / Distribution	Demand – side Management
X					X		

Source: California Energy Commission

Purpose: This initiative will address the technical barriers and research gaps related to ambient air quality and the adoption of renewable energy, new fuels and new generation technologies in IOU territories. Air pollutant emissions from biopower and power plants will be better characterized. This will include characterizing the fraction of nitrogen dioxide (NO_2) to mono-nitrogen oxides (NO_x) in exhaust from biopower and potentially at power plants. This work will further characterize particulate matter (PM) emissions from power plants, characterize the fate of nanoparticles and develop potential test protocols for measuring PM emissions.

Identification of effective approaches for mitigation, avoidance and adaptation to impacts of renewable resources may also be addressed by this initiative, specifically how to reduce air

emissions including the potential for emission of toxic compounds from the use of biogas to generate electricity. Due to California's poor air quality, the State has strict emissions requirements that could inhibit the adoption of biogas in power generation if emissions are not adequately controlled.

Health is a new research area at the Energy Commission. Some of the areas of research that may be covered include: public health implications of inductive charging of batteries for electric vehicles (EVs) and implications of exposure to electric and magnetic fields (EMF) from smart meters and remote energy controls.

Stakeholders: Ratepayers, utilities, non-governmental organizations, ARB, U.S. EPA, California Department of Public Health, Air Quality Management Districts.

Background: Air quality model results can be very sensitive to the assumed ratio of NO_2 to NO_x in power plant exhaust. Use of the default ratio frequently results in modeled impacts exceeding National Ambient Air Quality Standards for NO_2 and increased ozone production. Measurements are needed to better characterize the actual NO_2 to NO_x in power plant exhaust.

An ongoing research project supported by the Energy Commission suggests that although natural gas-burning power plants may have extremely low PM emissions in terms of total mass, the particles are so small that the number of particles emitted may be high. Preliminary results from this research indicate that the PM emissions strongly depend on sampling conditions and are in the form of nanoparticles (particles less than 100 nanometers in diameter). Other research indicates that inhaled nanoparticles may cause health problems including lung inflammation and heart problems. At the same time, nanoparticles may rapidly evolve or coagulate forming larger particles, but their actual fate is unknown. Improved emissions measurement protocols are needed to reflect the actual fate of PM in the atmosphere. Since the research program under EPIC is expanding to include health impacts of producing and using electricity, the *2012-2014 EPIC Investment Plan* will fund the preparation of a roadmap to direct this new research area. Health impacts of PM are likely to be an area identified in the roadmap.

The Energy Commission has focused on developing new test methods, instruments, and tools capable of measuring emissions from small and large generation sources and predicting both local and regional air quality impacts. It is supporting research on the air quality issues related to biogas from anaerobic digestion of food waste, the air quality impacts of implementing the Renewables Portfolio Standard, and economically and environmentally viable strategies for conversion of bioresources to power.

The ARB sponsors research on strategies and economic considerations for climate change mitigation, implications of air quality on public health, transportation technologies and systems, and sources, controls, models, and inventories of air pollutants. Other organizations such as the U.S. EPA and the New York State Energy Research and Development Authority have conducted similar research on ozone and particulate matter health effects, but additional California utility-specific research is needed.

S5.2 Proposed Funding Initiative: Develop Environmental Tools and Information for Future Renewable Energy Conservation Plans.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	Full-scale Demo	Early Deployment	Market Facilitation	Grid Operations / Market Design	Generation	Transmission / Distribution	Demand – side Management
X					X	X	

Source: California Energy Commission

Purpose: The intent of this initiative is to develop tools, technologies, and information that will help avoid, minimize, restore, or compensate for environmental impacts of renewable energy development in IOU territories and thereby expedite its deployment. Research on fossil fuel generation could also be addressed under this initiative. This initiative will emphasize resolving scientific data gaps and developing analytical tools related to sensitive terrestrial species and habitats to reduce delay and uncertainty in the siting process for energy facilities. In addition, some environmental issues related to zero or near zero energy technologies (for example, induced seismicity associated with geological sequestration) will be potentially covered. Potential research topics include scoping-level environmental analysis of emerging renewable planning areas, tools for identifying preferred geographic areas for energy facilities (integrating environmental and other factors), assessing life-cycle impacts of and developing mitigation strategies for forest biomass energy, and synthesis reviews of impacts of renewable energy development on species and habitats and of the relative success of mitigation strategies. This work may involve developing and testing innovative species mitigation strategies, building habitat suitability models and planning/management tools, and improving impact assessment protocols and scientific baselines. Research under this initiative could also inform implementation of renewable energy plans through monitoring and adaptive management to ensure that environmental impacts were acceptable or corrected. Ratepayers benefit by achieving RPS goals with lower environmental impact, with mitigation focused on effective habitat strategies.

Stakeholders: Ratepayers, utilities, research institutions, non-governmental organizations, U.S. EPA, state and federal wildlife agencies, renewable energy developers.

Background: Utility-scale renewable energy developments that are crucial to achieving California's RPS have large land requirements and can have negative impacts on threatened species, fragile ecosystems, and ecosystem services. Concerns about potential impacts and lack of detailed distribution and habitat information for sensitive species have been identified as barriers to permitting new renewable energy developments and make it more difficult to

achieve the RPS and other goals. Even the smaller DG facilities can encounter land-use conflicts with terrestrial resources and land uses such as agriculture. Several new, or revitalized, energy technologies (for example, hydraulic fracturing, enhanced geothermal energy, geologic carbon sequestration, and compressed air energy storage) pose an unknown level of risk of inducing earthquakes that could harm people or property. Key barriers and challenges include the following:

- Lack of baseline data, tools, and methods to assess the interactions of species and habitats with energy projects creates uncertainty and delays and increases the costs of permitting. For example, bird and bat deaths and injuries from collisions (for example, with power lines, wind turbines, solar panels and mirrors) and heat from solar flux at solar power towers are major challenges for siting renewable energy projects throughout the state.
- Lack of proven mitigation measures and strategies exacerbates this problem for large-scale solar projects, wind farms, geothermal energy, transmission lines, and forest biomass harvesting.

While a significant amount of research on the state's biological resources has been conducted, very little of this work has focused on applied research to address the environmental effects of electricity generation, storage, and carbon sequestration. Examples of research to inform the permitting process for energy development in California include efforts by the U.S. Forest Service and others to address avian and bat interactions with wind turbines. Furthermore, the U.S. Forest Service is addressing the effects of collecting forest biomass on songbirds and small mammals.

Thirteen current or recent Energy Commission research projects are facilitating renewable energy siting and planning in the Desert Renewable Energy Conservation Plan (DRECP), as identified in the *2009 IEPR*. The DRECP will guide renewable energy siting and conservation in California's Mojave and Colorado Deserts, and is being developed by the Renewable Energy Action Team made up of the Energy Commission, California Department of Fish and Wildlife (DFW), the U.S. Fish and Wildlife Service, and the U.S. Bureau of Land Management (BLM). These agencies, along with universities and other environmental stakeholders such as The Nature Conservancy, have recently invested in targeted research to promote the DRECP and other energy hot spots.

Research on induced seismicity is in its infancy. The BLM recently initiated a study for hydraulic fracturing, and the Energy Commission funded a project for geologic carbon sequestration.

S5.3 Proposed Funding Initiative: Improve Science for Water Management in Power Generation: Hydropower Forecasting and Alternative Sources of Cooling Water.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	**Full-scale Demo**	**Early Deployment**	**Market Facilitation**	**Grid Operations / Market Design**	**Generation**	**Transmission / Distribution**	**Demand – side Management**
X					**X**		

Source: California Energy Commission

Purpose: This initiative will develop tools, technologies, and information that will improve water management in electricity generation as well as reduce associated impacts of this use. The following areas of research would be supported under this initiative:

1. Developing Information and Tools to Facilitate Probabilistic Hydrologic Forecasting for High Elevation Hydropower Generation. Since precipitation is so highly variable in California, the best way to improve reservoir management for hydropower generation is developing the information and tools that will allow development of accurate probabilistic hydrologic forecasts. Such forecasts quantify the estimated risk or uncertainty increasing the operator awareness of forecasting uncertainties. Adoption of hydrologic forecasting has been limited due to the substantial uncertainty in the accuracy of the forecast; relegating many reservoir management decisions to rely on fixed operational rules and historical data, an inadequate approach given that a future conditions may not be reflected in the historical record. Probabilistic forecasts remove much of this uncertainty.

Development of accurate probabilistic hydrologic forecasting depends, however, on improved data collection. For example, coverage by stream gauges and snowpack measurements at the higher elevations in the Sierra Nevada where most of the snowpack resides is sparse, yet is becoming increasingly important as the climate warms. There are new sensors and wireless capabilities that can be used to substantially develop improved hydrological forecasts, but demonstration of these tools is not sufficient. In addition, hydrologic forecasting can be improved through improved understanding of meteorological processes, such as aerosols and atmospheric rivers, affecting precipitation and resulting hydropower generation. Improved hydrologic modeling will also improve the accuracy of precipitation and runoff. Existing models are deficient for several reasons, including the fact that they usually do not adequately consider aerosols, if at all. Prior Energy Commission-supported research, however, has demonstrated that aerosols substantially affect precipitation in California.

2. **Developing modern decision support systems for high elevation hydropower units.** Although high elevation hydropower units in California usually have minimal to no runoff storage, continuing reductions in snowpack and changes in runoff timing, if not in volume; present challenges to the operation of these units. To optimize the energy, economic, water and other environmental benefits of operating these units, there is a need for decision support systems to provide recommendations based on current data and dynamic forecasts of hydrology, energy prices and loads at hydro plants and within the overall system as well as environmental protection of downstream aquatic resources. This topic is also related to the topic above and some integrated work may be attempted.

3. **Use of degraded water in cooling towers.** In California, competing demands for the state's limited freshwater supplies are forcing thermal power plant developers, which may require significant amounts of water, to consider alternative cooling water supplies. At the same time, the use of alternative or degraded water supplies for power plants in place of limited freshwater supplies is limited. Degraded water is defined as water not suitable for municipal or agricultural uses because of natural or manmade contamination. A 500 MW gas-fired combined cycle plant may use more than 3 million gallons of water per day; as much water as a community of 12,000 people would use. Other than treated municipal effluent, there are very few developed alternate sources of degraded water used for cooling. Presently, uncertainties regarding the costs, and to a lesser extent, the environmental requirements for using degraded water for wet cooling are the major barriers to regular use in power generation in California. This research topic will focus on developing the tools, technologies and information to improve the assessment of degraded water sources for use in cooling towers and identify the appropriate treatment and disposal processes and environmental concerns, especially on those constituents posing worker safety concerns.

4. **Particulate Matter Emissions from Power Plant Cooling Towers.** As water is circulated through a cooling tower for power plant cooling, very small water droplets or spray, called "drift," exit the cooling tower. This drift, which contains an appreciable concentration of dissolved minerals and additives, quickly evaporates, leaving fine particles called particulate matter that raises air quality and public health concerns. Current practice is to assume that all the dissolved solids from cooling tower drift are PM10 and/or PM2.5, two of the regulated PM emissions. However, accurate measurements of particulate matter from cooling towers are not available, especially from cooling towers using degraded water. Permitting of power plants with cooling towers usually requires the purchase of expensive PM10 or PM2.5 offsets, but again, actual emissions may be much lower than assumed. There is a need for accurate assessment of particulate emissions from cooling towers to help inform the permitting process, and since existing approaches are acknowledged to overestimate emissions, these approaches may reduce the amount of expensive offsets needed to be purchased.

Stakeholders: PG&E, SCE, state and federal agencies, power plant operators, investors, and interested stakeholders.

Background:

Hydropower

Depending on precipitation, over the last decade hydropower has contributed from 8 to 17 percent[83] of the in-state generation; about three-quarters of this generation was produced by the 150 hydroelectric plants located above 1,000 feet in elevation, mainly on the western slope of the Sierra Nevada and Cascade Mountains.[84] Reservoirs within the high elevation hydropower system have only limited (less than a year) storage capacity; many of these high elevation hydropower plants rely on snowpack for seasonal water storage. It is important to use this system's in-state generation as efficiently as possible.

Given the high interannual and annual variability in runoff, more accurate probabilistic forecasts are the best way to improve reservoir management and hydropower generation. Probabilistic or ensemble forecasting is a numerical approach that generates multiple predictions using slightly different conditions to identify the probability of different outcomes, reducing uncertainty. Adoption of such an approach has previously been limited due to the substantial uncertainty involved, relegating many reservoir management decisions to rely on historical data, an inadequate approach given that a future climate may present conditions not reflected in the historical record.

As noted above, development of accurate probabilistic hydrologic forecasting depends on improved data collection. A major concern is to accurately predict the timing and rate of snow melt from higher elevations. Snow accumulation in these areas not only depends on the distribution of precipitation, but landscape factors as well. Therefore, snow cover and thickness may vary greatly even within a small area. Coverage by stream gauges and snowpack measurements at the higher elevations in the Sierra Nevada where most of the snowpack resides is sparse, making stream flow forecasts only 40 percent accurate. More accurate predictions of snow pack accumulation, water content, and melting rates will allow hydropower reservoir operators to better gauge generation opportunities and meeting downstream requirements against the need to spill water from the reservoir.

The usefulness of probabilistic forecasting was demonstrated by the *Integrated Forecast and Reservoir Management (INFORM) for Northern California: System Development and Initial*

83 California Energy Commission Energy Almanac web site: http://energyalmanac.ca.gov/electricity/electricity_generation.html.Accessed February 20, 2014.

84 Madani, K., and J. R. Lund (2009), *Modeling California's high-elevation hydropower systems in energy units*, Water Resour. Res., 45, W09413, doi:10.1029/2008WR007206.

Demonstration Project.[85] The probabilistic forecasting system in INFORM was coupled with a decision support system to help reservoir operators use the short and long-term runoff forecasts while balancing between often competing demands, such as hydropower generation, water supply, and flood control.

Although for the most part the high-elevation hydropower reservoirs are not multiple use, such as the lower elevation ones are, there is still a need for decision support systems to help reservoir operators integrate runoff forecasts, optimize hydropower operations and meet downstream environmental requirements. With anticipated changes in runoff patterns, an evolving electricity market, and continuing environmental requirements, there is a need for developing decision support models for high-elevation hydropower plants.

Degraded Water Sources for Cooling Tower Makeup

Although all electricity generating technologies use water throughout some portion of their life cycles, the most significant water demand is from those technologies, such as natural gas, biomass, geothermal and solar thermal power plants that use water for steam condensation, commonly referred to as power plant cooling. While water demand for electricity generation is not significant on a statewide basis, water demand for cooling may be a major competitor with urban and agricultural uses for limited freshwater supplies at the local level. One approach to reducing this freshwater demand is to use sources of cooling water that are unsuitable for potable use because of natural or manmade contamination; referred to here as degraded water.

Other than treated municipal effluent, however, there are few developed alternate sources of degraded water used for power plant cooling. Presently, uncertainties regarding the costs, and to a lesser extent, the environmental requirements for using degraded water for wet cooling are the major barriers to its regular use in power generation in California. One PIER funded study sought to provide the basic tools and guidelines necessary for source water evaluations for power plant projects in California. This report, *Use of Degraded Water Sources as Cooling Water in Power Plants* [86] identify potential types of degraded water available in California, the pollutants specific to these types of water and the water quality requirements necessary for cooling water. Reclaimed water used is usually high in dissolved salts and other mineral constituents as well as organic compounds such as ammonia and when used in power plants with cooling towers water is recycled a number of times, further concentrating these constituents.

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85 HRC-GWRI. 2007. *Integrated Forecast and Reservoir Management (INFORM) for Northern California: System Development and Initial Demonstration*. California Energy Commission, PIER Energy Related Environmental Research. CEC-500-2006-109. http://www.energy.ca.gov/pier/project_reports/CEC-500-2006-109.html.

86 *Use of Degraded Water Sources as Cooling Water in Power Plants,* EPRI, Palo Alto, CA, and California Energy Commission, Sacramento, CA: 2003. 1005359. http://www.energy.ca.gov/reports/2004-02-23_500-03-110.PDF

To facilitate use of degraded water sources for power plant cooling water makeup, PIER funded development of specific guidelines, *Cooling Tower Water Quality Parameters for Degraded Water*[87] and a model in the appendix to assist in calculating treatment requirements. There is a need for additional research on characterization, treatment and disposal on these sources to facilitate greater use of degraded water for cooling tower make up. There is also a need to address potential health related concerns from heavy metals, volatile organic compounds and biological contaminates. There is also the potential for health concerns from contaminates of concern in treated wastewater effluent used in cooling towers.

Particulate Matter (PM) Emissions from Cooling Tower (Drift)

Drift is very small water droplets or spray that exits the cooling tower. This spray drift, like the circulating water, contains an appreciable concentration of dissolved minerals and additives. These water droplets quickly evaporate, leaving fine particulate matter less than 10.0 micrometers, PM10, while others are less than 2.5 micrometers, PM2.5. Some of these droplets may also fall to the ground and may not result in PM emissions.

Significant portions of Southern California have been classified by the U.S. EPA as non-attainment areas for PM. Furthermore, many air quality districts in California regulate particulate emissions from cooling towers and require the purchase of air quality offsets to mitigate the emissions. These offsets can be a significant burden for power plant developers and may discourage the use of degraded water sources for cooling since these sources often have higher salt and mineral content.

S5.4 Proposed Funding Initiative: Provide Tools and Information for Regional Climate Change Adaptation Measures for the Electricity Sector.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	Full-scale Demo	Early Deployment	Market Facilitation	Grid Operations / Market Design	Generation	Transmission / Distribution	Demand – side Management
X					X	X	

Source: California Energy Commission

87 DiFilippo, Michael. 2006. Cooling Tower Water Quality Parameters for Degraded Water. California Energy Commission, PIER Energy-Related Environmental Research. CEC-500-2005-170. http://www.energy.ca.gov/2005publications/CEC-500-2005-170/CEC-500-2005-170.PDF

Purpose: This initiative will produce practical information on GHG emissions, mitigation, impacts, and adaptation to inform policy deliberations at the CPUC, Energy Commission, and other jurisdictions. The main focus will be on mitigation, impacts, and adaptation options within IOU service territories for the next few decades since that is the time frame used to develop energy policy. The following are potential areas of research under this initiative:

Probabilistic climate scenarios for the electricity sector: Under the first EPIC investment period researchers will develop improved downscaling techniques and develop climate and sea-level rise scenarios designed for the electricity sector. Under the *2015-2017 EPIC Investment Plan*, researchers will use these scenarios to develop probabilistic climate projections using numerical experimentation, historic information, and expert analysis.

Potential impacts of climate change to renewable sources of energy: Climate change will not only increase ambient temperatures, but may change wind regimes, cloudiness and therefore solar radiation reaching ground level, and biomass availability. Prior exploratory studies have been unclear about the potential impacts of climate change on renewable sources of energy in California. This work will explore this issue further and develop actionable estimates on how climate change would affect renewable sources of energy and therefore the cost and availability to meet utility and customers' requirements.

Long-term evolution of the electricity system taking climate change into account: Ongoing research developing potential energy scenarios will continue but, this time, with more in-depth consideration on reducing the climate vulnerability of the electricity system and the examination of unexplored issues such as large-scale deployment of microgrids, dynamic rating of T&D lines, and consideration of extreme weather-related events.

Barriers to adaptation to the electricity system: This area of work will identify potential institutional, regulatory, legal, economic, and other barriers that may impede a visionary design and implementation of technically and environmentally sound adaptation options for the electricity system within the IOU service territories.

Demonstration phase of seasonal and decadal probabilistic forecasts for the electricity system: The first EPIC investment period will study the utility of seasonal and decadal probabilistic forecasts for the electricity system. This follow-up project will advance this work with a demonstration phase involving actual electricity management activities. These probabilistic forecasts will assist securing enough generating capacity for the summer when extreme heat events are forecasted and with the installation of additional capacity in the long-term (10 to 20 years) to adequately address increased demand with a changing climate.

Measuring adaptation progress and effectiveness: This study involves the development of practical metrics to measure adaptation progress and effectiveness.

Stakeholders: Ratepayers, research institutions, air quality management districts, ARB, CPUC, and IOUs.

Background: California leads the nation on climate change research. While there are national research efforts by different federal agencies, including the U.S. DOE and the National Academy of Sciences, they will not specifically address California and the unique challenges that climate change will present. Nongovernmental organizations have also expressed strong support for the spirit of this initiative in comments submitted to the CPUC by The Nature Conservancy, the Natural Resources Defense Council, the Union of Concerned Scientists, the Sierra Club, the Environmental Defense Fund, and others during the deliberations that culminated with the creation of EPIC.

S5.5 Proposed Funding Initiative: Provide Small Grants to Solicit Innovative Energy-Related Environmental Research Concepts.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	Full-scale Demo	Early Deployment	Market Facilitation	Grid Operations / Market Design	Generation	Transmission / Distribution	Demand – side Management
X					X	X	

Source: California Energy Commission

Purpose: This initiative will use small grants to fund a broad range of ideas and technologies that involve innovative ways to address environmental energy-related issues. The small grants program will support the early development of promising new electricity-related environmental projects and fill unanticipated knowledge gaps, a niche not covered thoroughly by EPIC solicitations for other specific areas of research. The small grants will target innovative projects with the potential to make a significant difference in the energy-environment nexus. Research projects must address a California energy problem and provide a potential benefit to California electric ratepayers. Projects must also advance science or technology not adequately addressed by competitive and regulated markets, and be in the proof-of-concept phase (if developing a technology).

Stakeholders: Ratepayers, small businesses, non-profits, individuals, and academic institutions.

Background: California's rapidly evolving energy system has broad implications for the environment. The Energy Commission explores how new energy applications and products can solve environmental problems by assessing the impacts on air quality and public health, aquatic resources, terrestrial resources, and climate change. This research fills the critical need of informing decision makers and stakeholders on the environmental implications of developing various technologies.

Smart Grid Enabling Clean Energy

S6 Strategic Objective: Advance the Use of Smart Inverters as a Tool to Manage Areas with High Penetrations of PV.

Table 9: Ratepayer Benefits Summary for Strategic Objective 6

	Promote Greater Reliability	Lower Costs	Increased Safety	Societal Benefits	GHG emissions mitigation and adaptation	Lower emission vehicles/ transportation	Economic Development	Public Utilities Code Section 740.1	Public Utilities Code Section 8360
S6.1 Develop Smart Inverter Capabilities to Improve Grid Operations.	X	X						X	X

Source: California Energy Commission

Barriers and Challenges: Smart inverters have the potential to support the grid by providing reactive power, voltage regulation, and frequency regulation. However, grid support services from inverters have not been clearly defined and are not allowed under current regulations. Applied research and pilot demonstrations are needed to determine the most effective ways of using advanced inverter capabilities to optimize system performance.

Under the joint leadership of the CPUC and the Energy Commission, the Smart Inverter Working Group (SIWG) consisting of utilities, manufacturers, and other stakeholders, is working on recommendations for smart inverter settings and functions that require further research and demonstration to verify any grid benefits.

Using smart inverters to provide grid support services can improve grid reliability and allow more renewable generation on the grid. If additional smart inverter functions successfully demonstrate grid benefits, these functions can be standardized to reduce the cost of smart inverters and reduce the amount of equipment on the distribution system.

Investments in the *2012-2014 EPIC Investment Plan* addressing barriers and challenges: The first Investment Plan contained any funding initiatives that help advance smart inverter research. Funding Initiative S6.2 from the first Investment Plan included enhancements to existing distribution management systems (DMS) to monitor and control smart inverter activities. This second Investment Plan focuses on specific smart inverter functions.

S6.1 Proposed Funding Initiative: Develop Smart Inverter Capabilities to Improve Grid Operations.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	Full-scale Demo	Early Deployment	Market Facilitation	Grid Operations /Market Design	Generation	Transmission /Distribution	Demand – side Management
X						X	

Source: California Energy Commission

Purpose: This initiative will explore the capabilities for smart inverters to support the grid and microgrid operators. The SIWG suggested additional smart inverter functions that could be beneficial to the grid such as emergency alarms, supporting direct command to disconnect or reconnect, scheduling actual real power output at the point of connection, following schedules for energy, and ancillary service outputs. This initiative includes applied research on smart inverter functions that are not ready for utility demonstration. This research will go beyond the proposed functionality that addresses the problems caused by solar systems by researching additional functions to increase grid reliability and provide greater grid operator control of inverters. Proposed projects under this initiative may develop and/or demonstrate these functions that build on research results from projects funded under the *2012-2014 EPIC Investment Plan*.

Stakeholders: Utilities, smart inverter manufacturers, and distributed energy resources generators.

Background: The CPUC's Rule 21 Interconnection proceeding R.11-09-011 directed the exploration of smart inverters as a way to address some interconnection and operational issues facing California as it moves to integrate more renewable generation. In response to that direction, the SIWG was established to recommend various inverter functionalities for near-term development and deployment. The SIWG is working on recommendations for inverter functions that align with current national standards activities.

Advanced smart inverters offer solutions or mitigation to some of the challenges of high penetration levels of time-varying resources. While it is possible to implement features such as voltage ride-through external to the inverter, smart inverters providing active control could reduce the number of voltage issues at the grid level. An adaptive "plug-and-play" voltage controller that does not require full system data or extensive tuning of control parameters could be an inexpensive means of managing voltage in systems with significant numbers of distributed energy resources (DERs).

In January 2014, the SIWG recommended initial inverter functions to the CPUC regarding autonomous DER functions for inverters. The SIWG recommended seven autonomous functions become mandatory in Rule 21 for DER systems:

1. Support anti-islanding to trip off under extended anomalous conditions.
2. Provide ride-through of low/high voltage excursions beyond normal limits.
3. Provide ride-through of low/high frequency excursions beyond normal limits.
4. Provide volt/VAR control through dynamic reactive power injection through autonomous responses to local voltage measurements.
5. Define fault and emergency ramp rates as well as high and low limits.
6. Provide reactive power by a fixed power factor.
7. Reconnect by "soft-start" methods.

The functions listed above are also proposed for the Institute of Electrical and Electronics Engineers (IEEE) Standard 1547a. The SIWG is currently developing recommendations for smart inverter communications. The SIWG also recommended research in developing additional functions including some that would require two-way communication capabilities that have not been widely implemented.

S7 Strategic Objective: Develop Advanced Distribution Modeling Tools for the Future Smart Grid.

Table 10: Ratepayer Benefits Summary for Strategic Objective 7

	Promote Greater Reliability	Lower Costs	Increased Safety	Societal Benefits	GHG emissions mitigation and adaptation	Lower emission vehicles/ transportation	Economic Development	Public Utilities Code Section 740.1	Public Utilities Code Section 8360
S7.1 Develop Open-Source Electricity System Modeling Tools to Visualize California's Modern Distribution Systems.	X	X						X	X

Source: California Energy Commission

Barriers and Challenges: High penetrations of renewable generation create the need for new or expanded types of power system simulations. Improved transient and dynamic analysis tools using validated models for different types of renewable generation are needed to simulate their impacts on the distribution system. Research on what types of simulations are appropriate for these conditions will encourage the commercial implementation of those capabilities into current modeling tools. This research will be useful to ratepayers who want to interconnect renewable generation or microgrids to the distribution system.

Since voltage management is one of the major concerns with high penetrations of renewable generation on the distribution system, many utilities are evaluating more advanced methods. These advanced voltage management methods need to be incorporated into power system simulations.

Most modeling tools do not incorporate distributed energy resources (DERs) into the analysis, and none can simulate using DERs for reactive power support. DERs can be used to help manage grid voltage issues; however it is unknown how DERs will behave in conjunction with other voltage management strategies already used by utilities.

Data analytics is also important in determining the appropriate input data for modeling tools. Specific applications and tools are needed to extract useful information, as well as finding valuable uses for this data that will ultimately benefit electric ratepayers.

This objective will improve grid reliability and promote increased renewable generation on the grid. Coordinated control and effective data monitoring are likely to offer the most effective loss reduction and energy conservation. Better modeling tools will lead to cost-effective engineering solutions for modern grid systems and new control strategies for utility operators. These research efforts can inform future TD&D projects under the IOU's draft EPIC initiatives such as SCE's "Dynamic Distribution Circuit Configuration for Storage Siting" and PG&E's "Evaluating Storage on the Distribution Grid."

Investments in the *2012-2014 EPIC Investment Plan* addressing barriers and challenges: The *2012-2014 EPIC Investment Plan* did not contain any funding initiatives addressing the barriers and challenges described above. During the development of the *2012-2014 EPIC Investment Plan*, the Energy Commission was already funding distribution modeling projects under the PIER program, which included a literature search, interviews with utilities, and research gap analysis. This *2015-2017 EPIC Investment Plan* is addressing research gaps in distribution modeling that were identified in those PIER projects.

S7.1 Proposed Funding Initiative: Develop Open-Source Electricity System Modeling Tools to Visualize California's Modern Distribution Systems.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	Full-scale Demo	Early Deployment	Market Facilitation	Grid Operations/Market Design	Generation	Transmission/ Distribution	Demand – side Management
X						X	

Source: California Energy Commission

Purpose: This initiative will develop open-source modeling tools that incorporate all smart grid elements and simulate the operation of California's future "smart" distribution system.

This initiative will develop advanced modeling tools and power flow analysis techniques to study the operation of unbalanced, three-phase distribution systems. Features of these tools may include expanded model sizes, multi-control loops, time-series analysis, voltage-sensitive load models, and integration of additional datasets. These tools will incorporate non-proprietary algorithms.

Stakeholders: Utility distribution engineers, planners, and operators; researchers and consultants who perform power systems modeling, distribution system analysis software vendors, and ratepayers planning microgrids.

Background: Modeling software for power systems is undergoing significant development to address an increasingly complex electric grid. The rapid increase of penetration of solar PV systems is creating an equally rapid evolution of simulation models and tools. Some open-source and commercial tools are adding capabilities to handle DERs, but they each have different approaches and limitations. Representative software packages include MatLAB, OpenDSS, and GridLAB-D.

S8 Strategic Objective: Advance Customer Systems to Coordinate with Utility Communication Systems.

Table 11: Ratepayer Benefits Summary for Strategic Objective 8

	Promote Greater Reliability	Lower Costs	Increased Safety	Societal Benefits	GHG emissions mitigation and adaptation	Lower emission vehicles/ transportation	Economic Development	Public Utilities Code Section 740.1	Public Utilities Code Section 8360
S8.1 Develop Customer Systems to Manage Demand Response, Renewables, and Electric Vehicles, and Integrate these Tools with the Grid.	X	X		X			X	X	X

Source: California Energy Commission

Barriers and Challenges: A "smart" distribution system requires real-time information about customer systems, consisting of both generation and loads, to coordinate actions among the various system components and their operators. Appropriate sensors, communication systems, and controllable devices are needed to achieve a well-coordinated distribution system. Additional smart inverter functions with communications and controls can provide grid-level benefits.

Additional smart inverter functions suggested by the jointly led CPUC/Energy Commission Smart Inverter Working Group (SIWG) require inverter communications with utility systems; however, these additional functions require further research and demonstration to verify any grid benefits.

On the customer side, customer premise networks (CPNs) lack a central network controller and do not communicate with their respective utility systems.

Investments in the *2012-2014 EPIC Investment Plan* addressing barriers and challenges: In the *2012-2014 EPIC Investment Plan*, Funding Initiative 6.5: Develop Smart Grid Communication Systems that Interface with Customer Premise Networks and Distributed Energy Resources included applied research for communication interfaces between smart inverters and utility distribution management systems (DMS). However, this initiative was not implemented because the SIWG is still developing recommendations for inverter communications (IEEE Standard 1547.8), which may also apply to other distribution equipment. Therefore, this *2015-*

2017 EPIC Investment Plan will address communication interfaces for smart inverters instead of the *2012-2014 EPIC Investment Plan*.

S8.1 Proposed Funding Initiative: Develop Customer Systems to Manage Demand Response, Renewables, and Electric Vehicles, and Integrate these Tools with the Grid.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	**Full-scale Demo**	**Early Deployment**	**Market Facilitation**	**Grid Operations /Market Design**	**Generation**	**Transmission /Distribution**	**Demand – side Management**
X							**X**

Source: California Energy Commission

Purpose: This initiative will develop customer energy management systems that coordinate various energy devices and equipment capable of DR, renewable energy generation, and EV charging. This initiative will allow customer energy management systems to manage customer resources behind the meter and provide a single point of communication and control with the utility. This approach may avoid large data transfer and minimize grid impacts to provide cost savings.

Stakeholders: Utilities, CPN software vendors.

Background: Network-enabled devices such as programmable thermostats, plug modules, water sensors, lighting controls, and security devices are available for customer use. However, these types of devices available in the market use different communication protocols such as ZigBee, ZWave, Wi-Fi, and Bluetooth. Network hubs communicate over multiple protocols so that all devices in a single location can be controlled by an energy management system. A pilot of this approach is the Honda Smart Home at UC Davis, which provides cost savings to its residents and minimizes the impacts to grid. Information about the performance of these devices could be useful for demand-side management and improve coordination with utility operations.

S9 Strategic Objective: Advance Electric Vehicle Infrastructure to Provide Electricity System Benefits.

Table 12: Ratepayer Benefits Summary for Strategic Objective 9

	Promote Greater Reliability	Lower Costs	Increased Safety	Societal Benefits	GHG emissions mitigation and adaptation	Lower emission vehicles/ transportation	Economic Development	Public Utilities Code Section 740.1	Public Utilities Code Section 8360
S9.1 Advance Electric Vehicle Charging to Increase Renewable Energy Levels and Improve Grid Reliability.	X	X		X	X	X			
S9.2 Advance Vehicle-Grid Integration Technologies and Methods for Broader Use and Benefit for Residential, Private, and Public Users.	X	X		X	X	X			
S9.3 Advance Technologies and Methods to Enable Safe, Efficient, Smart Recycling of Electric Vehicle Batteries.		X	X	X					

Source: California Energy Commission

Barriers and Challenges: PEVs and other electric transportation technologies offer a promising and potentially revolutionary alternative for meeting the state's transportation needs. Furthermore, PEVs can provide a number of benefits to the electricity grid when integrated with smart charging technologies and other strategies including those identified in the *California Independent Systems Operator Vehicle-Grid Integration Roadmap*.[88] However, additional research is needed to determine how PEVs can effectively be integrated into the electricity grid, how to minimize carbon footprint, and which technologies can continue to advance the capabilities of PEVs. Barriers such as determining how vehicle grid integration can be implemented into residential and fleet applications, the role PEVs will play in grid stabilization, and advancing technologies for the efficient and safe recycling of PEV batteries should be addressed and examined further. For example, continued demonstration of vehicle grid integration needs to be pursued to ensure wider adoption of this technology that expands beyond military bases and government fleets. Although lithium is 100 percent recyclable, producing battery-grade lithium from current recycling processes is about five times more costly than production from new

88 California Independent System Operator, December 2013, http://www.caiso.com/Documents/Vehicle-GridIntegrationRoadmap.pdf

materials resulting in un-recycled yet useable materials ending up in landfills. Research investments that address these issues will continue to be explored to determine the benefits of PEV adoption in California. The R&D initiatives in this objective will advance technologies and strategies that provide optimal benefits that will help PEVs successfully integrate into California's grid system.

In forming initiatives to meet Strategic Objective S9, the Energy Commission met with stakeholders through advisory board meetings and technical working groups on smart grid and EV infrastructure research needs. Energy Commission staff also incorporated comments from the workshops held on the *2015-2017 EPIC Investment Plan*. Through this process, the Energy Commission developed smart charging initiatives that are not being adequately addressed in the competitive or regulated marketplace.

Investments in the *2012-2014 EPIC Investment Plan* addressing barriers and challenges: For the *2012-2014 EPIC Investment Plan*, funding initiatives included vehicle to grid communication interfaces, distributed storage through second-use EV battery storage applications, and battery recycling. The strategic objective in the *2015-2017 EPIC Investment Plan* will leverage technical advancements achieved as a result of projects awarded under the *2012-2014 EPIC Investment Plan*. Battery recycling was not pursued for the *2012-2014 EPIC Investment Plan* because of efforts already under way prior to implementation; however project results from current battery recycling projects will support efforts under this *2015-2017 EPIC Investment Plan*. Research on battery recycling, PEV charging to support gird stability, and vehicle to grid integration will address technological barriers and challenges that were not addressed in the *2012-2014 EPIC Investment Plan*, but will also leverage the results from projects funded in the *2012-2014 EPIC Investment Plan*.

S9.1 Proposed Funding Initiative: Advance Electric Vehicle Charging to Increase Renewable Energy Levels and Improve Grid Reliability.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	Full-scale Demo	Early Deployment	Market Facilitation	Grid Operations / Market Design	Generation	Transmission / Distribution	Demand – side Management
X				X	X	X	X

Source: California Energy Commission

Purpose: This initiative will develop advanced methods of smart and efficient charging for PEVs that help address intermittency issues associated with renewable generation allowing for a higher mix of renewable resources such as wind and solar into the grid. This initiative includes research into the development of streetlight-integrated PEV charge ports, opportunities to use the distributed battery capacity of an EV fleet as grid storage, and creating opportunities for rapid response and operational flexibility to provide regulation and load-following capabilities.

Stakeholders: Ratepayers, utilities, EV owners, and third-party aggregators.

Background: As the state electrifies the transportation sector to reduce air pollution, the Energy Commission and others need to ensure that EV charging infrastructure is designed to capture renewable benefits, for example by encouraging charging during times of high wind and low load.[89] With the emerging and increasing volume of electric fleets, there is a potential to make a substantial contribution toward meeting the new balancing requirements associated with the grid integration of growing wind and solar technology deployment. To what degree this potential can be realized in the future will depend on the economics of the implementation and a viable and compelling business model, for either the individual EV owner or a third-party service provider.

Today, the electricity grid relies on flexible natural gas plants to provide the services needed to operate the grid during intermittent situations. A range of alternative and complementary options such as energy storage and DR will help mitigate the intermittency. Moreover, to enable further deployment of a mix of renewable generation, methods to address intermittency need to be explored and demonstrated.

89 *2012 IEPR Update*: http://www.energy.ca.gov/2012publications/CEC-100-2012-001/CEC-100-2012-001-LCF.pdf

S9.2 Proposed Funding Initiative: Advance Vehicle-Grid Integration Technologies and Methods for Broader Use and Benefit for Residential, Private, and Public Users.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	Full-scale Demo	Early Deployment	Market Facilitation	Grid Operations /Market Design	Generation	Transmission /Distribution	Demand – side Management
X				X		X	X

Source: California Energy Commission

Purpose: This initiative builds on previous vehicle-grid integration (VGI) projects that developed the communication and protocols to enable bidirectional power flow to perform vehicle-to-grid and vehicle-to-building strategies. This research will advance the development of VGI technologies and methods by expanding beyond military bases and government fleets into home and private/public fleet applications, including the development of streetlight-integrated charge ports and development of VGI capabilities for them. The research will also leverage findings from ongoing U.S. Department of Defense (U.S. DOD) military installation VGI projects, including continuing to determine cost benefits of VGI through DR or load shifting, and to determine impacts VGI may have on PEV batteries. Additionally, this initiative investigates more complex but wider-ranging use cases beyond fleets. Geographically-distributed PEVs can be aggregated by utilities or third parties into resources large enough to participate in utility or independent system operator markets. The number of fleet PEVs is small in comparison to non-fleet PEVs; thus research into capabilities to aggregate non-fleet PEVs and allow them to facilitate VGI will be valuable for the future.

Examples of proposed research topics include:

- Understanding vehicle use profiles, EV cost benefits, battery warranty, and battery life challenges with VGI under home and private/public fleet applications.
- Assessing grid impacts for different VGI applications and technologies.
- Developing VGI business models for residential and private/public fleet applications.
- Exploring and developing capabilities for PEVs to be aggregated by utilities or third parties to provide VGI services.
- Identifying research gaps for further study and in support of scale-up efforts.

Stakeholders: Ratepayers who own EVs, utilities, and third-party aggregators.

Background: The interest in validating the benefits of VGI to the electricity grid is expanding rapidly. As a leader in promoting sustainable and clean energy, California has supported policies to mitigate climate change. One such policy includes an executive order that sets a target of 1.5 million zero-emission vehicles (ZEVs) by 2025, and a large portion of these vehicles will be PEVs.[90] Managing the aggregated load to the power grid for PEVs requires innovative methods to support the growth of these vehicles in California while exploring co-benefits, such as grid stabilization. VGI technologies not only provide the capability for PEVs to provide ancillary services, but have the opportunity to improve the health of the power grid by smoothing out variations in power generation. Furthermore, the economic value of VGI may help offset the initially higher costs of electric-drive vehicles, thus having the potential to accelerate their market penetration.

The U.S. DOD has a project to convert all nontactical vehicles at the Los Angeles Air Force Base to PEVs. These light- and medium-duty PEVs will demonstrate vehicle-to-grid services by actively participating in the California ISO ancillary services market. The project is ongoing, and research findings will guide future R&D.

To provide guidance for VGI, the California ISO took the lead in drafting a VGI Roadmap in coordination with the Governor's Office, the Energy Commission, the CPUC and the ARB. This effort included a comprehensive stakeholder review process to ensure the roadmap captured the ideal course of actions. The resulting VGI Roadmap maps a way to develop solutions that enable EVs to provide grid services while still meeting customers' driving needs.

S9.3 Proposed Funding Initiative: Advance Technologies and Methods to Enable Safe, Efficient, and Smart Recycling of Electric Vehicle Batteries.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	Full-scale Demo	Early Deployment	Market Facilitation	Grid Operations /Market Design	Generation	Transmission /Distribution	Demand – side Management
X				X			X

Source: California Energy Commission

Purpose: This initiative will further develop existing battery recycling strategies and pursue projects that can fill research gaps, and advance existing methods for battery production and recycling. This initiative includes further investigation on battery disposal impacts and

90 California Executive Order B-16-2012.

advanced tools and methods necessary for large-scale battery pack recycling. Additional research on recycling efficiency will be explored. As the number of EVs in California grows, it is essential that efficient, safe, environmentally sound, and cost effective recycling systems are developed for recycling format lithium-ion batteries.

Stakeholders: Vehicle original equipment manufacturers (OEMs), existing and start-up companies, and investors.

Background: Recycling can provide financial value by contributing to overall affordability and sustainability of PEVs, providing material resources, and reducing the costs and environmental concerns of battery component disposal. California must be prepared for an influx of electric vehicle batteries with degraded performance as early adopter vehicle leases come to a close. Battery production and disposal could have land-use impacts that negate the many benefits of PEV use, specifically if batteries are sent to landfills and not recycled. Research is needed to address these issues, to determine the economic and environmental impacts of recycling, and to explore new and advanced recycling methods.

In 2012, the Energy Commission awarded $1 million for two PIER funded projects through a competitive solicitation to develop of technologies, tools, methods, and scientific knowledge needed to enable large-scale battery recycling. The first project will develop an advanced recycling method to reclaim high-value materials for developing new large-format lithium ion batteries. The second project focuses on the development of battery recycling scenarios for California.

While battery recycling for PEVs was included in initiative S9.4 in the *2012-2014 EPIC Investment Plan*, funding was not allocated to this initiative pending results of the ongoing projects mentioned above. Research results from these projects will inform future funding opportunities under the EPIC Program to ensure that future projects will build on existing research, or identify the remaining gaps and barriers to advance recycling strategies.

Cross-Cutting

S10 Strategic Objective: Advance the Early Development of Breakthrough Energy Concepts.

Table 13: Ratepayer Benefits Summary for Strategic Objective 10

	Promote Greater Reliability	Lower Costs	Increased Safety	Societal Benefits	GHG emissions mitigation and adaptation	Lower emission vehicles/transportation	Economic Development	Public Utilities Code Section 740.1	Public Utilities Code Section 8360
S10.1 Provide Seed-Stage Funding for Disruptive Energy Technologies.	X	X		X	X	X	X	X	
S10.2 Conduct Incentivized Grant Competitions to Foster Breakthrough Ideas for Clean Energy Solutions.	X	X		X	X		X	X	

Source: California Energy Commission

Barriers and Challenges: Achieving the state's ambitious policy goals for the electricity sector in a cost-beneficial manner will likely require new breakthroughs in energy technologies. "It will be important that research on advanced technologies pursue paths that target both breakthrough as well as incremental technologies and the performance gains."[91] However, it's often difficult to predict what the next breakthrough ideas will be, when they will come, and where they will come from. These breakthrough ideas can come from individual innovators, small research teams, and small companies working on solutions to industry-specific needs or they can come from a large group of innovators collaborating across disciplines and geographic scales to address major challenges in the energy sector. However, funding opportunities to design, develop, and prove potentially breakthrough concepts are limited.

Investments in the *2012-2014 EPIC Investment Plan* addressing barriers and challenges: The Energy Commission's *2012-2014 EPIC Investment Plan* did not include seed funding for energy technologies.

91 *California Energy Efficiency Strategic Plan*, http://www.cpuc.ca.gov/NR/rdonlyres/A54B59C2-D571-440D-9477-3363726F573A/0/CAEnergyEfficiencyStrategicPlan_Jan2011.pdf.

S10.1 Proposed Funding Initiative: Provide Seed-Stage Funding for Disruptive Energy Technologies.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	Full-scale Demo	Early Deployment	Market Facilitation	Grid Operations /Market Design	Generation	Transmission /Distribution	Demand – side Management
X				X	X	X	X

Source: California Energy Commission

Purpose: This initiative will provide seed-level funding to businesses, non-profit organizations, individuals, national laboratories, academic institutions, and other qualifying entities for research that establishes the feasibility of innovative new energy concepts that benefit electricity ratepayers. As opposed to the other initiatives in this *2015-2017 EPIC Investment Plan* that focus on the more mature stages of technology development, this initiative will address an important gap in the early technology development phase where small amounts of funding can have a significant effect.

Stakeholders: Electricity ratepayers, early stage energy companies, local economies, energy-related academics, private investment groups, and energy industry groups.

Background: Prior to EPIC, the Energy Commission funded the Energy Innovation Small Grant (EISG) Program. The EISG Program provided up to $95,000 for research that established the feasibility of innovative energy concepts that provide potential benefits to electric ratepayers. At the federal level, the U.S. DOE's Small Business Innovation Research provides small businesses with awards up to $225,000 to prove the scientific or technical feasibility of the new energy approaches or concepts. In addition, ARPA-E through its OPEN IDEAS solicitation will provide up to $500,000 in funding for out-of-the-box ideas in energy technology.

S10.2 Proposed Funding Initiative: Conduct Incentivized Grant Competitions to Foster Breakthrough Ideas for Clean Energy Solutions.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	Full-scale Demo	Early Deployment	Market Facilitation	Grid Operations /Market Design	Generation	Transmission /Distribution	Demand – side Management
X					X	X	X

Source: California Energy Commission

Purpose: This initiative will conduct incentivized grant competitions that will allow a diverse set of innovators to collaborate and compete in the design of affordable, replicable, and marketable clean energy solutions for IOU ratepayers. As part of this initiative, contractors would be selected to run the competition including:

- Organizing the overall competition.
- Working with industry and other relevant stakeholders to define the design parameters and technical and economic performance targets for the competition. Defining the technical and cost requirements that designs must achieve.
- Providing open-source software tools that competitors can use to develop and test their designs.
- Identifying criteria and judges for selecting winners.

Topics that would be considered for incentivized grant competitions include:

- ZNE Buildings.
- Home Fuel-cells.
- Portable waste-to-energy technologies.
- Consumer electrics.

Stakeholders: Home builders, architects, licensed contractors in construction-related fields, vendors and manufacturers of clean energy technologies, open-platform architectural design software suppliers, clean energy startups and entrepreneurs, competition organizers, and conference/event facilitators.

Background: Tools such as incentivized grant competitions and crowd sourcing can offer a number of benefits to conventional R&D by encouraging greater competition as well as collaboration and integration of ideas to solve complex challenges, especially in markets that are stuck or haven't changed much. Organizations such as XPRIZE create and manage incentivized prize competitions to stimulate investment and ideas in R&D for grand challenges, including those in the energy sector. "The most important benefit of offering XPRIZES and similar awards is that they allow for outside innovators to provide solutions to traditionally industry-specific problems."[92] In addition to XPRIZE, the Defense Advanced Research Projects Agency (DARPA) has used competitions to foster innovative new ideas to technical challenges. In 2013, DARPA ran a prize competition to design a Fast-Adaptable Next-Generation Ground Vehicle (FANG). The purpose of the competition was to bring crowd sourcing to the problem of creating

92 DC Edition, *5 Things You Should Know about XPRIZE and Incentivized Prize Competitions,* http://tech.co/xprize-2014-02.

armored vehicles, with the hope of reducing design costs by a factor of five. As part of the competition, DARPA released open-source software that allowed 200 teams made up of 1,000 participants to design and run virtual tests on an amphibious tank, with the winning team receiving a $1 million award.

S11 Strategic Objective: Provide Federal Cost Share for Applied Research Awards.

Table 14: Ratepayer Benefits Summary for Strategic Objective 11

	Promote Greater Reliability	Lower Costs	Increased Safety	Societal Benefits	GHG emissions mitigation and adaptation	Lower emission vehicles/transportation	Economic Development	Public Utilities Code Section 740.1	Public Utilities Code Section 8360
S11.1 Provide Federal Cost Share for Applied Research Awards.		X		X			X		

Source: California Energy Commission

Barriers and Challenges: Historically, California entities (for example, entrepreneurs, small businesses, and research institutions) have not fared as well as expected when competing with other states for federal funding on clean energy initiatives. When these entities have been able to request cost share and support from the Energy Commission, there is usually a higher probability of winning a competitive federal award. When Energy Commission staff members have talked with federal agency representatives about the value of these Energy Commission co-funding and support letters of intent that are submitted with a proposal, these federal representatives indicated that this element is always perceived as a positive action and, in many cases, increases the proposer's competitive score. The result of this is additional federal funding coming into California, resulting in market growth, expansion, and jobs for these California entities. Normally, to ensure the commercial entity continues to have a commitment to the project, the Energy Commission contribution to the match is limited to no more than half of the federal-required match. As a result, the state ends up receiving a high leverage of these funds that is routinely 5 to 15 times the Energy Commission commitment (when you account for the industrial match and federal funding).

Investments in the *2012-2014 EPIC Investment Plan* addressing barriers and challenges: The *2012-2014 EPIC Investment Plan* included cost share for federal funding opportunities related to the applied research and development initiatives in the Energy Commission's *2012-2014 EPIC Investment Plan*. This initiative focuses on federal funding opportunities for the applied research and development initiatives included in the *2015-2017 EPIC Investment Plan*.

S11.1 Proposed Funding Initiative: Provide Federal Cost Share for Applied Research Awards.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	Full-scale Demo	Early Deployment	Market Facilitation	Grid Operations /Market Design	Generation	Transmission /Distribution	Demand – side Management
X				X	X	X	X

Source: California Energy Commission

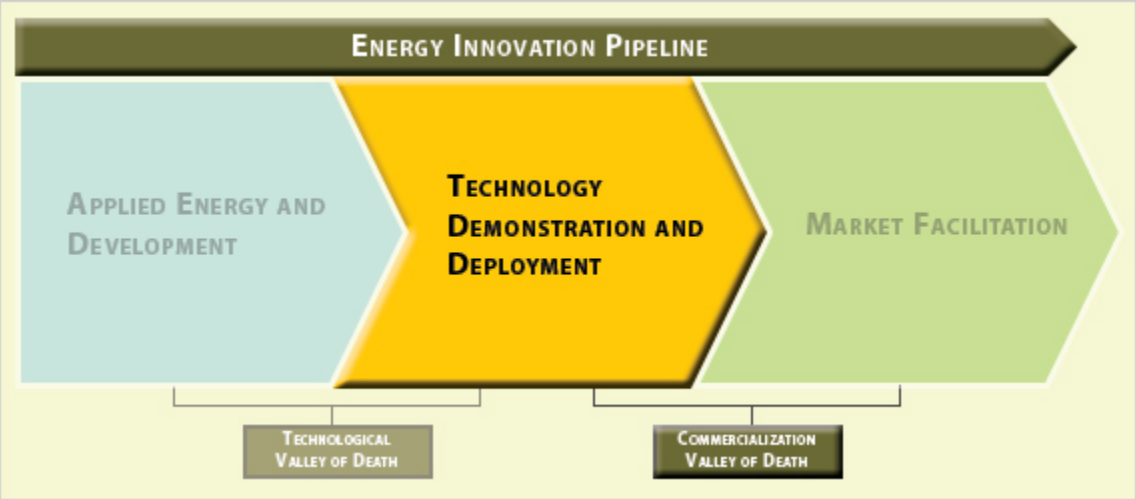
Purpose: This initiative will provide EPIC funds as cost share to leverage federal investments for projects that (a) meet the guiding principles of the decision and (b) are aligned with the strategic objectives listed in the applied research and development program area of this *2015-2017 EPIC Investment Plan*. Because these future cost-share opportunities are released through other federal agencies (for example, U.S. DOE, U.S. DOD, U.S. Department of Labor), the timing and scope of the proposed cost share opportunity cannot be predefined or preapproved in the *2015-2017 EPIC Investment Plan*.

Stakeholders: Research Institutions, companies, U.S. DOE, U.S. DOD, and nongovernmental organizations.

Background: Over the past few years, the Energy Commission has been able to leverage significant federal funding for California. For example, the Energy Commission provided cost share to California entities that received awards through the American Recovery and Reinvestment Act (ARRA). As a result of this cost share, California was able to leverage more than $500 million in ARRA funds with a contribution of only around $20 million of state funds. Without this state cost share, many of the projects would not have been selected by the U.S. DOE for funding, and California would have lost the benefits of the tax revenues, jobs, and California-based manufacturing capabilities that these ARRA projects provided. The U.S. DOD is pursuing the most aggressive clean energy goals of any federal or state agency in converting its state-side bases to high levels of renewable penetration (50 percent), aggressively installing new energy efficiency technologies (for both existing and new facilities), and transitioning its

nontactical vehicle fleet from fossil-fuel based to all electric. There are more than 30 U.S. DOD locations in California and the opportunity for co-funding and cost share projects is significant. For example, the U.S. DOD is planning its first regional roll out of EV transition at several California bases over the next few years. This creates a strong opportunity to cost share the research, deployment, and implementation of this critical technology. Furthermore, California companies that can become part of the regional rollout in California will have business opportunities throughout the nation and the world as the U.S. DOD completes its system-wide transition to EVs.

CHAPTER 4: Technology Demonstration and Deployment



Source: California Energy Commission

The applied research and development (R&D) stage develops novel clean energy technologies and strategies, evaluates technical performance, and tests promising prototypes. The technology demonstration and development (TD&D) stage aims to evaluate the performance and cost-effectiveness of these technologies at or near commercial scale.

Through the Technology Demonstration and Deployment program area, the Energy Commission will fund activities to test scalability and preliminary operating issues, bringing promising "pre-commercial" technologies and strategies closer to market. *Pre-commercial* refers to technologies and strategies that have not reached commercial maturity or deployed at scales and in conditions sufficiently large to reflect the anticipated actual operating environments to enable appraisal of the operational and performance characteristics and the financial risks. For this *2015-2017 EPIC Investment Plan*, the Energy Commission will provide $145.02 million for TD&D funding to test new technologies in conditions that approximate real-world applications.

Building on the Applied Research and Development initiatives, the Technology Demonstration and Deployment program will also promote the achievement of the state's energy policy priorities, including the "loading order." Demonstration projects funded in this category will also serve as a test bed to explore opportunities through a holistic approach to integrate efficiency, renewable generation, and clean transportation to make the whole system better than the sum of the individual technologies. The potential benefits are improved customer choice, lower costs achievement of energy goals, and a better interface with the "smart grid."

Demonstration and deployment activities will typically occur in investor-owned utility (IOU) service territories. IF there is a strong case that the project demonstrates IOU electricity ratepayer benefits, projects located outside IOU service territories may be considered. The

demonstration and deployment strategic objectives discussed below outline a set of proposed initiatives focused on particular proposal areas.

Proposed initiatives identified in this *2015-2017 EPIC Investment Plan* represent the full scope of possible awards. The Energy Commission may not issue solicitations or make awards in every initiative area if funding is inadequate, if there is a lack of qualified applicants, or if further analysis of market conditions indicates that an initiative is not a high priority or it is already adequately funded by other entities.

Table 15: Proposed Strategic Objectives for the Technology Demonstration and Deployment Program Area

Funding Area
S12 Strategic Objective: Overcome Barriers to Emerging Energy Efficiency and Demand-Side Management Solutions Through Demonstrations in New and Existing Buildings.
S13 Strategic Objective: Demonstrate and Evaluate Biomass-to-Energy Conversion Systems, Enabling Tools, and Deployment Strategies.
S14 Strategic Objective: Take Microgrids to the Next Level: Maximize the Value to Customers.
S15 Strategic Objective: Demonstrate Advanced Energy Storage Interconnection Systems to Lower Costs, Facilitate Market and Improve Grid Reliability.
S16 Strategic Objective: Expand Smart Charging and Vehicle-to-Grid Power Transfer for Electric Vehicles.
S17 Strategic Objective: Provide Federal Cost Share for Technology Demonstration and Deployment Awards.
Technology Demonstration and Deployment Program Area Total

Source: California Energy Commission

The proposed initiatives for the Technology Demonstration and Deployment program area provided in Table 15 were developed based on the priorities defined in the CPUC EPIC decision and Senate Bill 96.

S12 Strategic Objective: Overcome Barriers to Emerging Energy Efficiency and Demand-Side Management Solutions through Demonstrations in New and Existing Buildings.

Table 16: Ratepayer Benefits Summary for Strategic Objective 12

	Promote Greater Reliability	Lower Costs	Increased Safety	Societal Benefits	GHG emissions mitigation and adaptation	Lower emission vehicles/ transportation	Economic Development	Public Utilities Code Section 740.1	Public Utilities Code Section 8360
S12.1 Identify and Demonstrate Promising Energy Efficiency and Demand Response Technologies Suitable for Commercialization and Utility Rebate Programs.	X	X		X	X				
S12.2 Demonstrate Large-Scale Deployment of Integrated Demand-Side Management and Demand Response Programs in Buildings.	X	X		X	X		X		

Source: California Energy Commission

Barriers and Challenges: Once technologies have been successfully tested in bench-scale systems and meet pre-defined performance targets, the technologies must be fully demonstrated and deployed in actual commercial applications to document the benefits and savings in real-world conditions. Demonstrations and large-scale deployments are needed in real-world conditions to independently document technical feasibility, validate energy, water, and cost savings; and environmental benefits; resolve regulatory barriers, and determine overall life-cycle economics. Without an independent assessment of technical and economic viability, these technologies and strategies lack a solid value proposition to potential customers and often do not make it past the commercialization "valley of death."

Demonstrations of multiple, integrated demand-side management technologies are needed to document the synergies, overall economics and other benefits of combining technologies that would result in the greatest ratepayer benefits. These demonstrations are especially needed to establish the right mix of technologies for particular applications, document technical and economic feasibility, and minimize risk to building owners/operators.

There is a need for public funding for demonstrations to bridge the commercialization "valley of death." The private sector does not typically conduct applied research and is risk-averse regarding new, unproven technologies, often lacking the resources to analyze and evaluate various technologies. New technologies often are developed in academic communities that do not have the funding for large-scale demonstrations. Typically, the private sector only offers funding after a successful field demonstration.

Investments in the *2012-2014 EPIC Investment Plan* addressing barriers and challenges: The *2012-2014 EPIC Investment Plan* addressed three demonstration strategies: those associated with individual technologies (Funding Initiative S12.1), technology integration (Funding Initiative S12.2) and zero-net energy (ZNE) buildings and communities (Funding Initiative S14.1). The Energy Commission will release solicitations in fiscal year 2014 and 2015 in these areas.

- The solicitation for Funding Initiative S12.1 from the *2012-2014 EPIC Investment Plan* will focus on the industrial, agricultural and water sector. The *2015-2017 EPIC Investment Plan*, focuses on technology demonstrations in the building sector, primarily emphasizing technologies that were tested in the applied research program of the *2012-2014 EPIC Investment Plan* and are now ready for pre-commercial demonstrations or deployments.
- The solicitation for Funding Initiative S12.2 from the *2012-2014 EPIC Investment Plan* will focus on integrated demonstrations of pre-commercial energy efficiency, demand-side management, storage and other technologies to result in low-energy buildings/facilities.
- The solicitation for Funding Initiative S14.1 from the *2012-2014 EPIC Investment Plan* will emphasize large-scale deployment of technologies and strategies to advance ZNE building and community goals.

The *2015-2017 EPIC Investment Plan* will continue to support efforts from the *2012-2014 EPIC Investment Plan* through additional complementary demonstrations. Emphasis will be on large-scale deployment of technologies and strategies. With more demonstrations and deployments, it is anticipated that the value and the benefits of ZNE buildings and communities or maximizing energy efficiency retrofits in existing buildings will become more easily understood and accepted.

S12.1 Proposed Funding Initiative: Identify and Demonstrate Promising Energy Efficiency and Demand Response Technologies Suitable for Commercialization and Utility Rebate Programs.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	Full-scale Demo	Early Deployment	Market Facilitation	Grid Operations /Market Design	Generation	Transmission /Distribution	Demand – side Management
	X	X					X

Source: California Energy Commission

Purpose: The purpose of this initiative is to demonstrate pre-commercial technologies that are past the "proof-of-concept" stage in existing and new buildings, especially for technologies

developed from the *2012-2014 EPIC Investment Plan* (Strategic Objective S1). This initiative emphasizes large-scale demonstrations and deployment that may involve multiple residential and commercial building owners/developers, IOUs, major manufacturers, regulators and other research organizations.

Proposed demonstrations under this initiative must provide a minimum amount of match funding. The objective of these demonstrations is to collect independent technical and economic performance data in real world buildings. This independent performance data will provide verifiable information on energy savings and equipment performance to justify these technologies being eligible for utility energy efficiency rebate programs. This data collection can also ease the successful deployment of these technologies into the marketplace by expediting customer acceptance and market development. Demonstrations can also provide the data needed to inform future building efficiency codes and standards. For instance, the results from demonstrations deployed through utility rebate programs have provided the technical and economic performance data to justify their cost effectiveness and inclusion into future building energy efficiency standards.

Examples of technologies applicable under this initiative include, but are not limited to: advanced lighting, advanced heating, ventilation, and air conditioning (HVAC) systems and controls, advanced building envelopes, cost-effective retrofit strategies, indoor air quality improvement strategies, building commissioning, and other cost-effective technologies. Technologies, systems, and strategies will be applicable to new and existing commercial or residential buildings.

Stakeholders: Electric ratepayers who own and operate buildings, facilities, equipment manufacturers, engineers, contractors and consultants, academia, governmental agencies, utilities, national labs, code enforcement officials, construction companies, general contractors, and home performance contractors.

Background: The Energy Commission's past successes with demonstration activities include the State Partnership for Energy Efficient Demonstrations (SPEED), which focused primarily on demonstrations with public university and State of California buildings. The SPEED program resulted in widespread applications and installations of emerging technologies, particularly lighting improvements and HVAC controls, in several University of California and state buildings. The state is saving an estimated 61 million kilowatt-hours (kWh) per year and 4.2 million therms per year, resulting in $12 million per year in savings. The efforts of SPEED also resulted in many of the developed lighting technologies being included in the 2013 Title 24 California Buildings Standards Code update. Moreover, other efforts resulted in demonstrations of whole-building energy efficiency concepts in limited residential and commercial buildings in several climate zones. This initiative will expand these commercial demonstrations and emphasize large-scale demonstration and deployment of advanced technologies to private and additional publicly owned buildings.

Multiple stakeholder workshops were held to further specify research needs and pre-commercial technologies ready for demonstration at a commercial-facility scale. Furthermore, input from the IOUs and other stakeholders are received through participation in the Emerging Technology Coordinating Council and other venues such as the Emerging Technologies Summit. Both of these events had participation by the IOUs.

Projects focused exclusively on renewable energy or combined heat and power (CHP) will be eligible for funding under Strategic Objective 13, so they will not be considered in this initiative. While these types of projects could be associated with commercial and residential buildings (for example ZNE buildings, microgrids and community scale grids), they do not result in any energy efficiency benefits.

S12.2 Proposed Funding Initiative: Demonstrate Large-Scale Deployment of Integrated Demand-Side Management and Demand Response Programs in Buildings.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	Full-scale Demo	Early Deployment	Market Facilitation	Grid Operations /Market Design	Generation	Transmission /Distribution	Demand – side Management
X							X

Source: California Energy Commission

Purpose: The purpose of this initiative is to demonstrate and deploy of an integrated suite of pre-commercial demand-side management and other "smart" technologies that maximize energy efficiency and/or achieve ZNE buildings/communities.

Potential demonstration projects include the following:

- Demonstrate and deploy an integrated suite of pre-commercial demand-side management technologies, including energy efficiency, demand response (DR), and other "smart" technologies such as energy management systems. The objective is to ease large-scale deployment and market acceptance of integrated designs, technologies, and approaches that maximize energy efficiency (beyond the 2013 Title 24 building energy efficiency standards) in buildings. These demonstrations/deployments will provide independent, quantifiable data to measure the energy and cost savings, emission reductions, and other benefits associated with high-performance buildings, that may support future revisions to Title 20 appliance standards and Title 24 building standards.

- Demonstrate and deploy integrated ZNE turnkey package designs in multiple residential, multifamily and commercial developments. The objective is to demonstrate a variety of designs and approaches that incorporates high energy efficiency levels (that is beyond the 2013 Title 24 building energy efficiency standards), DR, localized renewable energy generation and storage technologies, and "smart" technologies. The goal is to demonstrate technology/designs that are cost comparable to conventional construction and result in large-scale deployment. This initiative includes demonstrations of ZNE buildings, subdivisions/communities or a combination of both. These demonstrations/deployments will provide independent, quantifiable data to measure the energy and cost savings, emission reductions, and other benefits associated with each ZNE design. They will also increase homebuyer awareness of ZNE homes and will inform future revisions to Title 20 appliance standards and Title 24 building standards.
- Integrate behavioral research into the development and implementation phases of the demonstrations to ensure that the demonstration designs consider the people who will live in and operate the buildings. Incorporate feedback and observations from the residents/operators and monitor operational parameters to help explain variation in building performance and suggest potential design changes.

This initiative will coordinate and complement existing CPUC/IOU activities associated with integrated demand-side management (DSM) pilots and ZNE building studies and demonstrations. This synergy will ensure consistent and coordinated definitions of ZNE buildings and communities, leverage synergies and avoid duplication.

Stakeholders: Electric ratepayers who own and operate buildings, developers, design professionals, equipment manufacturers, engineers, contractors, consultants, academia, governmental agencies, utilities, and national labs.

Background:

Integrated DSM:

The *California Energy Efficiency Strategic Plan* emphasizes a goal to deliver integrated DSM options that include efficiency, DR, energy management, and other measures through coordinated marketing and regulatory integration. Implementing integrated DSM options would result in increased energy savings at lower cost.

In Decision 07-10-032, the CPUC required the IOUs to "integrate customer demand-side programs, such as energy efficiency, self-generation, advanced metering, and DR in a coherent and efficient manner."[93] The intent was to achieve maximum savings while avoiding

93 http://www.calmac.org/events/EE_and_MEO_2103-14_decision_166830.pdf.

duplication of efforts, reducing transaction costs, and reducing customer confusion.[94] In this same decision, the IOUs were also directed to fund pilot projects to achieve integrated DSM.

The *California Energy Efficiency Strategic Plan* also sets retrofit targets for reducing energy consumption in existing building stock. In its Decision 12-05-015 on May 10, 2012, the CPUC stated that "these goals will require immediate action to drastically increase the uptake and scale of deep retrofit projects across the building sector."[95] The IOU's 2010-2012 energy efficiency program portfolios made notable steps toward this undertaking, but more needs to be done to expand deep retrofit programs in multifamily and nonresidential buildings, address cost-effectiveness issues, enable simple financing tools for retrofit projects where needed, and address the recommendations of the Draft AB 758 Action Plan.[96]

This initiative will coordinate with ongoing and planned CPUC/IOU activities associated with both integrated DSM and deep retrofits of residential and commercial buildings, and will complement the work undertaken through the Energy Upgrade California™ program, other Energy Commission building efficiency retrofit programs and Assembly Bill 758 (Skinner, Chapter 470, Statutes of 2009).

Zero-Net-Energy Buildings

The CPUC's *California Energy Efficiency Strategic Plan* established big, bold initiatives to achieve home and commercial ZNE in new construction by 2020 and 2030, respectively. ZNE buildings have been demonstrated on a limited scale in both commercial and residential buildings in California. In addition, early adopter institutions, facilities, and neighborhoods in California are implementing zero- or near-zero-energy approaches at the community scale. San Diego Gas & Electric (SDG&E) operates an "energy-smart community" demonstrating state-of-the-art technologies at Borrego Springs. The University of California, Davis West Village is the largest planned ZNE community in the United States. However, the technical feasibility of ZNE buildings and communities is still in the early stages of demonstration and market acceptance. The *California Energy Efficiency Strategic Plan* states, "significant additional resources will be required to scale these efforts up for full-scale production at affordable prices"[97]

The primary barriers to ZNE buildings and communities are the cost of required technologies and components, whether these added costs can be recovered at the time of sale, and overall customer acceptance and demand for ZNE buildings. Also, the deployment of distributed

94 Ibid.

95 http://www.calmac.org/events/EE_and_MEO_2103-14_decision_166830.pdf.

96 Ibid.

97 *California Energy Efficiency Strategic Plan.* http://www.cpuc.ca.gov/NR/rdonlyres/A54B59C2-D571-440D-9477-3363726F573A/0/CAEnergyEfficiencyStrategicPlan_Jan2011.pdf

renewable generation, such as wind and solar, results in a variable local energy generation profile and increases the need for local ancillary services. Current building-scale ZNE solutions may not take advantage of the full range of benefits offered by community energy systems, such a renewable energy system serving an entire community rather than an individual home.

While ZNE communities are technically possible, previous demonstration attempts have encountered a number of issues and barriers that hinder their success including:

- An inadequate supply of builders and developers who have the skills and experience to create ZNE buildings and communities and enunciate the benefits. Without properly trained builders and developers to create ZNE buildings and communities, new technologies will never reach market maturation because of the lack of exposure or poor performance related to incorrect designs and installations.
- Many design challenges and site-specific considerations are required to effectively achieve ZNE design goals. Developers and builders must apply holistic design principles and effectively take advantage of solar orientation, natural ventilation, nighttime cooling, daylighting, thermal mass, and other passive assets to minimize loads and consumption.
- The value and benefits of ZNE buildings and how this can be reflected in the value of the building at time of sale.
- Lack of long-term financing mechanism for ZNE buildings and homes. Financing opportunities are especially critical to low-income qualified buildings, which make up a large percentage of multiunit dwellings. The limited availability of financing and incentive options make it difficult for builders to realize any payback from new ZNE buildings or building retrofits.

S13: Strategic Objective: Demonstrate and Evaluate Biomass-to-Energy Conversion Systems, Enabling Tools, and Deployment Strategies.

Table 17: Ratepayer Benefits Summary for Strategic Objective 13

	Promote Greater Reliability	Lower Costs	Increased Safety	Societal Benefits	GHG emissions mitigation and adaptation	Lower emission vehicles/ transportation	Economic Development	Public Utilities Code Section 740.1	Public Utilities Code Section 8360
S13.1 Demonstrate and Evaluate Environmentally and Economically Sustainable Biomass-to-Energy Systems for Woody and Other Dry Biomass.	X	X		X	X		X	X	X
S13.2 Accelerate the Demonstration and Early Deployment of Emerging Bio-Digester and Integrated Clean Generation to Efficiently Use Agricultural, Municipal, and Other Organic Waste.	X	X		X	X		X	X	X

Source: California Energy Commission

Barriers and Challenges: Biomass-to-energy, also referred to as biopower, technologies have a variety of challenges that currently limit their full-scale commercial deployment. Many of these barriers and challenges have been identified in public workshops held by the Energy Commission and other agencies and are being addressed through the Bioenergy Action Plan.[98], [99] Technologies are now available to convert biomass or organic wastes from various sources such as forest, agricultural (including dairies), municipal, and food processing facilities into industrial products and liquid and gaseous fuels for electricity generation or transportation.

This strategic objective will focus on electricity and heat generation as the main product. There are two main pathways for converting biomass to electricity: the thermochemical pathway and the biological pathway. The thermochemical pathway occurs at elevated temperature and generally at a faster conversion rate than the biological pathway, which is more commonly identified as anaerobic digestion. Each of these pathways has a distinct set of deployment

98 O'Neill, Garry, John Nuffer. 2011. *2011 Bioenergy Action Plan*. California Energy Commission, Efficiency and Renewables Division. Publication number: CEC-300-2011-001-CTF.

99 O'Neill, Garry. 2012. *2012 Bioenergy Action Plan*. California Energy Commission, Efficiency and Renewables Division.

barriers and challenges, is in different stages of pre-commercial and commercial readiness, and warrants a unique set of solutions.

Challenges specific to thermochemical conversion technologies and generation systems include high capital cost and the need for demonstration facilities to assess downstream gas treatment and catalyst system air emissions, cost, and reliability.[100] Thermochemical conversion processes are expensive because of the low energy conversion efficiencies and need research and full-scale demonstration to help lower costs and improve efficiency. Anaerobic digestion systems, which convert wastes (for example, manure, food processing waste, organic portion of municipal waste) to biogas, are also challenged with costs, biogas cleanup requirements, and emissions requirements for downstream engine or equipment. Because of these challenges, these technologies currently capture a small portion of available wastes. For example, estimates are that only 1 percent of dairy farm manure is captured and converted to biogas.

Other complicating barriers and challenges include the costs associated with managing and transporting the biomass feedstock. To harness the economies of scale that larger projects can provide, new fuel handling systems or technologies that reduce the transportation costs of biomass feedstocks must be demonstrated at market scales. Within the dairy industry, the dairy market and the perceived technical risk of on-farm biopower systems have made financing and development of pre-commercial systems difficult and expensive.[101] These technologies will play a critical role in meeting the state goal of diverting 75 percent of the compostable/digestible materials from landfills in 2020 and beyond to achieve the Assembly Bill 341 recycling goals.

Investments in the *2012-2014 EPIC Investment Plan* addressing barriers and challenges: The *2012-2014 EPIC Investment Plan* contained funding initiatives on demonstration and evaluation of emerging clean energy generation technologies and deployment strategies that support the deployment of bioenergy technology systems. This strategic objective will leverage any technical and economic advances made as a result of projects awarded under the *2012-2014 EPIC Investment Plan*.

100 O'Neill, Garry, John Nuffer. 2011. *2011 Bioenergy Action Plan.* California Energy Commission, Efficiency and Renewables Division. Publication number: CEC-300-2011-001-CTF.

101 *Economic Feasibility of Dairy Manure and Co-Digester Facilities in the Central Valley of California*. May 2011. Prepared for the California Regional Water Quality Control Board, Central Valley Region by Environmental Science Associates.

S13.1 Proposed Funding Initiative: Demonstrate and Evaluate Environmentally and Economically Sustainable Biomass-to-Energy Systems for Woody and Other Dry Biomass.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	Full-scale Demo	Early Deployment	Market Facilitation	Grid Operations / Market Design	Generation	Transmission / Distribution	Demand – side Management
	X	X			X		X

Source: California Energy Commission

Purpose: This initiative will advance pre-commercial technology demonstration and early-stage deployment of thermochemical biomass-to-energy conversion technologies, systems, and market strategies that have been successfully demonstrated at pilot scale. Proposed demonstration and deployment projects under this initiative may include bioenergy facilities in the forest or wildland/urban interface regions, agriculture or municipal regions utilizing woody and other commonly dry or low moisture organic wastes such as orchard prunings, shells or straws and the organic fraction of municipal solid wastes, and integrating low-emission distributed generation (DG) technologies. The overall goal of this initiative is to address issues limiting full-scale deployment of promising bioenergy systems and develop publicly available data on the operational characteristics of these technologies and best practices. The biopower demonstration projects will use technologies and strategies sized for environmentally and economically sustainable utilization of locally available biomass resources and provide benefits to local communities and IOU electricity ratepayers. The demonstration projects will also support efforts to advance sustainability standards for harvesting biomass in forestry and agricultural settings to ensure that future bioenergy development is environmentally sustainable. Some of the possible TD&D activities may include:

- Demonstration of innovative technologies, techniques, and deployment strategies to expand the efficient and sustainable use of California's various biomass feedstocks to generate electricity and useful thermal energy from California's organic waste streams, including biomass from fire prevention activities, with a target to achieve cost parity with fossil-fuel power plants by 2020.
- Demonstration of thermochemical conversion systems and technologies, including advanced pollution controls, and ultra-low emission generation technologies capable of meeting local air quality standards at new or existing facilities.
- Demonstration of advanced biomass fuel handling and delivery systems or strategies that have been successfully evaluated through "applied research" and are ready for full-scale demonstration. This demonstration may include innovative approaches to pre-processing, drying and densification systems, combining different fuel streams to facilitate fuel storage,

and energy conversion to reduce handling and transportation costs and expand fuel markets.

- Demonstration of pre-commercial integrated systems that leverage synergies of co-locating biopower with other biomass to energy projects, manufacturing facilities, waste diversion, composting, transfer/processing, or disposal facilities.

Stakeholders: Ratepayers in rural and urban communities, technology providers and operators, biomass wastes managers and facility owners, California Department of Food and Agriculture (CDFA), local air quality districts, California Air Resources Board (ARB), California Department of Forestry and Fire Protection (CalFire), California Department of Resources Recycling and Recovery (CalRecycle), California Department of Transportation (CalTrans), United States Department of Agriculture (USDA), United States Environmental Protection Agency (U.S. EPA), bioenergy developers, and bioenergy and waste management industry groups.

Background: The Energy Commission has provided funding to develop a number of pilot scale biopower projects, including demonstration and testing of advanced thermochemical conversion technologies at a variety of settings in California. These projects have shown that additional demonstrations and early stage deployment projects are needed to bring down the development costs and improve environmental compliance of these technologies. With the implementation of the ARB 2013 targets for mono-nitrogen oxides (NO_x) and carbon monoxide (CO) emissions from non-natural gas fuels such as those from waste and other bio-derived sources, new combustion technologies are needed to meet these stringent air quality rules.

On December 15, 2010, the Energy Commission adopted a memorandum of understanding (MOU) between the Energy Commission and the Departments of General Services, Corrections and Rehabilitation, Transportation, Water Resources, and Fish and Game "to facilitate the development of renewable energy projects on state buildings, properties, and rights-of-way." Under this MOU, the agencies, among other things, will collaboratively study, plan, and develop electricity infrastructure and develop statewide request-for-proposals to make these properties available to interested developers. "Energy Commission staff recommends that the state install 2,500 MW of renewable energy on state-owned property by 2020. EPIC funds can further this cause through targeting demonstration and deployment projects on pre-screened public lands."[102]

There are a number of other grant opportunities for the demonstration of biomass to energy systems, such as USDA Rural Business Opportunity Grants, USDA Rural Energy for America Program (REAP), and a joint USDA and US DOE Biomass Research and Development Initiative, where the EPIC program can leverage funding to resolve outstanding bioenergy issues.

102 Barker, Kevin, Jim Bartridge, Heather Raitt. 2011. *Developing Renewable Generation on State Property*, California Energy Commission. Publication number: CEC-150-2011-001.

Implementation of this initiative will be coordinated with other Energy Commission renewable energy commercialization activities, including those pursued under the Alternative and Renewable Fuel and Vehicle Technology Program.

S13.2 Proposed Funding Initiative: Accelerate the Demonstration and Early Deployment of Emerging Bio-Digester and Integrated Clean Generation to Efficiently Use Agricultural, Municipal, and Other Organic Waste.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	Full-scale Demo	Early Deployment	Market Facilitation	Grid Operations / Market Design	Generation	Transmission / Distribution	Demand – side Management
	X	X			X		X

Source: California Energy Commission

Purpose: This initiative will advance pre-commercial technology demonstration and early-stage deployment of anaerobic digestion and enabling technologies, systems, and market strategies that have been successfully demonstrated at pilot scale. Proposed demonstration and deployment projects under this initiative may include digester facilities located at dairies and other animal facilities, municipal wastewater treatment plants, food processing facilities, and possibly waste handling or recovery facilities for collected green wastes, that integrate low-emission DG technologies. The overall goal of this initiative is to address issues limiting full-scale deployment of promising bioenergy systems and develop publicly available data on the operational characteristics of these technologies and best practices. The biopower demonstration projects will use technologies and strategies sized for environmentally and economically sustainable utilization of locally available biomass resources and provide benefits to local communities and IOU electricity ratepayers. Eligible projects under this initiative will reduce the waste products while providing additional co-benefits to electricity ratepayers and facility operators. Some of the possible TD&D activities may include:

- Demonstration of agricultural-based anaerobic digesters, advanced pollution controls, and ultra-low emission generation technologies capable of meeting local air quality standards. Demonstration of new ownership models for on-farm energy generators including multi-farm cooperatives or third-party ownership may also be considered under this initiative.
- Demonstration of innovative approaches in biological conversion, such as new anaerobic digester enabling technologies, low-cost, sustainable fuel and effluent handling and processing systems, biogas cleanup technologies and upgrading systems to increase electricity generated from biomass waste resources.

Stakeholders: Ratepayers in rural and urban communities, industrial and commercial food processing facilities, dairy and agriculture facilities, and wastewater treatment facilities, CDFA, local air quality districts, ARB, CalFire, CalRecycle, CalTrans, USDA, U.S. EPA, bioenergy developers, and bioenergy and waste management industry groups.

Background: Although many of the core digester technologies have been established on a global scale, these systems have not reached commercial maturity for use in agricultural and urban waste settings in California. Technology demonstrations that could dramatically improve future on-farm bioenergy adoption include cost-effective low-emission internal combustion engines, micro-turbines or fuel cells, and inexpensive emissions control technologies.[103, 104]

Recently, a federal grant was provided to assess the feasibility of a centralized dairy digester model. The study advances this conceptual model and lays the foundation for development of centralized dairy digester projects in California. The feasibility study reported that the dairy digester projects provide significant environmental benefit opportunities that far exceed other renewable energy resources, such as wind and solar. In addition to the benefits of fossil fuel replacement, dairy digester projects provide significant "front-end" greenhouse gas (GHG) capture and destruction. Dairy biogas-to-transportation fuel projects also provide significant criteria air pollutant benefits when used to displace heavy-duty vehicle diesel use. [105]

Other grant opportunities exists through federal agencies such as USDA Rural Business Opportunity Grants, USDA Rural Energy for America Program (REAP), and a joint USDA and US DOE Biomass Research and Development Initiative, that this initiative can leverage to accelerate the deployment of bio-digester and clean generation technologies.

Implementation of this initiative will be coordinated with other Energy Commission renewable energy commercialization activities, including those pursued under the Alternative and Renewable Fuel and Vehicle Technology Program.

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103 *Economic Feasibility of Dairy Manure and Co-Digester Facilities in the Central Valley of California*. May 2011. Prepared for the California Regional Water Quality Control Board, Central Valley Region by Environmental Science Associates.

104 *Advanced Technology to Meet California's Climate Goals: Opportunities, Barriers & Policy Solutions.* ETAAC Advanced Technology Sub-Group. December 14, 2009. Pages 4-11.

105 http://www.calepa.ca.gov/Digester/Documents/CentDigStudy.pdf.

S14 Strategic Objective: Take Microgrids to the Next Level: Maximize the Value to Customers

Table 18: Ratepayer Benefits Summary for Strategic Objective 14

	Promote Greater Reliability	Lower Costs	Increased Safety	Societal Benefits	GHG emissions mitigation and adaptation	Lower emission vehicles/transportation	Economic Development	Public Utilities Code Section 740.1	Public Utilities Code Section 8360
S14.1 Use Microgrids to Evaluate a Combination of Emerging Technologies to Determine the Best Integrated Performance and Least Cost Configuration to Meet the Customers Energy Needs.	X	X	X	X	X		X	X	X

Source: California Energy Commission

Barriers and Challenges: There are many energy technologies available to help customers save energy, increase reliability, provide environmental benefits and enhance grid operation. Integrated systems composed of energy efficiency measures, DR, storage, and renewable energy resources have not been widely adopted because they are seen as complex, require specialized dedicated staff, have technological and regulatory barriers, and are only cost effective for large single owner facilities. Furthermore, ideal configurations of these technologies have not yet been determined, and therefore present some risk to early adopters. Microgrids can serve as testing tools for evaluating systems of integrated energy technologies and the benefits they can provide to customers and the grid.

Some microgrid systems have been designed to address these challenges, but most developers do not evaluate maximizing energy efficiency measures, DR opportunities, storage, locally available renewable energy resources and the full range of emerging clean energy technologies for the facilities they serve. Microgrid systems consisting of these technologies will provide resiliency and climate change adaptation for facilities needing high reliability.

Microgrids with their controls for renewables, DR, CHP, energy storage, and facility-related energy efficiency, offer the benefits of increased reliability, stability, and resiliency in the face of power outages. Demonstration projects can showcase and document commercially available and emerging technologies and strategies to supply multiple benefits to the facilities they serve as well as the larger grid.

Investments in the *2012-2014 EPIC Investment Plan* addressing barriers and challenges: This initiative continues the activities of S14.2 of the *2012-2014 EPIC Investment Plan* to demonstrate microgrid control and operation. This strategic objective will take microgrids to the next level by using them to evaluate a system of energy technologies and resources to determine their best performance and least cost configuration.

S14.1 Proposed Funding Initiative: Use Microgrids to Evaluate a Combination of Emerging Technologies to Determine the Best Integrated Performance and Least Cost Configuration to Meet the Customers Energy Needs.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	Full-scale Demo	Early Deployment	Market Facilitation	Grid Operations / Market Design	Generation	Transmission / Distribution	Demand – side Management
	X			X			X

Source: California Energy Commission

Purpose: This initiative will use microgrid demonstrations as testing tools for evaluating systems of integrated energy technologies and the benefits they can provide to customers and the grid. These microgrids will demonstrate the technical and economic feasibility of operating high penetrations of renewable energy sources with DR, CHP, energy storage, and energy efficiency measures. These demonstrations will also evaluate a full range of state of the art clean energy technologies that include, advanced vehicle charging, demand side management strategies, and advanced microgrid controls. Proposed demonstrations will maximize local renewable energy utilization, potentially even exporting power during high supply and/or low demand periods. These microgrid projects will demonstrate and deploy commercially available and emerging technologies that support residential, commercial/industrial, and mixed-use communities. The goal is to demonstrate a variety of applications and produce technical and economic performance data, such as cost and benefits. Where possible, instances where the microgrid provides resiliency to grid events and impacts caused by global climate change will also be documented.

This initiative requires renewables and mandatory DR participation either in the current IOU programs or in emerging California Independent System Operator (California ISO) markets. These demonstrations will also focus on maximizing energy efficiency for all facilities served by the microgrid.

Proposed demonstration projects under this initiative will build on research results from projects funded under the *2012-2014 EPIC Investment Plan*. Projects will also identify installation issues and other barriers, such as permitting requirements, and participation potential for DR programs that could facilitate the successful deployment of integrated energy systems of high penetration renewables into the marketplace. Additionally, projects must include an assessment of potential to perform DR. Projects may include an assessment of potential to provide ancillary services to the grid.

Stakeholders: Commercial centers and industrial parks, residential/multifamily developments, water and wastewater treatment plants, municipal complexes, mixed-use communities, other commercial and industrial facilities, utilities, microgrid vendors, and local governments, and the Unites States federal government, including the U.S. Department of Defense (U.S. DOD).

Background: In addition to providing reliability benefits for critical facilities and other deployment sites, microgrid systems may be used as a tool to facilitate the integration of higher penetrations of intermittent renewable resources than are currently allowed by typical electricity distribution systems. Ideal configurations for systems of high penetration renewables and enabling technologies have not yet been determined. Microgrids can serve as testing tools for evaluating systems of integrated energy technologies and the benefits they can provide to customers and the grid. Business cases for the widespread deployment of such microgrids have yet to take shape.

A few microgrids were deployed at college campuses and institutional facilities, such as military bases and jails. However, the benefits of microgrids may also be realized by a wider variety of facilities and communities, including residential mixed-use developments, industrial parks, commercial business facilities, and mixed-use communities. Microgrids allow for a significant increase in the amount of intermittent renewable energy that can be connected at the distribution level and help residents and businesses conserve electricity, preserve the environment and be a model for future ZNE communities when incorporated with energy efficiency and DR.

In June 2013, SCE announced that it would close the San Onofre Nuclear Generating Station (SONGS) permanently. This closure poses a major challenge to Southern California's electric system. The CPUC committed to work with the California ISO to ensure Southern California has an adequate supply of electricity this summer and into the future. The CPUC will place a greater emphasis on energy efficiency and DR as preferred resources.

The CPUC issued a decision (D.14-03-026) [106] for rulemaking for DR (R.13-09-011). Starting in 2017, this decision bifurcates the CPUC-regulated DR portfolio of programs into two categories: 1) load modifying resources, which reshape or reduce the net load curve; and 2) supply resources, which are integrated into the California ISO energy markets. A CPUC proposal to

106 http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M089/K480/89480849.PDF.

create a capacity bidding program (an auction for demand response) for supply-side DR resources will follow this decision. Microgrids with renewables and the ability to participate in demand response can help alleviate the loss of SONGS.

S15 Strategic Objective: Demonstrate Advanced Energy Storage Interconnection Systems to Lower Costs, Facilitate Market and Improve Grid Reliability.

Table 19: Ratepayer Benefits Summary for Strategic Objective 15

	Promote Greater Reliability	Lower Costs	Increased Safety	Societal Benefits	GHG emissions mitigation and adaptation	Lower emission vehicles/ transportation	Economic Development	Public Utilities Code Section 740.1	Public Utilities Code Section 8360
S15.1 Demonstrate Advanced Energy Storage Interconnection Technologies and Systems in Transmission, Distribution, and Customer-Side Applications to Transition to the Commercial Market.	X	X	X	X	X		X	X	X

Source: California Energy Commission

Barriers and Challenges: Many recent advances in the development of various energy storage technologies and systems have occurred. Energy storage has a large potential to provide numerous services and benefits throughout the electricity system. However, interconnection of energy storage systems at all grid points remains a significant challenge because of high cost and lack of appropriate communication hardware and software, as well as appropriate uniform standards and protocols. At present, each energy storage system's operation and control communication software and hardware is custom made to meet limited specific requirements and needs. Also, utilities often cite lack of operational experience for using energy storage, high cost of energy storage and interconnection systems, lack of commercially available energy storage and interconnection products, and limited information on energy storage systems' performance, reliability, durability and safety. As a result, deployment of energy storage as a valuable and clean flexible resource is very limited, but is needed to manage high penetration of variable and intermittent renewable generation. Inefficient, highly polluting conventional "flexible" resources (for example, peakers, gas turbines, engine generators) are currently used along with nearly 4 GW of pumped hydro energy storage for grid stability and reliability.

Advanced fast-response energy storage technologies and systems as well as suitable interconnection technologies and systems that have a good potential for operational cost savings and emission reductions are not being used.

Energy storage provides additional flexibility to the electricity system which is needed to maintain system stability and reliability, provided it can be seamlessly integrated with the generator and the transmission and distribution (T&D) system through interconnection and operation and control communication systems. Seamlessly integrated energy storage systems also reduce the system requirements to manage high penetrations of intermittent and variable solar and wind generation. They can be used in many diverse applications depending on the storage technology type, size, grid-point connection or location, response time of energy storage and delivery. Energy storage also provides flexibility and reliability benefits for grid infrastructure and critical facilities and other deployment sites. Advanced energy storage systems can facilitate the integration of higher penetrations of intermittent and variable output renewable resources, demand-side management, load following, electric vehicle (EV) charging, and the ancillary services better than are currently allowed by typical electricity generation, transmission and distribution systems. At this time, another major barrier to widespread energy storage systems deployment is the inability of local electricity ratepayers to capture the substantial benefits and monetary value provided by the energy storage systems. The inability of utilities and their ratepayers to capture the value of energy storage systems makes such systems appear artificially uneconomic to utilities and their customers.

On October 17, 2013, the CPUC established the Assembly Bill 2514 Energy Storage Procurement Target of 1,325 MW by 2020 beginning 2014 and all operational by 2024 for Southern California Edison (SCE) –580 MW, Pacific Gas and Electric (PG&E) – 580 MW, and SDG&E – 165 MW. Three points of interconnection differentiate the total MW target: transmission (700 MW), distribution (425 MW) and customer-side (200 MW). The 2014 energy storage procurement applications were due by March 1, 2014. Also, the CPUC ordered SCE to procure 50 MW of energy storage in addition to procuring preferred resources to make up for the permanent shutdown of nearly 2,000 MW of nuclear power generation in southern California. Similarly, the CPUC issued its final decision on March 13, 2014, requiring SDG&E to procure at least 25 MW of energy storage. Meeting these targets will require a rapid development of commercially available and cost-effective energy storage systems to fill an estimated over $2 billion energy storage market in California alone. The CAISO anticipates receiving interconnection requests for energy storage from IOUs and many new participants into the ISO interconnection process. Efforts are underway at CAISO to identify issues and develop solutions related to energy storage interconnection.

Fully integrated advanced energy storage systems are still not widespread in California. They must be demonstrated to verify performance, reliability, and monetary value, and the business cases for widespread deployment at the lowest possible cost of interconnection and through a standardized, streamlined interconnection process.

Investments in the *2012-2014 EPIC Investment Plan* addressing barriers and challenges: These initiatives build on the activities of the *2012-2014 EPIC Investment Plan* addressing the barriers and challenges described above. Energy storage interconnection systems remain a significant gap for full deployment of energy storage systems in California.

S15.1 Proposed Funding Initiative: Demonstrate Advanced Energy Storage Interconnection Technologies and Systems in Transmission, Distribution, and Customer-Side Applications to Transition to the Commercial Market.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	Full-scale Demo	Early Deployment	Market Facilitation	Grid Operations / Market Design	Generation	Transmission / Distribution	Demand – side Management
	X		X	X	X	X	X

Source: California Energy Commission

Purpose: The purpose of this initiative is to demonstrate, at full-scale, various advanced energy storage systems (for example, batteries, flywheels, adiabatic compressed air energy storage, advanced pumped hydro, flexible capacity output gas turbines, thermal energy storage) and interconnection systems to transmission, distribution, and customer side. Transmission connected advanced energy storage interconnection systems will be demonstrated at full-scale to assess and verify their capability for firming variable and intermittent solar and wind generation while providing critical support services for renewable integration and grid stability and reliability. The purpose of this initiative also includes demonstrating various full-scale advanced distributed energy storage systems and related interconnection systems connected to sub-station and distribution systems for distribution system support services, such as distribution reliability, power quality, volt amp reactive support, frequency regulation, load following and demand management, and sub-station system requirements and options. Developing and demonstrating solutions to reduce the high cost of interconnecting and long lead times required to complete the interconnection process on the customer-side is also a focus of this initiative. This also includes facilitating market deployment of various advanced energy storage technologies and interconnection systems, including opportunities for streamlining regulatory processes and project permitting to reduce cost of interconnection, evaluating work force development needs, and further refining potential markets for immediate deployment of energy storage technologies. In addition, the identification and correction of any interconnect issues and technical problems identified during demonstrations and operational testing is necessary for full commercialization of energy storage technologies. Finally, verifying that the

product performs as expected, and that all product features are functional, under normal operating conditions is necessary for product deployment into the market place.

Stakeholders: Utilities, independent power producers, energy storage system developers and vendors, energy storage project developers and service providers, CPUC, California ISO, U.S. DOE, national labs, CESA, ESA, ratepayers, the real estate developers and owners of residential commercial, industrial, and mixed-use communities, and water and wastewater treatment plants.

Background: The California ISO identified energy storage as an important resource to enable integration of renewable energy at increasing penetration levels, along with DR and flexible natural gas-fired power plants. Energy storage and fast-ramping power plants allow electricity supply to follow the increasingly unpredictable minute-to-minute electricity demand, and avoid potential grid stability issues due to over-generation by solar and wind resources during off peak hours. Conventional flexible capacity resources, such as peakers, are inefficient and highly polluting and offset the GHG emission reductions by renewables. Also, additional flexible resource capacity is needed because of permanent shutdown of nearly 2GW of nuclear generation in southern California, and this deficit will be filled with preferred but unpredictable resources including renewables. The CPUC Assembly Bill 2514 energy storage procurement target decision requires 700 MW of transmission connected energy storage by 2020, beginning 2014 and all operational by 2024.

Utilities recognize certain grid-scale energy storage technologies as immature, very capital extensive and risky. Utility investment policies mandate that the benefits of projects must exceed costs. This condition will be satisfied more often once plant-level energy storage technologies and interconnection systems are developed and demonstrated. This energy storage interconnection technology systems demonstration will be coordinated with the California ISO. This will also build confidence amongst utilities and energy storage vendors regarding technical and economic performance of energy storage systems.

IOUs, currently, have a few energy storage projects at pilot scale demonstrations in California. These projects are demonstrating Lithium-ion and Sodium-Sulfur batteries for renewable integration. A few other projects, jointly funded by the Energy Commission and USDOE, are developing flow batteries such as Zinc-Halogen and Iron-Chromium. These projects use costly custom made operation and control communication hardware and software and often have limited functionality and reliability. Frequent software glitches and hardware failures erode any confidence in the effective use of energy storage systems.

At this time, local electricity ratepayers cannot capture the substantial benefits and monetary value provided by distributed energy storage systems. This makes the value of distributed energy storage systems appear artificially uneconomic to utilities and their customers.

Currently, energy storage at customer sites such as commercial buildings is used as uninterrupted power supply systems for critical loads and for meeting high power quality

needs. Cost of simple interconnections remains high. New business models for electrical energy storage and thermal energy storage are also developing. However, these new models are dependent on regulatory changes needed to allow customers or building owners to monetize and capture the value of energy storage, and it could facilitate a rapid market growth of energy storage deployment. Lower battery costs and reductions in other components of energy storage systems such as two-way power inverters and management systems along with increased demand for batteries for EVs would also help the future growth of advanced energy storage systems deployment. As renewable installations at customer sites such as residential and commercial buildings as well as EV population increase, there will be more opportunities to integrate and interconnect energy storage systems and their applications to realize the full potential of energy storage systems at customer sites.

S16 Strategic Objective: Expand Smart Charging and Vehicle-to-Grid Power Transfer for Electric Vehicles.

Table 20: Ratepayer Benefits Summary for Strategic Objective 16

	Promote Greater Reliability	Lower Costs	Increased Safety	Societal Benefits	GHG emissions mitigation and adaptation	Lower emission vehicles/ transportation	Economic Development	Public Utilities Code Section 740.1	Public Utilities Code Section 8360
S16.1 Demonstrate the Ability of Electric Vehicles To Provide Advanced Grid Services.	x	x	x	x	x		x	x	x

Source: California Energy Commission

Barriers and Challenges: The benefits of using plug-in electric vehicles (PEVs) to enhance grid performance and reliability are numerous and compelling, but they are not yet economically proven at a large-scale. The most straightforward and economical application for PEVs to utilize vehicle-grid integration (VGI) capabilities, which include either 1-directional controllable "smart" charging (V1G) or 2-directional charge/discharge (V2G), is in vehicle fleets. In fleets, the PEVs are co-located geographically as one resource and are owned and controlled by the same entity.

Thus, PEV fleets represent the technical and economic "low-hanging fruit "for providing grid services through VGI.

Although one direction of research is to develop the more complex but wider-ranging applications where individual PEVs in geographically distributed locations are aggregated by a utility or third-party aggregator into resources large enough to participate in utility or independent system operator markets, the enabling factors for such aggregations are not as mature as for fleet VGI applications. Thus, research into aggregations of individual PEVs is addressed in Chapter 3 while this strategic objective will establish the real-world benefits of advanced VGI applications for fleets.

Investments in the *2012-2014 EPIC Investment Plan* addressing barriers and challenges: This strategic objective continues to expand the established benefits of V1G and V2G applications, collectively called VGI, addressed in the *2012-2014 EPIC Investment Plan*. This strategic objective will expand the possible use cases by calling for demonstrations of fleet PEVs that are aggregated by the fleet operator, a utility, or a third-party aggregator such that the PEVs appear as a single, larger resource to the grid.

S16.1 Proposed Funding Initiative: Demonstrate the Ability of Electric Vehicles To Provide Advanced Grid Services.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	Full-scale Demo	Early Deployment	Market Facilitation	Grid Operations / Market Design	Generation	Transmission / Distribution	Demand – side Management
X				X			X

Source: California Energy Commission

Purpose: This purpose of this initiative is to expand the scope of vehicle-grid integration demonstrations in size and quantity. This initiative calls for the demonstration of more complex but wider-ranging use cases where fleet PEVs are resources large enough to participate in utility or independent system operator markets. It also aims to establish the feasibility of streetlight-integrated PEV charge ports by establishing the business case for them, documenting where they are practical to implement, and developing vehicle-grid integration capabilities for them. The demonstrations will take place in IOU service territories.

Proposed demonstrations under this initiative will address the technical and regulatory challenges encountered by fleets of PEVs in locations such as ports, school bus facilities, federal facilities (e.g. military bases), delivery services (e.g. UPS and FedEx units), and other commercial businesses. In these demonstrations, the PEVs may be owned by one or more

entities, and they may be capable of either 1-directional smart charging or 2-directional charging/discharging.

Stakeholders: California PEV fleet owners and operators, utilities, third-party energy aggregators, PEV manufacturers, and PEV charging station manufacturers.

Background: The grid benefits of one-directional smart charging (V1G) and two-directional charging/discharging (V2G), collectively called "vehicle-grid integration," are numerous and can be categorized as follows:

- Wholesale market services
    - Frequency regulation
    - Spinning, non-spinning, and supplemental reserve
    - Load following and ramping support for renewable generation
    - Ability to absorb excess renewable generation
- Distribution infrastructure services
    - Distribution upgrade deferral
    - Voltage support
    - Ability to absorb excess renewable and/or distributed generation
- Customer-facing services
    - Power quality
    - Power reliability
    - Retail energy time-shift
    - Demand charge mitigation
    - Potential islanding capability and electricity availability during outage in the case of V2G

In real-time vehicle-grid integration activities, PEV owners can earn revenue by making their parked vehicles available for participation in independent system operator or utility markets. In these applications, PEVs would provide frequency regulation, reserve capacity, ramping support for renewable generation, voltage support, and the ability to absorb excess renewable generation to avoid curtailment.

PEV fleets with time-of-use electricity rates can save on utility bills by charging PEVs at times of low demand, and can also save on bills by modulating the vehicle charge rate (or discharging in the case of V2G) to provide peak shaving and load shifting to their facility. These applications fall under the category of customer-facing services.

A significant amount of literature exists showing the potential benefits of, and barriers to, deploying vehicle-grid integration at a large-scale. Two recent California publications are notable here:

1. California Vehicle-Grid Integration Roadmap: Enabling vehicle-based grid services
    - California Independent System Operator, December 2013 http://www.caiso.com/Documents/Vehicle-GridIntegrationRoadmap.pdf
2. Vehicle-Grid Integration: A vision for zero-emission transportation interconnected throughout California's electricity system
    - California Public Utilities Commission, October 2013 http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M080/K775/80775679.pdf

S17 Strategic Objective: Provide Federal Cost Share for Technology Demonstration and Deployment Awards.

Table 21: Ratepayer Benefits Summary for Strategic Objective 17

	Promote Greater Reliability	Lower Costs	Increased Safety	Societal Benefits	GHG emissions mitigation and adaptation	Lower emission vehicles/ transportation	Economic Development	Public Utilities Code Section 740.1	Public Utilities Code Section 8360
S17.1 Provide Federal Cost Share for Technology Demonstration and Deployment Awards.	x	x	x	x	x	x	x	x	x

Source: California Energy Commission

Barriers and Challenges: Federal awards for clean energy funding usually require the applicant to provide match funding; for demonstration projects the amount of match funding required can be difficult for applicants to provide. State cost share can improve the competitiveness of proposals, increasing the amount of federal funding for projects located in California.

Investments in the *2012-2014 EPIC Investment Plan* addressing barriers and challenges: The *2012-2014 EPIC Investment Plan* included cost share for federal funding opportunities related to the technology demonstration and deployment initiatives in the Energy Commission's *2012-2014 EPIC Investment Plan*. This initiative focuses on federal funding opportunities for the technology demonstration and deployment initiatives included in the *2015-2017 EPIC Investment Plan*.

S17.1 Proposed Funding Initiative: Provide Federal Cost Share for Technology Demonstration and Deployment Awards.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	Full-scale Demo	Early Deployment	Market Facilitation	Grid Operations / Market Design	Generation	Transmission / Distribution	Demand – side Management
	X	X		X	X	X	X

Source: California Energy Commission

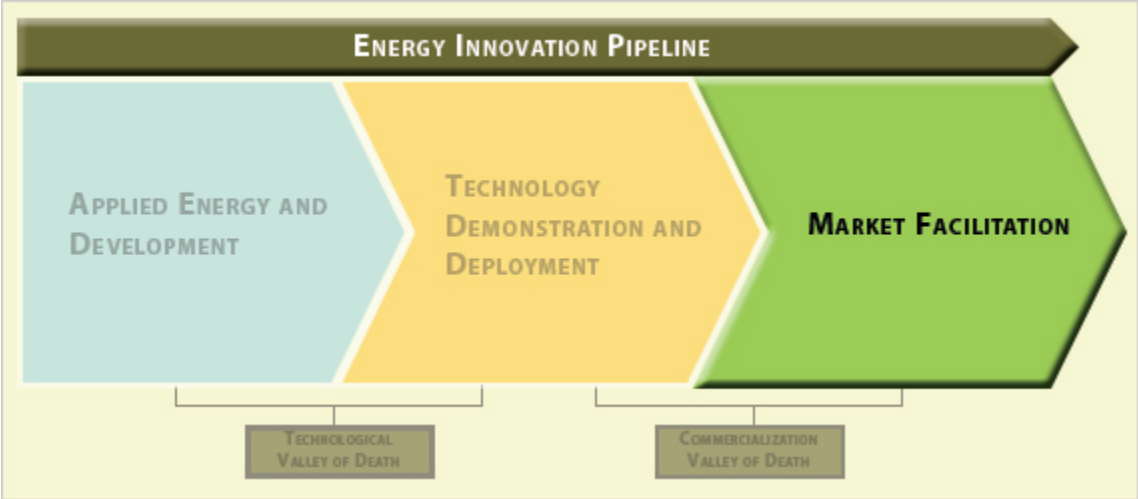
Purpose: This initiative will provide EPIC funds as cost share to leverage federal investments for projects that (a) meet the guiding principles of the decision; and (b) are aligned with the strategic objectives listed in the TD&D program area of this *2015-2017 EPIC Investment Plan*. Examples of federal cost share opportunities include:

- Co-funding technology demonstration and deployment projects in IOU territories with federal agencies including the U.S. DOE, U.S. DOD, and others, as appropriate.
- Providing cost-share funding for California entities that receive funding from the U.S. DOE, the U.S. DOD, and others as appropriate for TD&D projects.

Stakeholders: Research institutions, companies, U.S. DOE, U.S. DOD, nongovernmental organizations.

Background: By providing cost share for federal awards in the past, the Energy Commission has catalyzed investment to help achieve California's clean energy goals. For example, California was able to leverage more than $500 million in ARRA funds with a contribution of only around $20 million in state funds. Without this state cost share, many of the projects would not have been selected by the U.S. DOE for funding and California would have lost the ratepayer benefits, jobs, and economic development opportunities provided by these projects.

CHAPTER 5:
Market Facilitation



Source: California Energy Commission

To achieve the 21st century electricity system envisioned in Chapter 2 more than technological advancements are needed. Innovations are also needed to address the non-technical barriers and challenges limiting market adoption and expansion of ratepayer beneficial technologies and strategies in investor-owned utility (IOU) territories. This includes new approaches, new ideas, and new thinking for business models to help nascent technologies find early market footholds. It also includes procurement and permitting approaches that reduce the time, costs, and uncertainties of technology deployment, while maintaining safety, reliability, and environmental and public health. In addition, staff proposes initiatives to advance analytical tools that inform investment decisions for priority technologies and strategies in support of ensuring a clean, safe, affordable, reliable, and resilient electricity grid for IOU ratepayers. Through the Market Facilitation program area, the Energy Commission proposes funding initiatives to help overcome non-technical barriers to accelerate the commercial viability of high-priority technologies and strategies in IOU service territories. Strategic Objectives for the Market Facilitation area are listed in Table 22.

Table 22: Proposed Strategic Objectives for the Market Facilitation Program Area

Funding Area
S18 Strategic Objective: Foster the Development of the Most Promising Energy Technologies into Successful Businesses.
S19 Strategic Objective: Facilitate Inclusion of Emerging Clean Energy Technologies into Large-Scale Procurement Processes.
S20 Strategic Objective: Accelerate the Deployment of Energy Technologies in IOU Territories Through Innovative Local Planning and Permitting Approaches.
S21 Strategic Objective: Inform Investments and Decision-Making Through Market and Technical Analysis.
Market Facilitation Program Area Total

Source: California Energy Commission

S18 Strategic Objective: Foster the Development of the Most Promising Energy Technologies into Successful Businesses.

Table 23: Ratepayer Benefits Summary for Strategic Objective 18

	Promote Greater Reliability	Lower Costs	Increased Safety	Societal Benefits	GHG emissions mitigation and adaptation	Lower emission vehicles/ transportation	Economic Development	Public Utilities Code Section 740.1	Public Utilities Code Section 8360
S18.1 Facilitate a Commercialization Assistance Network to Foster Successful Clean Energy Entrepreneurship.	X	X	X	X	X	X	X	X	X
S18.2 Integrate Market Insight into the Selection and Management of EPIC Funded Technologies and Strategies.	X	X	X	X	X	X	X	X	X
S18.3 Provide Support for Entrepreneurs to Test, Verify, and Certify Their Innovations.	X	X	X	X	X	X	X	X	X

Source: California Energy Commission

Barriers and Challenges: Clean energy entrepreneurs and startup companies face a number of obstacles to successfully commercializing their promising innovations. Chief among these is the need to raise capital to further develop and scale-up their technologies. Investors often need to see a viable path to commercialization before they are willing or ready to make a financial commitment. They need assurance that the technology is feasible from a technical standpoint, that it has an early winnable market and commercial potential, and that it can be implemented at scale. Many entrepreneurs lack viable strategies; business expertise, experience, and connections; and an understanding of the needs of potential customers. In addition, many if not all are under financial and time constraints and do not have the means to purchase and permit the equipment and facilities needed to develop, test, validate, and obtain certification for their technologies. While a number of organizations throughout the state provide incubator- and accelerator-type services for clean energy companies, "At present the industry of clean energy technology incubation in California is poorly connected, insufficiently funded, and unreliably coordinated with the public interest funding provided by the state or the potential follow-on financing available from private investors. Moreover, there exists no structured mechanism whereby the firms and industries in need of clean energy solutions can make those needs, and the associated procurement processes, known to entrepreneurs and their financial partners."[107]

Investments in the *2012-2014 EPIC Investment Plan* addressing barriers and challenges: This initiative expands and updates activities that may be funded through S10 *Leverage California's Regional Innovation Clusters to Accelerate the Deployment of Early-Stage Clean Energy Technologies and Companies* in the *2012-2014 EPIC Investment Plan*. Proposals must explain how they avoid duplication and create synergies with opportunities available through S10.

S18.1 Proposed Funding Initiative: Facilitate a Commercialization Assistance Network to Foster Successful Clean Energy Entrepreneurship.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	Full-scale Demo	Early Deployment	Market Facilitation	Grid Operations / Market Design	Generation	Transmission / Distribution	Demand – side Management
			X	X	X	X	X

Source: California Energy Commission

107 Comment from questionnaire following February 7, 2014, public workshop from the California Clean Energy Fund.

Purpose: Lessons learned have identified the need to provide commercialization assistance for clean energy entrepreneurs to help ensure technologies have a viable path-to-market. Panel discussions held as part of EPIC workshops on August 3, 2012, August 10, 2012, and February 7, 2014, highlighted some commercialization assistance activities for clean energy entrepreneurs in California and throughout the U.S. Recurring themes at these three workshops, and in written stakeholder comments received, included the need to:

- Provide commercialization assistance for the most promising technologies.
- Establish an incubator network to provide comprehensive and coordinated commercialization assistance programs for entrepreneurs developing technologies with IOU-ratepayer-benefits.
- Develop a mechanism to identify and disseminate information on potential customer needs to entrepreneurs.
- Provide greater visibility for entrepreneurs to potential investors and customers.

This initiative will help facilitate a network of stakeholders to provide commercialization assistance and services to clean energy entrepreneurs and start-up companies. This network will exchange: ideas and best practices, information on promising technologies, and insights into specific market opportunities and customer needs. Also, this network will provide opportunities for entrepreneurs to engage with industry and investor stakeholders and receive market feedback and validation, as well as services to match entrepreneurs with customers in IOU service territories and guidance on incubators for product testing. This initiative may fund projects to:

- Enhance the best incubators and accelerators to provide entrepreneurs with facilities, equipment, mentoring, business expertise, and other resources needed to successfully transition good innovations from laboratory concepts to commercially viable clean energy products and services.
- Develop a suite of commercialization tools that helps entrepreneurs pull together information and resources needed to figure out how to successfully commercialize their innovations.
- Develop an online platform that connects entrepreneurs and other stakeholder groups working in the clean energy innovation space, such as incubators, accelerators, investors, and early-adopter customers.
- Conduct technology forums, showcase events, business plan competitions, and other activities that allow entrepreneurs to meet and engage with investors and customer in formalized settings.
- Convene a consortium of clean energy customers to define and articulate end-user needs for the electricity sector in IOU services territories. Market insight from this consortium would be disseminated and deployed to the network of incubators and accelerators supported through this initiative.

Stakeholders: Clean energy entrepreneurs and start-up companies, investors, innovation clusters, technology incubators and accelerators, universities, and small businesses.

Background: Projects funded by this initiative will build on, complement, and coordinate the most successful commercialization assistance efforts, some of which are described below, for technologies with the most potential to provide benefits to California IOU ratepayers.

- The Governor's Office of Business and Economic Development (GO-Biz) Innovation and Entrepreneurship unit administers California's Innovation Hub (iHub) Program, which includes support for cleantech businesses. The iHub Program leverages assets such as research parks, technology incubators, universities, and federal laboratories to provide an innovation platform for startup companies, economic development organizations, business groups, and venture capitalists.
- In addition to the iHub Program, California has a number of technology incubators, such as Prospect Silicon Valley and the Los Angeles Cleantech Incubator, that provide facilities and other services for entrepreneurs to develop and demonstrate their technologies. Other incubators, such as GreenStart, work with cleantech entrepreneurs to design business models, user experiences, and interfaces that improve a technology's commercial appeal. As part of an award it received from the Entrepreneurial Mentor Corps (EMC) pilot program run by the United States Department of Energy (U.S. DOE) and SBA, CleanTECH San Diego provides mentoring resources for clean energy start-ups, including targeted advice on revenue growth, employee growth, opportunities for outside financing, and avoiding pitfalls.
- The New York State Energy Research and Development Authority created an online platform called Cleantech NY Connect that provides a space for entrepreneurs to find funding, research trends in the cleantech market, and access the cleantech innovation ecosystem in New York. Entrepreneurs can connect with other entrepreneurs, investors, companies, government agencies and universities. The website posts events to help cleantech companies find funding, create a marketable product, and develop an effective business model. In addition, the New York State Energy Research and Development Authority has recently released a solicitation seeking proposals to develop a comprehensive self-guided program, called the Cleantech Commercialization Toolkit. The toolkit will provide resources, templates, and instructions for cleantech companies to build capabilities for commercialization. The toolkit will facilitate progress tracking and document sharing through an interactive website.
- The U.S. DOE has launched several programs focusing on early commercialization, including the Innovation Ecosystem Initiative, which develops regional partnerships to help bring new energy technologies to market. The U.S. DOE released a funding opportunity announcement seeking applicants to establish the National Incubator Initiative for Clean Energy to improve the performance of existing and new clean energy business incubators across the country by setting a high performance standard, fostering best practices, and improving coordination of the incubator community. In addition, the

U.S. DOE has organized an annual regional and nationwide cleantech business competition, which provides funding opportunities for top companies, and networking opportunities for cleantech companies, potential investors, business partners, and customers.

- The National Science Foundation (NSF) Innovation Corps (I-Corps) Teams and I-Corp Nodes help entrepreneurs commercialize NSF funded research. NSF I-Corps helps to transition technologies out of the laboratory, noting that skill sets required for research are not the same as the skills required to succeed in start-up business environments.

S18.2 Proposed Funding Initiative: Integrate Market Insight into the Selection and Management of EPIC Funded Technologies and Strategies.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	**Full-scale Demo**	**Early Deployment**	**Market Facilitation**	**Grid Operations / Market Design**	**Generation**	**Transmission / Distribution**	**Demand – side Management**
			X	X	X	X	X

Source: California Energy Commission

Purpose: This initiative will provide market intelligence and other analysis to ensure technologies and strategies funded though the EPIC Program are viable from a market standpoint, and can be economically scaled and widely deployed in IOU service territories. This initiative will help ensure real-time market analysis and investor perspectives are incorporated into the Energy Commission's selection and management of EPIC-funded projects. This initiative will provide funding for the following:

- Convene public forums with investors to generate input for decision-making regarding investment trends and market analysis for targeted energy sectors.
- Monitor and analyze real-time market trends and customer needs in IOU service territories. This includes engaging with customers, through surveys and other mechanisms, to ensure that innovations funded through EPIC are needed and wanted by an industry.
- Provide third-party analysis that helps Energy Commission staff evaluate the market viability of proposals received for select EPIC solicitations. Energy Commission technical staff will consider these analyses as part of the proposal scoring process.

- Review and evaluate commercialization plans submitted by EPIC award recipients as part of their grant or contract agreement deliverables. These evaluations will be used by Energy Commission staff during critical project reviews (see Chapter 7 for a description) to assess whether a project should continue to receive funding, be re-scoped, or be terminated.
- For select projects, assist EPIC recipients in updating their market strategies and commercialization plans and facilitating market handoffs after EPIC funding for the project has ended.
- Provide commercialization status updates on EPIC-funded innovations after the Energy Commission's agreement with the recipient has ended. This includes whether it has made sales or received private sector funding.

Stakeholders: Recipients of EPIC funds, investors, customers in IOU service territories.

Background: This initiative leverages best practices utilized by other energy research and development (R&D) organizations to ensure funded technologies have a viable path to market. Some of these best practices were discussed at EPIC workshops on August 3, 2012, August 10, 2013, and February 7, 2014, including the U.S. DOE's Advanced Research Projects Agency-Energy (ARPA-E) Technology-to-Market program, which prepares technologies funded through ARPA-E for an eventual transfer from lab to market. The Technology-to-Market team complements the technical program managers to evaluate projects from a market lens and works with grant recipients to develop market strategies, commercialization plans, and key commercialization milestones for each project. Similarly, the Cleantech to Market (C2M) program at the Haas School of Business at University of California, Berkeley conducts deep-dive market analyses and commercialization strategies for promising clean energy technologies being developed at UC Berkeley, Lawrence Berkeley National Laboratory, and CalTech. In addition, comments received by CalCEF recommended the formation of a market-facing partner that would provide a range of decision-support services to Energy Commission staff. These services would include revealing the perspective of private investors regarding specific technology opportunities of interest to the Energy Commission and determining how much EPIC investments have mobilized subsequent, private sector and other funding for technology commercialization.

S18.3 Proposed Funding Initiative: Provide Support for Entrepreneurs to Test, Verify, and Certify Their Innovations.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	**Full-scale Demo**	**Early Deployment**	**Market Facilitation**	**Grid Operations / Market Design**	**Generation**	**Transmission / Distribution**	**Demand – side Management**
			X	X	X	X	X

Source: California Energy Commission

Purpose: This initiative will provide support for entrepreneurs and start-ups to test, validate, and certify their innovations. This initiative will help provide assurance to potential customers and investors that the technology is fundamentally sound and meets customer specifications. This initiative may fund projects to:

- Survey entrepreneurs, customers, and investors to determine the most applicable independent testing and validation services and identify high priority technologies for these services.
- Provide support for existing testing and verification centers to enhance services and increase the ability of entrepreneurs with high priority technologies to utilize these services. This funding would support access to facilities, permitting, and testing equipment to enable companies to test and verify their technologies in controlled environments to approximate real-world conditions.
- Providing support for companies to demonstrate their technologies on test beds, including those operated by IOUs and the U.S. Department of Defense (U.S. DOD). California's IOUs currently have a number of test centers to evaluate electricity technologies in simulated scenarios, including Pacific Gas and Electric's (PG&E) Applied Technology Services test center in San Ramon, which is primarily focused on advanced transmission, distribution, and power electronics technologies. Emerging energy technologies could benefit from a similar model and leverage California's regional engineering and technical experts to streamline commercialization.
- Providing support for companies with the most promising technologies to obtain third-party certification that meets safety and performance specifications from key entities such as Underwriter Laboratories. A certification from UL can be costly; not only must company's pay for the testing, but they must also produce sample products that are often used in destructive testing. Furthermore, companies incur additional expenses if a tester needs to make a field visit, and may even have to pay for testing equipment on site. The total cost of a given certification can easily exceed $10,000, even if the product is assembled from previously approved components.

Stakeholders: Clean energy entrepreneurs and start-up companies, investors, customers.

Background: Activities funded by this initiative will be similar to testing used by the U.S. DOD and Wal-Mart before widespread adoption of new technologies. However, this initiative will not duplicate testing conducted elsewhere. Specifically, a report published by the Consortium for Science, Policy and Outcomes at Arizona State University, Energy Innovation at the Department of Defense Assessing the Opportunities, March 2012,[108] found that this approach was also key to the innovation model used by the U.S. DOD:

> "The centerpiece of DOD's innovation model for facilities energy is its Installation Energy Test Bed. The test bed is designed to demonstrate emerging energy technologies in a real-world, integrated building environment in order to reduce risk, overcome barriers to deployment, and facilitate wide-scale commercialization. The test bed requires no new physical infrastructure; rather, it operates as a distributed activity whose key element is the systematic evaluation of new technologies, both to determine their performance, operational readiness, and life cycle costs, and to provide guidance and design information for future deployment across installations (p. 38)."

This report also found that the value of this approach is applicable in the private sector:

> "One indication of the value of this approach is that Wal-Mart, the largest private sector energy consumer in the United States, has its own test bed. Wal-Mart systematically tests innovative energy technologies at designated stores to assess their performance and cost-effectiveness. The technologies that prove to be cost-effective (not all of them do, which is itself a valuable finding) are deployed by Wal-Mart in all of its stores. This approach has helped Wal-Mart dramatically reduce its energy consumption (p. 38)."

The U.S. DOD is required to produce or procure 25 percent of facility energy consumption from renewable sources by 2025.[109] To support this effort, U.S. DOD funded the operation of multiple energy technology testing centers across the United States. One such testing center, the Technikon Renewable Energy Testing Center at McClellan Air Force Base in California, provides third-party analysis of promising waste-to-energy technologies.

Third party certification can be a major selling point for new companies as they try to convince consumers of their product's integrity and differentiate their product from the competition. In addition, industrial, commercial, and consumer-level customers will need the confidence to know that a new technology has been certified to perform efficiently, safely, reliably and correctly. Many products need certain certifications before they can be sold internationally, such as CE marking in the United Kingdom and the CCC mark in China. Companies that wish to label their products with the Energy Star label must obtain the United States Environmental

108 http://bipartisanpolicy.org/sites/default/files/Energy%20Innovation%20at%20DoD.pdf

109 10 U.S.C. 2911(e), as cited in American Council on Renewable Energy (ACORE), February 2014. *RENEWABLE ENERGY FOR MILITARY INSTALLATIONS: 2014 INDUSTRY REVIEW*, p. 25.

Protection Agency (U.S. EPA)-recognized third party testing, often from a Nationally Recognized Testing Laboratory (NRTL). LEED building certification involves a lengthy application and certification process and can be quite expensive and can reach $1/sq.ft. Underwriters Laboratories (UL) is approved by the Occupational Safety and Health Administration (OSHA) and is internationally respected as an important certifier in the cleantech space.

S19 Strategic Objective: Facilitate Inclusion of Emerging Clean Energy Technologies into Large-Scale Procurement Processes.

Table 24: Ratepayer Benefits Summary for Strategic Objective 19

	Promote Greater Reliability	Lower Costs	Increased Safety	Societal Benefits	GHG emissions mitigation and adaptation	Lower emission vehicles/ transportation	Economic Development	Public Utilities Code Section 740.1	Public Utilities Code Section 8360
Initiative S19.1: Develop Tools and Strategies to Encourage Large-Scale Purchasers to Adopt Emerging Energy Technologies.	X	X	X	X	X			X	X
Initiative S19.2: Facilitate Innovative Procurement Strategies to Reduce Costs for Clean Energy Technologies.		X			X			X	X

Source: California Energy Commission

Barriers and Challenges: One of the key challenges for companies developing and commercializing energy emerging technologies is finding initial markets that will allow them to scale-up their innovations. EPIC funding to advance procurement practices by large procurers in IOU service territories can help address this barrier. Large procurers, such as military bases, government facilities, ports, hospitals, Department of General Services, University of California and building developers, capable of widely deploying clean energy technologies can help create the early market pull needed for companies to ramp up production and build economies of scale. In addition to cost, these large procurers are often motivated by reliability, power quality, and other factors when purchasing energy technologies. However, due to long lead times, lengthy procurement processes, and competing demands for limited resources, advances in clean energy are slow to be widely adopted by large procurement entities. This means

government and large commercial enterprises may be failing to capture opportunities to reduce costs and improve energy services. To accelerate the deployment of cutting edge technologies and energy upgrades, solutions are needed for procurement challenges, such as:

- Limited technical expertise, experience, and resources needed to assess and compare product offerings from a multitude of vendors.
- Lack of unbiased and objective information on technology performance, including cost-effectiveness, reliability, and end-user acceptance.
- Questions and concerns regarding regulatory, permitting, and installation requirements. This includes whether the product can be incorporated into existing systems or construction processes; and whether there is a sufficient labor force to install and maintain the equipment.
- Additional tools, resources, and mechanisms to streamline procurement processes.
- Wider adoption of innovative procurement strategies to reduce the "soft costs" associated with energy technology purchases.

Investments in the *2012-2014 EPIC Investment Plan* addressing barriers and challenges: The *2012-2014 EPIC Investment Plan* did not address barriers and challenges that limit the ability of large purchasers to procure advances in clean energy.

S19.1 Proposed Funding Initiative: Develop Tools and Strategies to Encourage Large-Scale Purchasers to Adopt Emerging Energy Technologies.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	Full-scale Demo	Early Deployment	Market Facilitation	Grid Operations / Market Design	Generation	Transmission / Distribution	Demand – side Management
			X		X		X

Source: California Energy Commission

Purpose: This initiative would develop tools and enhance technical assistance to reduce risk and uncertainty related to purchasing decisions for clean energy and would encourage large purchasers to adopt emerging energy technologies into their procurement practices. This initiative may fund activities to:

- Enhance the ability of technical assistance providers to incorporate next generation clean energy technologies into their business services. For example, this initiative could fund third-party evaluation services to better compare proposals from a common set of analytics, as well as expanded technical support to prepare itemized scopes of work detailing how installations are to be performed.
- Focus on high priority technologies and strategies for energy upgrades and enhancements identified by large facility managers and builders in IOU service territories. This may also build on results from ARB AB32 audits of industrial facilities, "big data" initiatives, software for remote audits, energy usage surveys, and related proceedings at the CPUC and the Energy Commission. This will help develop "demand-driven acceleration and multiple institutional relationships, tailored to the needs of local clients and the types of innovation evident in or desired by the region."[110] Results from this survey would identify key technology areas to include in the best-in-class designation tools for selected emerging clean energy technologies.
- Develop and disseminate tools to incorporate clean energy technologies into facility design, project development, and maintenance operations. These tools could include best-in-class designations, construction price catalogs for clean energy equipment and services, and industry specific case studies to help facility mangers quickly assess which products offer the best value. This initiative could also fund enhancement of tools to help builders assess the types of clean energy technologies best suited for the location of a project based on site characteristics and available energy, geographic, and financial resources.
- In support of the best in class designation, evaluate a portfolio of selected clean energy technologies previously demonstrated to work under general operational conditions to determine which technologies are ready for procurement in specific, highly risk-averse markets. This will allow would-be purchasers to compare alternatives and assess whether the equipment would improve energy affordability, reliability, and safety in their facilities. This best in class designation testing would help clean energy technologies become procurement eligible by large-scale purchasers in target markets.

Stakeholders: Utilities, builders, facility managers, third-party energy service providers, clean energy technology vendors.

Background: This initiative would complement, enhance, and expand similar services currently available for clean energy purchasing decisions. For example, in partnership with participating Southern California local governments, the Southern California Regional Energy Network offers services ranging from education and outreach to financing to help expand

110 http://www.energy.ca.gov/research/epic/documents/2014-02-07_workshop/comments/D_Adler_2014_EPIC_questionnaire_-_CalCEF_Climate_Solutions_Accelerator_2014-03-13_TN-72778.pdf.

implementation of energy efficiency upgrades in private and public sector projects. This network brings together energy consulting firms in a collaboration which allows them to learn from each other experiences, to compile and share data generated by technologies that get implemented and utilized, and which generates feedback loops in regard to proper application and installation of emerging clean energy technologies.

S19.2 Proposed Funding Initiative: Facilitate Innovative Procurement Strategies to Reduce Costs for Clean Energy Technologies.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	**Full-scale Demo**	**Early Deployment**	**Market Facilitation**	**Grid Operations / Market Design**	**Generation**	**Transmission / Distribution**	**Demand – side Management**
			X		X		X

Source: California Energy Commission

Purpose: This initiative would facilitate new applications of innovative procurement strategies to reduce the cost and time needed for large-scale purchasing of clean energy technologies in IOU service territories. Expansion of buyer-collaborative purchasing arrangements, lease agreements, and innovative financing mechanisms can help achieve deep market penetration for clean energy technologies by large-scale entities. Potential strategies include:

- New applications of local and regional collaborative procurement processes to aggregate multiple buyers into group requests for proposals. For example, this initiative could help facilitate collaborative procurement processes between the military and local governments in IOU service territories. These processes provide ratepayer benefits by attracting volume discounts, lowering administrative overhead, and reducing transaction costs.
- Expanded use of lease agreements and innovative financing strategies for clean energy beyond solar photovoltaic (PV) systems. For example, third-party leases have been widely deployed for rooftop solar systems; this initiative could facilitate utilization of this for other technologies, such as electric vehicle (EV) battery second-use agreements. Companies, such as Mosaic, are beginning to use crowd sourcing to finance solar systems.

Stakeholders: Utilities, builders, facility managers, third-party energy service providers, and clean energy technology vendors.

Background: Examples of successful collaborative bulk purchasing programs have been demonstrated in both the public and private sector. Local or regional solar collaborative purchasing programs have been implemented in Minnesota, Massachusetts, Oregon and California. In California, the cities of Los Angeles and San Francisco have implemented successful programs. In addition private sector companies have built a successful business model around solar group discounts. These entrepreneurs market group buying initiatives to solar providers across the U.S. based on demand generated by aggregated groups of individuals and businesses that are interested in having solar installed.[111]

For example, the Silicon Valley Collaborative Renewable Energy Procurement (SV-REP) Project has installed 12 megawatts (MW) of solar across six jurisdictions using the aggregated purchasing model. The project has demonstrated that by working together, jurisdictions could lower project risks and realize higher returns; dramatically reduce transaction costs and administrative effort; and effectively consolidate fragmented efforts to pursue viable options. This type of purchasing model could be more broadly applied in IOU service territories.

In addition, the US EPA has a clean energy collaborative procurement initiative for local agencies located within the metropolitan Washington D.C. area. Through this initiative, the U.S. EPA is partnering with federal and local government, military facilities, and local schools to develop an effective and collaborative platform for deploying clean energy (predominately solar PV).[112]

111 www.statesadvancingsolar.org/.

112 U.S. Environmental Protection Agency, www.epa.gov/greenpower/initiatives/cecp/documents/MWDC_CleanEnergyProcurement_LocalAgencies.pdf.

S20 Strategic Objective: Accelerate the Deployment of Energy Technologies in IOU Territories Through Innovative Local Planning and Permitting Approaches.

Table 25: Ratepayer Benefits Summary for Strategic Objective 20

	Promote Greater Reliability	Lower Costs	Increased Safety	Societal Benefits	GHG emissions mitigation and adaptation	Lower emission vehicles/ transportation	Economic Development	Public Utilities Code Section 740.1	Public Utilities Code Section 8360
S20.1 Develop Innovative Approaches to Integrate Utility and Local Government Planning for Emerging Technology Deployment.	X	X			X		X	X	X
S20.2 Develop Innovative Strategies to Streamline the Permitting Process for Zero Net Energy Buildings.	X		X	X	X	X	X	X	X

Source: California Energy Commission

Barriers and Challenges: Despite their potential benefits to ratepayers, emerging energy technologies and strategies can often be held up by regulatory, permitting, and land use requirements. Improved planning at the regional and local levels can help accelerate the deployment of new clean energy technologies and strategies in a manner that optimizes the energy, environmental, and societal benefits to the local community as well as the larger electricity grid. However, local governments currently lack the advanced tools, information, and process innovations for deploying these technologies in a timely and optimal manner, leading to a long and expensive process for potential clean energy solution providers. For instance, projects using emerging clean energy technologies face uncertainty and delays related to assessing and mitigating environmental impacts. This hampers progress and increases costs toward achieving California's clean energy goals.

In recent years, super storms and other extreme weather events have raised awareness of the need to improve preparedness for extreme natural and manmade emergency events affecting availability of electricity supply and demand. However, action to respond to this need is slow due to inadequate funding needed to update or develop energy assurance strategies.

New opportunities for energy end-users to become energy providers, zero-net energy (ZNE) users, and well informed market players are in the early stages of deployment in California. There is a need for land use decisions and policies at the local level anticipating growing interest and availability for distributed energy resources, especially in communities that embrace these changes as an economic development opportunity. Recent legislation focuses

attention on plans to coordinate land use planning and electricity infrastructure needs for distributed energy. However, some local governments may need access to additional expertise and resources to implement best practices, safety regulations, and other permitting processes to capture these opportunities and avoid problems that could arise in this changing clean energy market place.

Investments in the *2012-2014 EPIC Investment Plan* addressing barriers and challenges: The *2012-2014 EPIC Investment Plan* also addresses permitting barriers and challenges. Initiative S20.1 will build on Initiative S16.2 from the *2012-2014 EPIC Investment Plan*. This initiative will seek to provide IOU electricity ratepayer benefits through complementing other programs available to assist local government regulatory processes and permit streamlining, such as grants related to DRECP and regional energy planning, smart chargers for electric vehicles, and hydrogen infrastructure. Initiative S20.1 will offer competitive grants for selected local governments to update their comprehensive plans, regulations, and codes where needed to incorporate findings from the Distribution Resources Plan that is required by Assembly Bill 327 (Perea, Chapter 611, Statutes of 2013). This legislation requires each IOU to prepare a distribution resources plan to identify optimal locations for distributed renewable generation resources, energy efficiency, energy storage, EVs, and demand response (DR) technologies consistent with the goal of yielding net benefits to ratepayers. These plans are due to the CPUC by June 1, 2015, and will inform local governments of anticipated needs so they can identify and include compliance safety standards when permitting next generation clean energy technologies, such as storage and microgrids.

S20.1 Proposed Funding Initiative: Develop Innovative Approaches to Integrate Utility and Local Government Planning for Emerging Technology Deployment.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	Full-scale Demo	Early Deployment	Market Facilitation	Grid Operations / Market Design	Generation	Transmission / Distribution	Demand – side Management
			X	X	X	X	X

Source: California Energy Commission

Purpose: This initiative will provide support for selected local governments in IOU territories to upgrade comprehensive plans, regulations, and codes to promote next generation clean energy technologies identified in the Distribution Resources Plan required by Assembly Bill 327 (Perea, Chapter 611, Statutes of 2013).

The Distribution Resources Plan will inform local governments of anticipated needs so that they can identify and include compliance safety standards when permitting next generation clean energy technologies, such as storage and microgrids. This will allow local governments to build on best practices and lessons learned from previous storage, microgrid and other clean energy research and demonstration projects in California and other states.

In addition, this initiative will build on existing processes for planning and development of energy assurance strategy documents for local governments in the California IOU service territories. In coordination with EPIC IOU initiatives for emergency preparedness, this initiative will provide funding to assist local governments with the preparation of energy assurance strategy documents using the California Local Energy Assurance Planning (CaLEAP) program, Cal-Adapt or other existing tools. In addition, this initiative will help build knowledge networks for deployment of microgrids, combined heat and power (CHP) facilities, and new approaches to strengthening resilience and reliability of electricity systems.

This initiative is different than current efforts in place to assist local governments. Local governments will need to update their regulations for the installation of next generation clean energy technologies that are entering the market in order to ensure that developers or installers of these technologies will not incur delays and uncertainty.

Stakeholders: Electric ratepayers, utilities, clean energy equipment manufacturers, building designers, developers, contractors and consultants, distribution grid operators, local governments, ports, military, preferred resource developers, environmental organizations.

Background: The Energy Commission has developed grant solicitations outside of EPIC that involved working with local governments with energy planning and development. Projects funded under this initiative will not duplicate similar projects already funded by the Energy Commission, which include the projects listed below and projects funded under Public Resources Code Section 25619.[113]

The Governor signed Assembly Bill 327 into law on October 7, 2013, and added Public Utilities Code Section 769, which specified requirements including:

- By July 1, 2015, each IOU prepare a distribution resources plan to identify optimal locations for distributed renewable generation resources, energy efficiency, energy storage, EVs, and DR technologies consistent with the goal of yielding net benefits to ratepayers.
- Evaluate locational benefits and costs of distributed resources located in the distribution system.
- Identify barriers to the deployment of distributed resources, including, but not limited to, safety standards related to technology or operation of the distribution circuit in a manner that ensures reliable service.

113 California Energy Commission, Renewable Energy and Conservation Planning Grants, Docket No. 12-GREP-1, http://www.energy.ca.gov/renewables/planning_grants/

The CaLEAP and Cal-Adapt programs have been recognized in many state plans, including the *2013 Integrated Energy Policy Report (IEPR)*[114] and State Hazard Mitigation Plan. The CaLEAP uses a web tool application that local governments use in preparing plans to ensure key assets are resilient to disasters that affect energy. Cal-Adapt is a web-based interactive visualization tool that allows the user to identify potential climate change risks in specific geographic areas through the state.

The Energy Commission sponsored the CaLEAP program to assist local governments with developing energy assurance plans that focus on energy and functionality of key assets within a community. CaLEAP used American Recovery and Reinvestment Act funding to develop its program and began accepting applications in December 2012, through the CaLEAP website. Funding for technical support of the website expired in July 2013. Through the efforts of CaLEAP, nine counties and over one hundred cities located in California have developed energy assurance plans. However, many local governments still do not have energy assurance plans in place. For example, the 2012 Census of Governments reports that there are approximately 539 general purpose governments in the state of California. These general purpose governments include all counties, cities and other localities.

Along these lines, the State of Massachusetts is investing $50 million to address vulnerabilities to climate change in public health, transportation, energy, and the environment.

S 20.2 Proposed Funding Initiative: Develop Innovative Strategies to Streamline the Permitting Process for Zero Net Energy Buildings.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	Full-scale Demo	Early Deployment	Market Facilitation	Grid Operations/ Market Design	Generation	Transmission / Distribution	Demand – side Management
			X	X	X	X	X

Source: California Energy Commission

114 *2013 Integrated Energy Policy Report*, dated January 2013, CEC-100-2013-001-CMF, page 335, http://www.energy.ca.gov/2013publications/CEC-100-2013-001/CEC-100-2013-001-CMF.pdf

Purpose: This initiative would develop and test innovative permitting strategies in IOU ratepayer territories that achieve ZNE community readiness by mid-2015 to provide reduced development fees for ZNE projects located in the community. ZNE community readiness means a streamlined process with permitting rules and regulations in place to facilitate the development of ZNE communities.

This initiative would provide a grant for communities to initiate innovative approaches to streamlining permitting and development of ZNE-ready communities. For example, applicants should propose permitting and siting solutions to projects that meet the goals of S1.2 *Developing Model Designs and Strategies for Cost-Effective Zero Net Energy Homes and Buildings*, or S14.1 *Using Microgrids to Evaluate a Combination of Emerging Technologies to Determine the Best Integrated Performance and Least Cost Configuration to Meet the Customers Energy Needs*. Applicants could propose permitting and siting innovations for a potential design for a 2030 community (for example, a single substation) today, including advances energy efficiency, DR, distributed renewable energy, storage, and so forth. This initiative seeks innovative answers to the question, "how can we reduce the permitting costs of developing ZNE communities?" Those that have an agreement in place with building developers would receive a grant to help buy-down the cost of implementing the agreement. Results of the project would be shared widely to showcase best practices for other local governments to follow in future projects.

Stakeholders: Local governments, building industry, clean energy technology vendors, clean energy project developers.

Background: The 2013 *IEPR*[115] discussed the Energy Commission's policy recommendations regarding the pursuit of ZNE Buildings for newly constructed buildings. "These policies have been supported by the CPUC in the Long-Term Energy Efficiency Strategic Plan, the California Air Resources Board (ARB) in the *Climate Change Scoping Plan,*[116] and Governor Brown's *Clean Energy Jobs Plan.*[117] Separately, Governor Brown's Executive Order B-18-12[118] calls for all newly constructed state buildings and major renovations that begin design after 2025 be constructed as ZNE facilities. The Executive Order also calls for achieving ZNE for 50 percent of the square footage of existing state-owned building area by 2025."

115 *2013 Integrated Energy Policy Report*, dated January 2013, CEC-100-2013-001-CMF, page 34, http://www.energy.ca.gov/2013publications/CEC-100-2013-001/CEC-100-2013-001-CMF.pdf

116 California Air Resources, *Climate Change Scoping Plan: A Framework for Change*, 2008, http://www.arb.ca.gov/cc/scopingplan/document/adopted_scoping_plan.pdf

117 Clean Energy Jobs Plan, http://gov.ca.gov/docs/Clean_Energy_Plan.pdf

118 Executive Order B-18-12, April 25, 2012, http://gov.ca.gov/news.php?id=17508

The CPUC, *California Energy Efficiency Strategic Plan*, January 2011 Update,[119] outlined several "big bold" goals related to ZNE buildings which included, all new residential construction in California will be ZNE by 2020, and all new commercial construction in California will be ZNE by 2030. The goals identified in the Strategic Plan provide long term targets for the CPUC and the Energy Commission, and are not mandated.

S21 Strategic Objective: Inform Investments and Decision-Making Through Market and Technical Analysis.

Table 26: Ratepayer Benefits Summary for Strategic Objective 21

	Promote Greater Reliability	Lower Costs	Increased Safety	Societal Benefits	GHG emissions mitigation and adaptation	Lower emission vehicles/ transportation	Economic Development	Public Utilities Code Section 740.1	Public Utilities Code Section 8360
S21.1 Conduct Analyses on Different Technology Options and Strategies for the Electricity System.	X	X	X	X	X	X	X	X	X
S21.2 Develop a Clearinghouse for Advanced Energy Technologies, Strategies and Tools.	X	X	X	X	X	X	X	X	X
S21.3 Measure and Verify the Ratepayer Benefits of EPIC-Funded Innovations.	X	X	X	X	X	X	X	X	X

Source: California Energy Commission

Barriers and Challenges: The draft 2013 *Safeguarding California Report*[120] and the 2013 *IEPR*[121] suggest that the energy sector, in addition to reducing greenhouse gas (GHG) emissions, should

119 *California Energy Efficiency Strategic Plan*, January 2011 Update, http://www.cpuc.ca.gov/NR/rdonlyres/A54B59C2-D571-440D-9477-3363726F573A/0/CAEnergyEfficiencyStrategicPlan_Jan2011.pdf

120 CNRA. 2013. *Safeguarding California: Reducing Climate Risk*. http://resources.ca.gov/climate_adaptation/docs/Safeguarding_California_Public_Draft_Dec-10.pdf

121 California Energy Commission. 2013. *2013 Integrated Energy Policy Report*. Publication Number: CEC-100-2013-001-CMF.

evolve in a way that reduces its vulnerabilities to climate impacts. There is a need to assist the clean energy market to develop products and strategies that are robust under a wide range of plausible potential futures, taking into account multiple factors that introduce uncertainty. At the same time, priority should be given to options and business models that are win-win strategies for ratepayers, utilities, and clean energy under current and future climate conditions.

Also, future funding opportunities and priorities for EPIC may change as new state energy policies are implemented and emerging technologies are developed and deployed into the state's evolving electricity system. To ensure efficient use of ratepayer funds in this dynamic and ever-changing environment, research is needed to develop gap analyses, scenario assessments, and other decision-making tools to ensure that EPIC funds are optimally directed towards technologies and barriers that provide the greatest benefits to IOU ratepayers.

Investments in the *2012-2014 EPIC Investment Plan* addressing barriers and challenges: The *2012-2014 EPIC Investment Plan* did not contain funding initiatives addressing the barriers and challenges described above.

S21.1 Proposed Funding Initiative: Conduct Analyses on Different Technology Options and Strategies for the Electricity System.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	Full-scale Demo	Early Deployment	Market Facilitation	Grid Operations / Market Design	Generation	Transmission / Distribution	Demand – side Management
			X	X	X	X	X

Source: California Energy Commission

Purpose: This initiative will assess clean energy technologies, business models, and strategies under a range of conditions and scenarios to inform investments and decision-making to benefit IOU ratepayers. This initiative will include funding for analysis to:

- Identify trends, gaps, and performance characteristics needed for emerging clean energy technologies, business models, and strategies to fare well under a wide range of potential energy scenarios and climate outcomes over the next several decades.
- Encourage modeling efforts that investigate the long-term system impacts of policies that promote technology development.
- Collect and synthesize multiple datasets into high-resolution tools that can be used to analyze key trends and drivers affecting energy use; evaluate and improve the

effectiveness of energy policies and programs, and target energy investments to areas where they will have the greatest impact.

- Analyze regulatory changes and business models to help accelerate adopting emerging clean energy technologies by making a better business case that benefits both ratepayers and IOUs.
- Conduct forums for decision-makers to ensure transfer of scientific studies into policy and regulatory decisions impacting IOU ratepayers.
- Develop, technology status reports, market analyses, gap analyses, and roadmaps needed to inform development of future EPIC initiatives and other decision-making to advance IOU ratepayer benefits. Results of the analyses will be used to strategically target future EPIC investments in a manner that provides optimal benefits to IOU ratepayers, and maximizes the use of public R&D investments. Specifically, these analyses may include the following topics:
    - Industrial, Agricultural and Waste Energy Efficiency
        - Data centers.
        - Petroleum refineries.
        - Electronics industry.
        - Food processing.
        - Industrial (for example, cement, pharmaceutical, glass).
        - Water/wastewater (coordinated with Water Research Foundation roadmapping effort).
        - Food processing.
        - Pre-harvest agriculture (for example, irrigation and sensors).
    - Building Energy Efficiency
        - Lighting.
        - Heating, ventilation, and air conditioning (HVAC).
        - Envelopes.
        - Plug-loads (coordinated with CalPlug roadmapping effort).
        - ZNE buildings (coordinated with PGE roadmapping effort).
        - Existing buildings (coordinated with IOU roadmapping effort).
    - Clean Energy Generation
        - Distributed renewable energy systems.
        - Biopower.

- Strategies to increase utility scale power plant performance.
- Reducing environmental barriers to renewable energy permitting and Deployment (including water, habitats and species, and air quality).
- ZNE communities (coordinated with energy efficiency efforts).

Studies suggest that low income communities may be least resilient to climate change impacts (Shonkoff et. al. 2011;[122] Cooley et. al. 2012).[123] This initiative may support studies to identify energy efficiency, renewable energy, and related clean energy trends that hold the most promise for addressing this concern, as well as business models to facilitate greater access to these advances in clean energy for low-income households. This initiative will inform selection of priorities for future technology development and deployment to reduce the cost to IOU ratepayers in achieving California's climate goals under a range of climate and energy scenarios. This work will fund evaluations of potential impacts of breakthrough technologies and heavily leverage past and future work supported by EPIC initiatives designed to develop long-term energy scenarios and assess their impacts to IOU ratepayers.

For the third part of this initiative, studies exploring regulatory changes and business models to advance clean energy may assess technologies such as microgrids, ZNE buildings, whole building retrofits, second-use EV batteries, and EV charging across IOU territories.

Stakeholders: Ratepayers, clean energy entrepreneurs and start-up companies, investors, electric utilities, California Independent System Operator (California ISO), CPUC, ARB, U.S. DOE, U.S. DOD, other federal agencies, policymakers, local governments, building developers, energy researchers, and energy industry groups.

Background: Past research supported by the Energy Commission has developed multiple energy scenarios, including transportation energy, natural gas, and electricity system scenarios and an evaluation of electricity system needs in 2030 prepared in support of the 2013 *IEPR*. Going forward, funding from EPIC could support analysis to expand this work, considering issues such as potential financial constraints to the rapid transformation of the energy system, the impact of climate change on energy demand and generation, and consideration of electricity distribution networks at the regional/urban scales. Scenarios with relatively high geographical and temporal resolutions should be used to avoid unanticipated environmental impacts. Further development and sensitivity testing of potential energy scenarios for ratepayers are needed, with in-depth consideration on reducing the climate vulnerability of the energy system.

122 Shonkoff, S. B., Morello-Frosch, R., Pastor, M., & Sadd, J. 2011. The climate gap: environmental health and equity implications of climate change and mitigation policies in California—a review of the literature. *Climatic change*, *109*(1), 485-503

123 Cooley, H., E. Moore, M. Heberger, and L. Allen (Pacific Institute). 2012. *Social Vulnerability to Climate Change in California*. California Energy Commission. Publication Number: CEC-500-2012-013

Recent studies suggest that multiple paths are available for meeting our 2050 GHG emissions goals. However, projected costs vary widely depending on the policy environment. These studies will identify strategies and technologies likely to have the greatest impact. For example, a recent study indicated that achieving the SunShot goal of $1 per watt for central station solar technologies by 2020 would significantly reduce costs of achieving California's 2050 emissions target and would greatly increase the share of solar in the energy mix (Mileva et. al. 2013).[124]

In addition, there are a number of clean energy technologies with promising potential to provide IOU ratepayer benefits, advance California's clean energy goals, and provide additional complementary benefits. However, existing regulatory environments and business practices may not reflect the innovation needed to capture win-win opportunities that can be created through deployment of these technologies in IOU ratepayer territories.

Roadmaps and gap analyses conducted under this initiative will help:

- Identify critical current and future research funding gaps to achieve IOU ratepayer benefits encompassed in state policy goals**.**
- Prioritize potential research activities based on near-term, mid-term, and long-term needs; potential to benefit ratepayers; investment risk; and other criteria to maximize IOU ratepayer benefits for each dollar invested.

In the past, the Energy Commission has funded gap analyses and other assessments to identify R&D activities needing public interest funding support. These assessments have been critical to identifying and prioritizing funding opportunities in research roadmaps, budget plans, and other R&D planning documents. Existing Energy Commission research roadmaps contain gap analyses to identify critical barriers and R&D opportunities that are not covered by other private or public funding sources, however many of these roadmaps need to be updated to reflect current technology advances and market trends.

In addition to gap analyses, scenario assessments can also help direct EPIC investments to technologies that will provide the greatest ratepayer benefits.

124 Mileva, A., Nelson, J. H., Johnston, J., & Kammen, D. M. 2013. SunShot solar power reduces costs and uncertainty in future low-carbon electricity systems. *Environmental science & technology*, *47*(16), 9053-9060.

S21.2 Proposed Funding Initiative: Develop a Clearinghouse for Advanced Energy Technologies, Strategies and Tools.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	**Full-scale Demo**	**Early Deployment**	**Market Facilitation**	**Grid Operations / Market Design**	**Generation**	**Transmission / Distribution**	**Demand – side Management**
			X	X	x	x	X

Source: California Energy Commission

Purpose: This initiative will develop an on-line clearinghouse for information on advanced energy technologies, strategies and tools for use by the residential, commercial, industrial, agriculture and water and other sectors. This on-line tool will provide these sectors with information about the results of various Energy Commission funded research, such as technical and economic feasibility, demonstration sites, status of technology and contact information. Another potential activity is creation of an information exchange for facility owners, design professionals, and skilled labor working in facilities construction, operation, and maintenance trades to share integrated DSM, ZNE and other information and experiences based on demonstration and deployment results. This information exchange will take into account existing online activities and can include lessons learned, innovative financing mechanisms, and evaluation of "phased" or incremental approaches to integrated DSM and ZNE buildings, such as determining the technical/economic feasibility of achieving various levels of efficiency or ZNE building attainment.

Key Stakeholders: EPIC Program administrators, grant recipients, and ratepayers.

Background: The building, industrial, agriculture and water, and regulatory sectors often do not know about the results of research activities conducted by the Energy Commission's R&D programs. Without this knowledge, successful emerging technologies do not have an opportunity to be adopted, duplication of efforts can result, and improvements to technologies may not occur.

S21.3 Proposed Funding Initiative: Measure and Verify the Ratepayer Benefits of EPIC-Funded Innovations.

Technology Pipeline Stage				Electricity System Value Chain			
Applied R&D and Pilot-scale Testing	Full-scale Demo	Early Deployment	Market Facilitation	Grid Operations / Market Design	Generation	Transmission / Distribution	Demand – side Management
			X	X	x	x	X

Source: California Energy Commission

Purpose: This initiative will conduct assessments for select projects funded through the EPIC Program to evaluate and verify their benefits to ratepayers. This initiative will fund the following activities:

- Conduct independent measurement and verification for select projects to determine whether recipients of EPIC funds are meeting performance targets stated in their proposal and agreement.
- Develop technical and market potential estimates for technologies and strategies funded through the EPIC Program.
- Conduct independent evaluation of the Energy Commission's portfolio of projects funded through the EPIC Program.
- Conduct follow-up to obtain information regarding the project's potential benefits to ratepayers after the recipient's agreement with the Energy Commission has ended. Examples of the type of information that would be collected include:
    - Type, location, and number of jobs created.
    - Follow-on funding received.
    - Transfer of project results to stakeholders.

Key Stakeholders: EPIC Program administrators, grant recipients, and ratepayers.

Background: Evaluation and verification conducted through this initiative will provide information needed for the Energy Commission to understand how well the program is meeting its goals, providing ratepayer benefits, and addressing barriers to achieving the state's clean energy goals.

CHAPTER 6: New Solar Homes Partnership

In Decision 13-11-025, the CPUC modified and approved the Energy Commission's proposed *2012-2014 EPIC Investment Plan* without funding for the New Solar Homes Partnership (NSHP) Program. Instead, the CPUC transferred consideration of the funding source and budget for the NSHP under Public Utilities Code section 2851 (e)(3) to Rulemaking 12-11-005; the CPUC Rulemaking Regarding Policies, Procedures, and Rules for the California Solar Initiative (CSI), the Self-Generation Incentive Program, and Other Distributed Generation (DG) Issues.[125]

For the *2015-2017 EPIC Investment Plan*, the Energy Commission requests that the CPUC reserve discretion to reconsider the direction provided in Decision 13-11-025 to utilize EPIC collections to fund the NSHP Program if necessary to avoid an interruption or possible suspension of the NSHP Program due to increased demand for program funds.

The NSHP is currently underfunded. Although it was established by Senate Bill 1 as a $400 million program under the CSI, the law did not create a vehicle for adequately funding the NSHP.[126] Instead, the law relied on moneys in the Renewable Resource Trust Fund (RRTF) that were allocated to the Energy Commission's Emerging Renewables Program, and supported by the public goods charge (PGC) collections under Public Utilities Code section 399.8, to fund the NSHP.[127] These PGC collections ended on December 31, 2011.

The gap between RRTF funds already collected and available for NSHP and the $400 million program cap under Senate Bill 1 exceeds $130 million. This is the amount Energy Commission staff seeks to have available to encumber for NSHP through 2016. At this time, the Energy Commission proposes keeping all options for NSHP funding open, including combining different funding sources, provided total funding does not exceed the $400 million cap for NSHP under Senate Bill 1.

125 Decision 13-11-025 at pages 36 -40.

126 Senate Bill 1 (Murray, Stats. 2006, Ch. 132, Sec. 7), as codified in former Public Utilities Code section 2851 (e), provided in pertinent part "… The financial components of the California Solar Initiative shall consist of . . . (3) Programs for the installation of solar energy systems on new construction, administered by the State Energy Resources Conservation and Development Commission … and funded by nonbypassable charges in the amount of four hundred million dollars ($400,000,000), collected from customers of San Diego Gas and Electric Company, Southern California Edison Company, and Pacific Gas and Electric Company pursuant to Article 15 (commencing with Section 399)." Section 2851 (e) has subsequently been amended by Senate Bill 1018 (Stats. 2012, Ch. 39, Sec. 111).

127 Public Resources Code section 25744.5.

As of April 4, 2014, the Energy Commission has NSHP Program funds totaling approximately $57.4 Million.[128] Based on historical activity and industry comments, the Energy Commission expects to reserve current program funds by the middle of 2015. However, program funds may be exhausted sooner. If this occurs and other funding is not available, the Energy Commission would want the CPUC to act quickly to address additional NSHP funding under Public Utilities Code section 2851 (e)(3).

Using EPIC monies to fund the NSHP is consistent with sections 740.1 and 8360 of the Public Utilities Code, and is no longer precluded by section 2851 (e)(3) of the Public Utilities Code, as noted in Decision 13-11-025.[129] The modifications to section 2851 (e)(3) in 2012 by Senate Bill 1018 (Chapter 39, Statutes of 2012) removed funding constraints for the NSHP Program and allowed the program to be funded with EPIC moneys. In this *2015-2017 EPIC Investment Plan*, it may be appropriate to allocate EPIC monies for the NSHP Program if other sources of funding are not available. If so, the CPUC should retain the discretion and flexibility to consider the use of EPIC funds for the NSHP as part of the EPIC proceeding, separate and apart from any considerations under proceeding R.12-11-005.

Options the CPUC could consider include funding the NSHP Program exclusively with EPIC funds over the *2015-2017 EPIC Investment Plan* cycle or over the Investment Plan cycle from 2015-2020, funding it in part with EPIC funds and in part with funds available through the CSI proceeding, and funding it through additional EPIC collections or through a redirection of existing EPIC collections allocated to the Energy Commission. To facilitate the consideration of these options, the Energy Commission will keep the CPUC informed on the status of the NSHP and available program funding.

Specifically, the Energy Commission's future annual EPIC reporting to the CPUC will include a recommendation on whether EPIC funds should be transferred to the NSHP in a given year; the level of total funds that have been collected and made available for NSHP applications; and the balance of funds still available for new reservations.

If other funding sources are not available to NSHP, and EPIC funds are needed to fill a funding gap for NSHP, the Energy Commission recommends reducing EPIC funds allocated to proposed initiatives in other program areas. NSHP falls under the market support program area.

The NSHP follows the state's "loading order" which identifies an order for guiding energy decisions: electricity needs should first be addressed by increased energy efficiency and demand response (DR), second by renewable resources, and third by clean fossil fuel

128 Information on the status of NSHP funding is available online at http://www.gosolarcalifornia.org/about/nshp.php.

129 Decision 13-11-025 at page 37.

generation. This decreases the customer's electricity demand and ensures properly sized systems. By encouraging the installation of residential solar systems, NSHP also supports the goals of Senate Bill 626 (Chapter 355, Statutes of 2009), Assembly Bill 32, and Executive Order S-3-05.

The NSHP Program addresses the principles in the Public Utilities Code Sections 740.1 and 8360 by providing market support and promoting the purchase and installation of solar energy systems, and encouraging the development and improvement of new and existing solar technologies. The NSHP is the only program in investor-owned utility(IOU) service territories that provides incentives for installing solar photovoltaic systems on new residential construction. The incentives do not cover the full system costs, maximizing the use of ratepayer funds and ensuring that funds are spent efficiently. The incentive offsets solar energy system costs, helping to transform the new housing market to expand the use of rooftop solar as a standard feature and making solar energy systems affordable for more IOU ratepayers.

CHAPTER 7: Program Administration

This chapter discusses the procedures and processes the Energy Commission will follow for selecting, funding and managing projects and programs, and conducting program outreach efforts. The chapter starts with a discussion of how stakeholders can participate then continues with a discussion of how projects will be selected and awarded. The award process section covers the types of funding mechanisms that will be used, examples of possible eligibility criteria, and funding limitations. The project management section discusses oversight and monitoring of funded projects to ensure they meet their stated objectives. This chapter concludes with an overview of outreach strategies that will be used to disseminate results and the Energy Commission's approach to intellectual property within the EPIC Program framework.

An independent third-party will conduct an evaluation of the EPIC Program, overseen by the CPUC, at the completion of each triennial term. The purpose of this evaluation is to assess the effectiveness of the program and provide recommendations for improvement.

Stakeholder Participation

Investment Plan Development

The Energy Commission sent out a survey questionnaire soliciting stakeholder input on ideas for proposed initiatives in each of the program areas and held the first stakeholder workshop on February 7, 2014, in Northern California. The purpose of the workshop was to gain stakeholder input on Market Facilitation prior to the development of the *2015-2017 EPIC Investment Plan*. The EPIC administrators held two joint workshops on March 17, 2014 in Northern California and March 21, 2014 in Southern California to provide an overview and solicit public comment on each of the administrators' draft Investment Plan.

Public comments received as a result of the workshops are summarized in the appendices.

The Energy Commission has created a website (http://energy.ca.gov/research/epic/) that provides information and activities associated with EPIC funding, including information on past workshops, public comments, upcoming events, how to sign up for the list serve, and all the latest documents associated with the program.

Investment Plan Implementation

Energy Commission staff will hold public meetings in order for any interested individuals or entities (stakeholders) to provide input on the implementation of the *2015-2017 EPIC Investment Plan*, including seeking advice on project implementation, identifying synergy with other

projects, solicit end-user needs and path to market opportunities, and facilitate a faster and more effective sharing of program results. These informal stakeholder meetings will not create a formal decision-making body and will work within the decisions of the CPUC. They will serve to provide transparency and accountability for investments, coordinate research to avoid duplication, seek opportunities to leverage funds, and ensure research is targeting ratepayer benefits. The Energy Commission will conduct stakeholder meetings in a public forum at least twice each year to provide program updates and gain valuable insight on progress and direction.

As required by CPUC Decision 12-05-037, the Energy Commission will consult with interested stakeholders no less than twice a year, both during the development of each investment plan and during its execution. 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 Independent System Operator (California ISO)
- Consumer groups
- Environmental organizations
- Agricultural organizations
- Academics
- Business community
- Energy efficiency community
- Clean energy industry and/or associations
- Other industry associations

The Energy Commission will invite members of the public to participate in these meetings.

Annual Reporting Requirements

The Energy Commission will submit annual reports to the CPUC in February of each year beginning in 2013. As articulated in the CPUC Phase 2 decision, 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 (statutes of 2013) added section 25711.5 to the California Public Resources Code. Regarding annual reports, Public Resources Code section 25711.5 requires the Energy Commission 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 that shall include all of the following:

1. 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.
2. 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.
3. 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.
4. Identification of the award recipients that are California-based entities, small businesses, or businesses owned by women, minorities, or disabled veterans.
5. 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.
6. Identification of the total amount of administrative and overhead costs incurred for each project.

Competitive Award Preference for EPIC Funds

Public Resources Code section 25711.5, added in 2013 by Senate Bill 96, requires the Energy Commission to use competitive bids as the preferred method to solicit project applications and award funds pursuant to the EPIC Program.

The vast majority of initiatives included in this *2015-2017 EPIC Investment Plan* will be implemented through the Energy Commission's competitive solicitation process to ensure a

fair, open, and transparent opportunity for interested parties. The competitive process is outlined later in this chapter.

Senate Bill 96 states that the Energy Commission may use a sole source or interagency agreement method 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 Energy Commission, at least 60 days prior to making an award pursuant to this subdivision, 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.

Section 25711.5 states that it is the intent of the Legislature to ensure legislative oversight for EPIC awards is made by the Energy Commission on a sole source basis or through an interagency agreement.

The Energy Commission's preference for a competitive selection process in EPIC will apply to public and private entities. The procedures for competitive solicitations will follow applicable requirements from the State Contracting Manual, State Public Contracts Code, Public Resources Code, and other laws and regulations, such as civil service restrictions, prevailing wages, and the California Environmental Quality Act.

Administrative Cost Containment

The Energy Commission will monitor its administrative costs to manage the EPIC Program within the 10 percent cap established in the CPUC's EPIC decision. Administrative cost will also be part of the competitive proposal evaluation process, as discussed later in this section, please refer to Tables 30, 35, and 38. Additionally, as required by Senate Bill 96, the Energy Commission and award recipients will justify actual administration and overhead costs incurred.

Foster Investments in California

EPIC investments will maximize funds spent in state to foster and grow California-based businesses and institutions. This will have direct and indirect economic benefits statewide and to regional economies, as discussed further in the project selection criteria section.

Coordination with Other Research, Demonstration and Deployment Efforts

The Energy Commission will stay abreast of both in-state and national research, demonstration, and deployment activities. Agencies with energy-related activities such as the United States Department of Energy (U.S. DOE), the United States Department of Defense (U.S. DOD), the CPUC, and the California Air Resources Board (ARB) will provide key input into the EPIC gap analysis and road mapping activities. In the past, Energy Commission staff has participated in U.S. DOE's 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 U.S. DOE and California's energy agencies (the CPUC, the ARB, the California ISO, and the Energy Commission) have initiated a high-level dialogue to facilitate improved collaboration.

At the request of Energy Commission Chair Robert Weisenmiller, the Energy Commission's Energy Research and Development Division is collaborating with the U.S. DOE to leverage public research dollars in California. On June 4, 2013, the Energy Commission entered into a Memorandum of Understanding with the U. S. DOE's Advanced Research Projects Agency (ARPA-E) to maximize coordination of funding opportunities. ARPA-E funds the development and deployment of transformational energy technologies and systems. Consistent consultation and coordination between the Energy Commission and U.S. DOE will improve current funding processes, and will provide greater cost-share opportunities to potential awardees and maximize the public/ratepayer benefits associated with innovative energy technologies.

California's national labs, academic institutions and other private organizations are leaders in clean energy research innovations. The Energy Commission will encourage broad participation across the state in EPIC implementation through public stakeholder workshops and meetings and outreach efforts. The purpose is for interested individuals to provide input on the implementation of the *2015-2017 EPIC Investment Plan*, identify synergies and path to market opportunities, and sharing of program results.

The Energy Commission is committed to on-going collaboration with the three utility administrators at least twice a year. Coordination meetings have been valuable in the development of this *2015-2017 EPIC Investment Plan* to identify each administrator's area of focus, as well as to suggest synergistic opportunities to collaborate. On-going collaboration will

be a cornerstone of the program to assure EPIC activities return the highest benefit to California ratepayers.

Competitive Solicitation Process

Prior to releasing a solicitation, staff will identify the specific research, demonstration, or deployment objectives for the solicitation. Solicitation objectives will be designed to remove specific clean energy deployment barriers and will be mapped to achieve specific clean energy goals. These objectives are typically derived from a roadmap, through stakeholder workshops or responses to a questionnaire sent to stakeholders on the EPIC list serve. The questionnaire asks stakeholders to present their ideas for applied research, development, technology demonstration, deployment or market facilitation. Roadmaps are documents prepared for specific program areas that identify high priority funding initiatives needed to meet state policy, industry, and private sector goals.

The solicitation process will begin with posting a Program Opportunity Notice (PON) or a Request for Proposal (RFP) announcement on the Energy Commission's website that contains all the information needed by interested parties to participate in the solicitation. The Energy Commission will notify interested parties of the funding opportunity through a number of available list servers.[130] All funding opportunity announcements will indicate the topic or topics addressed in the solicitation, the amount of funding available, and project and applicant eligibility requirements.

The posted solicitations on the Energy Commission website will contain all the materials, including electronic files, needed for a successful submission. These documents will include the application manual, required templates, and all instructions. The application manual will identify the solicitation purpose and objectives, the funding levels for research topics, project and applicant eligibility requirements, screening and/or scoring criteria, match funding requirements, selection and award process, grounds for submittal rejection and the solicitation schedule. The application manual will also include standardized templates for preparing work statements and budgets. Also included will be the Energy Commission's award terms and conditions that each applicant must agree to comply with. The appendix contains examples of recently released solicitations.

Bidder Eligibility

EPIC solicitations will be open to all public and private entities and individuals interested in electricity-related applied research and development (R&D), technology, demonstration, and deployment (TD&D), and market facilitation. However, some solicitations may target specific

130 To register for the EPIC List Serve: http://www.energy.ca.gov/research/epic/.

entities, such as universities or local governments. Eligibility for receiving EPIC funding through the competitive process is based on the specific screening and scoring criteria set forth in the solicitation application manual as explained in the following sections.

Solicitation Workshop and Schedule

Shortly after a solicitation has been posted, Energy Commission 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 Energy Commission 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 Energy Commission website. An estimation of a typical solicitation schedule is shown in Table 27.

Table 27: Solicitation Timeline

Estimated Solicitation Schedule	Approximate Timeline (calendar days)
Solicitation Release	Day 0
Pre-Application Workshop	Day 14
Deadline for Written Questions	Day 16
Post Questions, Answers and Addenda to Website	Day 26
Deadline to Submit Applications	Day 56
Post Notice of Proposed Awards	Day 120
Business Meeting Date	Day 300
Agreement Start Date	Day 360

Source: California Energy Commission

Project Award Requirements in the Three Funding Areas

The CPUC's EPIC decision outlined three funding areas for the Energy Commission administered program: Applied Research and Development, Technology Demonstration and Deployment, and Market Facilitation. Additionally, rather than set aside a specific amount of funding for federal cost share (with U.S. DOE, U.S. DOD and other federal appropriate entities), the EPIC Program will allow applied R&D and TD&D strategic objectives to apply up to 10 percent of their approved funding to support federal cost share opportunities through initiatives S11: *Strategic Objective: Provide Federal Cost Share for Applied Research Awards* and S17: *Strategic Objective: Provide Federal Cost Share for Technology Demonstration and Deployment Awards*.

The purpose is to help California companies and research entities secure federal funds that will benefit California ratepayers and the state's economy.

The following describes the award process for funding opportunities with a single-stage proposal process.

Applied Research and Development Award Requirements

Projects in the Applied Research and Development investment area will focus on new technologies, methods, and approaches from early bench-scale up to pilot-scale prototype demonstrations that seek to solve identified problems in the electricity system "value chain." Nontechnology approaches are also included, such as strategies and methods to enhance adoption of clean energy technologies and R&D that addresses electricity-related environmental and public health impacts, clean energy transportation, and building and appliance codes and standards. Awards in this area will help remove barriers and advance state energy goals for renewable energy, energy efficiency, the smart grid, and electric transportation.

Staff will evaluate the technical feasibility and practicality of proposed solutions, strategies, or technologies. At this phase in the energy innovation pipeline, projects that are awarded funding will likely not have a clear business case for deployment of private capital, meaning that the amount of match funding in most cases will be low, if any. Therefore, match funding is typically not required for research proposals in this program area. However, bidders that provide match funding can receive higher scores during the proposal evaluation process. This criterion is clearly spelled out in the application manual. Proposals will be initially screened (Stage One Screening) by Energy Commission staff to ensure that they meet minimum administrative requirements (for example, Table 28). Failure in any one criterion could result in rejection of the entire proposal.

All proposals passing the initial Stage One Screening will then be scored by a committee consisting of Energy Commission staff and possibly others, who can receive assistance from external technical reviewers when needed. The committee will apply a scoring scale (for example, Table 29) to a set of technical scoring criteria (for example, Table 30). These criteria helps ensure that the proposed project has merit, is feasible and does not duplicate other efforts, the team is qualified and the budget is reasonable. Technical scoring criteria will differ from solicitation to solicitation, depending on the specific solicitation objectives and expected products.

Each technical criterion has an assigned number of points, and is divided into multiple sub-criteria. The sub-criteria are not equally weighted. Each applicant submits a project narrative which responds to each sub-criterion and this is one of the main documents used to score the applications. The Energy Commission staff may require that applications achieve a minimum passing score on certain criteria in order to be considered for an award. The total minimum passing score is typically 70 out of 100 points.

Table 28: Example Stage One Administrative Evaluation Criteria

EXAMPLE SCREENING CRITERIA *The Application must pass ALL criteria to progress to Stage Two.*	**Pass/Fail**
1. The proposal is received by the Energy Commission's Contracts, Grants, and Loans Office by the due date and time specified in the solicitation.	☐ Pass ☐ Fail
2. The proposal addresses at least one of the funding initiatives, as indicated in the Solicitation.	☐ Pass ☐ Fail
3. The requested funding falls within the minimum and maximum range specified in the solicitation.	☐ Pass ☐ Fail
4. The applicant and project meet the Eligibility Criteria in of the solicitation.	☐ Pass ☐ Fail
5. The proposal is prepared in the format specified in the solicitation.	☐ Pass ☐ Fail
6. The proposal is complete, meaning that it: (1) includes all documents required (2) includes all information required within each document; and (3) is signed where required by an authorized representative.	☐ Pass ☐ Fail
7. The project end date does not extend past the end date specified in the solicitation.	☐ Pass ☐ Fail
8. Match Funding *(required only for Technology Demonstration and Deployment applications).* The Application Form and budget specify that the applicant will provide at least 20% or greater of the requested Energy Commission funds as match funding.	☐ Pass ☐ Fail ☐ N/A (project does not involve demonstration)
9. *Applicable only to Technology Demonstration and Deployment projects* <u>Demonstration Projects require that</u>: o The Application Form identifies one or more demonstration site locations. o All demonstration sites are located in a California electric IOU service territory (PG&E, SDG&E, or SCE). o The Project Narrative includes a measurement and verification plan as described in the solicitation.	☐ Pass ☐ Fail ☐ N/A (project does not involve demonstration)
10. The proposal does not contain any confidential information or identify any portion of the proposal as confidential.	☐ Pass ☐ Fail
11. The applicant has not included a statement or otherwise indicated that it will not accept the terms and conditions, or that acceptance is based on modifications to the terms and conditions.	☐ Pass ☐ Fail
12. The proposal includes one or more commitment letters as described in the solicitation.	☐ Pass ☐ Fail

Source: California Energy Commission

Table 29: Example Scoring Scale

% of Possible Points	Interpretation	Explanation for Percentage Points
0%	Not Responsive	• Response does not include or fails to address the requirements being scored. • The omission(s), flaw(s), or defect(s) are significant and unacceptable.
10-30%	Minimally Responsive	• Response minimally addresses the requirements being scored. • The omission(s), flaw(s), or defect(s) are significant and unacceptable.
40-60%	Inadequate	• Response addresses the criteria • There are one or more omissions, flaws, or defects or the criteria are addressed in such a limited way that it results in a low degree of confidence in the proposed solution.
70%	Adequate	• The response adequately addresses the criteria. • Any omission(s), flaw(s), or defect(s) are inconsequential and acceptable.
80%	Good	• The response fully addresses the requirements being scored with a good degree of confidence in the Applicant's response or proposed solution. • No identified omission(s), flaw(s), or defect(s). Any identified weaknesses are minimal, inconsequential, and acceptable.
90%	Excellent	• The response fully addresses the criteria with a high degree of confidence in the applicant's response or proposed solution. • The applicant offers one or more enhancing features, methods, or approaches exceeding basic expectations.
100%	Exceptional	• All requirements are addressed with the highest degree of confidence in the Applicant's response or proposed solution. • The response exceeds the requirements in providing multiple enhancing features, a creative approach, or an exceptional solution.

Source: California Energy Commission

Table 30: Example Technical Scoring Criteria and Maximum Points – Applied Research

Maximum Points	Technical Scoring Criteria
20	Technical Merit and Need a. Provides a clear and concise description of the goals, objectives, technological or scientific knowledge advancement, and innovation in the proposed project. b. Explains how the proposed project will lead to technological advancement and breakthroughs that overcome barriers to achieving the state's statutory energy goals. c. Summarizes the current status of the relevant technology and/or scientific knowledge, and explains how the proposed project will advance, supplement, and/or replace current technology and/or scientific knowledge. d. Justifies the need for EPIC funding and why the proposed work is not adequately supported by competitive or regulated markets. e. Discusses the degree to which the proposed work is technically feasible and achievable. f. Provides a clear and plausible test plan that describes how energy savings and other benefits specified in the proposal will be determined and measured.

Maximum Points	Technical Scoring Criteria
20	Technical Approach a. Describes the technique, approach, and methods to be used in providing and performing the work described in the Scope of Work. b. Describes how tasks will be executed and coordinated with various participants and team members. c. Identifies and discusses factors critical for success, in addition to risks, barriers, and limitations. d. Describes how the knowledge gained, experimental results, and lessons learned will be made available to the public and key decision-makers.
20	Impacts and Benefits to California IOU Ratepayers. [131] a. Explains how the proposed project will benefit California Investor-Owned Utility (IOU) electricity ratepayers with respect to the EPIC goals of greater reliability, lower costs, and/or increased safety. b. Provides clear, plausible, and justifiable **quantitative** estimates of potential benefits for California IOU electricity ratepayers, including annual energy savings, peak load reduction, energy cost reductions, greenhouse gas emission reductions, and other benefits. c. States the timeframe, assumptions, and calculations for the estimated benefits, and explains their reasonableness. d. Identifies impacted market segments in California, including size and penetration or deployment rates, with underlying assumptions. e. Discusses any qualitative or intangible benefits to California IOU electricity ratepayers, including timeframe and assumptions. f. Provides a cost-benefit analysis that compares project costs to anticipated benefits and explains how costs and benefits will be calculated and quantified and identifies any underlying assumptions.

131 All of the scoring criteria will evaluate benefits to ratepayers. For example, technical approach and team experience will lead to higher probability of success while cost criteria ensure ratepayer value at lower costs.

Maximum Points	Technical Scoring Criteria
10	Team Qualifications, Capabilities and Resources a. Describes the organizational structure of the applicant and the project team. b. Identifies key team members, including the project manager and principal investigator. c. Summarizes the qualifications, experience, capabilities, and credentials of the key team members d. Explains how the various tasks will be managed and coordinated, and how the project manager's technical expertise will support the effective management and coordination of all projects in the application. e. Describes the facilities, infrastructure, and resources available to the team. f. Describes the team's history of successfully completing projects (for example, RD&D projects) and commercializing and/or deploying results/products. g. Identifies past projects that resulted in a market-ready technology. h. References are current, meaning within the past three years. i. Identifies any collaboration with utilities, industries, or others. Explains the nature of the collaboration and what each collaborator will contribute. j. Demonstrates that the applicant has the financial ability to complete the project, as indicated by the responses to the following questions: o Has your organization been involved in a lawsuit or government investigation within the past five years? o Does your organization have overdue taxes? o Has your organization ever filed for or does it plan to file for bankruptcy? o Has any party that entered into an agreement with your organization terminated it, and if so for what reason? o For Energy Commission agreements listed in the application that were executed (for example, approved at a Commission business meeting and signed by both parties) within the past five years, has your organization ever failed to provide a final report by the date indicated in the agreement? k. Support or commitment letters (for match funding, test sites, or project partners) indicate a strong level of support or commitment to the project
10	Budget and Cost Effectiveness a. Justifies the reasonableness of the requested funds relative to the project goals, objectives, and tasks. b. Justifies the reasonableness of costs for direct labor, non-labor (for example, indirect overhead and general and administrative costs), and operating expenses by task. c. Explains why the hours proposed for personnel and subcontractors are reasonable to accomplish the activities in the Scope of Work. d. Explains how the applicant will maximize funds for technical tasks and minimize expenditure of funds for program administration and overhead.

Maximum Points	Technical Scoring Criteria
15	Funds Spent in California a. Applicants must indicate that the amount of EPIC funds to be spent in California. The Energy Commission solicitation will specify the points to be awarded based on the percentage of funds spent in California. b. "Spent in California" means that: (1) Funds under the "Direct Labor" category and all categories calculated based on direct labor in the B-4 budget attachments (Prime and Subcontractor Labor Rates) are paid to individuals who pay California state income taxes on wages received for work performed under the agreement; and (2) Business transactions (for example, material and equipment purchases, leases, rentals, and contractual work) are entered into with a business located in California. Airline ticket purchases and payments made to out-of-state workers are not considered funds "spent in California." However, funds spent by out-of-state workers in California (for example, hotel and food) are considered funds "spent in California."
5	Ratio of Direct Labor and Fringe Benefit Rates to Loaded Labor Rates • The score for this criterion will be calculated from the Rates Summary worksheet in the budget forms, which compares the weighted direct labor and fringe benefits rate to the weighted loaded rate. This ratio, as a percentage, is multiplied by the possible points for this criterion.

Source: California Energy Commission

For applied research there is no match requirement. However, applicants that provide match funding will receive additional points during the scoring phase, similar to the process described in Table 31 or as delineated in the solicitation.

Table 31: Example Method for Awarding Match Funding Points

Maximum Points	Example Match Fund Criteria
10	**Match Funding (Optional)** • Each match funding contributor must submit a commitment letter that meets the requirements specified in the solicitation • Funds pledged must be consistent with the amount or dollar value described in the commitment letter(s) and in the application. • 5 points for this criterion will be awarded based on the percentage of match funds relative to the EPIC funds requested. This ratio will be multiplied by 5 to yield the points, and rounded to the nearest whole number. For example: If requested EPIC funds are $1,000,000 and match funds are $500,000, the match funding ratio is 0.50. The proposal will be awarded 3 points. • The remaining 5 points for this criterion will be based on the level of commitment, dollar value justification, and funding replacement strategy described in the match funding commitment letter. The proposal scoring scale in Table 29 will be used to rate these criteria.

Table 32 shows an example of how the points from Table 29, scoring scale, and Table 30, technical scoring criteria, are applied to determine the score for the proposal. Passing proposals are typically those that achieve at least 70 percent of all points.

Table 32: Calculating the Proposal Score for Company A

Technical Scoring Criteria	Table 30 A Maximum Points	Table 29 B Evaluator Applies Scoring Scale	A x B Evaluator Score
Technical Merit	20	80%	16
Technical Approach	20	80%	16
Impacts and Benefits to California IOU Ratepayers	20	80%	16
Team Qualifications	10	90%	9
Budget Cost Effectiveness	10	80%	8
Funds Spent in California	15	70%	10.5
Ratio of Direct Labor and Fringe Benefit Rates to Loaded Labor Rates	5	80%	4
Total	**100**		**79.5**

Source: California Energy Commission

All 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 staff funding amount recommended, match funding and score status. Funding will first be awarded to the top ranked proposal and then to the next ranked until all funds have been expended. A sample NOPA is shown in Table 33.

Table 33: Sample NOPA

Name of Bidder/Applicant	Funds Requested	Funds Awarded	Match Amount	Score	Status
A Company	$1,000,000	$1,000,000	$200,000	83.5	Awardee
B Company	$500,000	$500,000	$5,000	80	Awardee
C Company	$3,000,000	$3,000,000	$200,000	79.5	Awardee
D Company	$2,000,000	$2,000.000	$10,000	77	Awardee
E Company	$2,000,000	$0	$100,000	71	Finalist*
F Company	$500,000	$0	$5,000	65	Did not pass
G Company	$2,000,000	$0	$20,000	50	Did not pass
Total	**$11,000,000**	**$6,500,000**			

Source: California Energy Commission

* To be awarded only if additional funds are available.

Table 34 provides a summary of the three-year funding for applied R&D on average, the estimated project award per recipient, match fund requirement, and amount of funding set aside to match federal grants. Each solicitation would have a minimum and maximum funding level for each proposal, tailored to the individual solicitation. Some initiatives may exceed the typical maximum project award per recipient.

Table 34: Summary of Three Year Funding for Applied Research and Development

3-Year Funding for Applied Research and Development	$151.63 million
Estimated Minimum/Maximum Project Award Per Recipient	$250,000 to $3 million*
Match Funding Requirement	None but those providing match will receive higher scores during proposal evaluation
Estimated Funding to Match Federal Program Investments (3 years)	EPIC Program will allow applied research and development strategic objectives to apply up to 10 percent of the funding to support federal cost share opportunities

Source: California Energy Commission

* Individual projects vary due to broad spectrum of projects under applied research from a simple component project to a pilot scale test. Pilots will generally not exceed $3 million of EPIC funds though the Energy Commission retains the option for larger pilot-scale demonstrations with higher matching funds.

**Set aside funding to leverage federal program investments to promote federal economic investments in California.

Technology Demonstration and Deployment Award Requirements

Projects under the TD&D investment area will focus on technologies, methods, and approaches that are beyond the "proof-of-concept" stage. These projects must have completed field, lab, bench-scale and/or pilot-scale work with verified performance data to warrant pre-commercial/commercial scale-up.

The overall goal for projects funded under the TD&D is to demonstrate innovative technologies at an appropriate scale, at an appropriate host-site (that is, demonstrated in the intended market of the technology), under real-world conditions, and to validate energy, water and cost savings, air quality and electric transportation sector improvements, overall economics (including operation and maintenance costs), reliability, life-cycle cost assessment, and other criteria necessary to commercialize the technology/strategy and gain public acceptance. EPIC TD&D projects will be expected to have a clearly articulated path to market that will then be specified in the project scope of work.

When appropriate, the EPIC Program will coordinate with the investor-owned utilities (IOUs) to provide research results and technologies that can be incorporated into utility-sponsored incentive/rebate programs to accelerate wider market adoption and deployment. Additionally, there may be opportunities to collaborate on projects to maximize the synergistic effect of both utility and Energy Commission EPIC Programs. The EPIC Program will also strive to partner with private companies in the industrial, agriculture, and renewable energy sectors and in the residential and commercial building industries, as well as with automotive manufacturers and entrepreneurs in clean energy markets. Projects that receive awards should demonstrate a clear

link to business and commercialization with a plan to manufacture and market successful technologies within five years after successful demonstration.

Since TD&D projects have higher levels of private benefits and are near to commercialization, match funding will be required for TD&D projects. Typically, a minimum 20 percent of requested EPIC funds must be pledged as match funds. The solicitation application manual may require contingency plans to replace lost match funds, or specify stricter requirements on the level of matching funds and define what may be counted as matching funds.

Similar to applied research, proposals will be initially screened to ensure compliance with minimum requirements, such as using the criteria in Table 28. Proposals that pass this initial screening will then be evaluated by a technical scoring committee using a scoring scale, such as the one shown in Table 29 and applying technical scoring criteria such as shown in Table 35. The technical scoring committee will typically consist of technology experts from the Energy Commission staff, who can receive assistance from external reviewers when needed.

Table 35: Example Technical Scoring Criteria and Maximum Points for Technology Demonstration and Deployment Projects

Maximum Points	Technical Scoring Criteria
20	Technical Merit and Need a. Provides a clear and concise description of the goals, objectives, technological or scientific knowledge advancement, and innovation in the proposed project. b. Explains how the proposed project will lead to technological advancement and breakthroughs that overcome barriers to achieving the state's statutory energy goals. c. Summarizes the current status of the relevant technology and/or scientific knowledge, and explains how the proposed project will advance, supplement, and/or replace current technology and/or scientific knowledge. d. Justifies the need for EPIC funding and why the proposed work is not adequately supported by competitive or regulated markets. e. Discusses the degree to which the proposed work is technically feasible and achievable. f. Provides a clear and plausible test plan that describes how energy savings and other benefits specified in the proposal will be determined and measured.

Maximum Points	Technical Scoring Criteria
20	Technical Approach a. Describes the technique, approach, and methods to be used in providing and performing the work described in the Scope of Work. b. Describes how tasks will be executed and coordinated with various participants and team members. c. Identifies and discusses factors critical for success, in addition to risks, barriers, and limitations. d. Describes how the knowledge gained, experimental results, and lessons learned will be made available to the public and key decision-makers.
20	Impacts and Benefits to California IOU Ratepayers. [132] a. Explains how the proposed project will benefit California Investor-Owned Utility (IOU) ratepayers with respect to the EPIC goals of greater reliability, lower costs, and/or increased safety) b. Provides clear, plausible, and justifiable **quantitative** estimates of potential benefits for California IOU electricity ratepayers, including annual energy savings, peak load reduction, energy cost reductions, greenhouse gas emission reductions, and other benefits. c. States the timeframe, assumptions, and calculations for the estimated benefits, and explains their reasonableness. d. Identifies impacted market segments in California, including size and penetration or deployment rates, with underlying assumptions. e. Discusses any qualitative or intangible benefits to California IOU electricity ratepayers, including timeframe and assumptions. f. Provides a cost-benefit analysis that compares project costs to anticipated benefits. Explains how costs and benefits will be calculated and quantified, and identifies any underlying assumptions. g. *For Technology Demonstration and Deployment Projects* Provides a measurement and verification ("M&V") plan that describes how the actual project benefits will be measured and quantified

132 All of the scoring criteria will evaluate benefits to ratepayers. For example, technical approach and team experience will lead to higher probability of success while cost criteria ensure ratepayer value at lower costs.

Maximum Points	Technical Scoring Criteria
10	Team Qualifications, Capabilities and Resources a. Describes the organizational structure of the applicant and the project team. b. Identifies key team members, including the project manager and principal investigator. c. Summarizes the qualifications, experience, capabilities, and credentials of the key team members d. Explains how the various tasks will be managed and coordinated, and how the project manager's technical expertise will support the effective management and coordination of all projects in the application. e. Describes the facilities, infrastructure, and resources available to the team. f. Describes the team's history of successfully completing projects (for example, RD&D projects) and commercializing and/or deploying results/products. g. Identifies past projects that resulted in a market-ready technology. h. References are current, meaning within the past three years. i. Identifies any collaboration with utilities, industries, or others. Explains the nature of the collaboration and what each collaborator will contribute. j. Demonstrates that the applicant has the financial ability to complete the project, as indicated by the responses to the following questions: • Has your organization been involved in a lawsuit or government investigation or audit within the past ten years? • Does your organization have overdue taxes? • Has your organization ever filed for or does it plan to file for bankruptcy? • Has any party that entered into an agreement with your organization terminated it, and if so for what reason? • For Energy Commission agreements listed in the application that were executed (for example, approved at a Commission business meeting and signed by both parties) within the past five years, has your organization ever failed to provide a final report by the date indicated in the agreement? k. Support or commitment letters (for match funding, test sites, or project partners) indicate a strong level of support or commitment for the project.
10	Budget and Cost Effectiveness a. Justifies the reasonableness of the requested funds relative to the project goals, objectives, and tasks. b. Justifies the reasonableness of costs for direct labor, non-labor (for example, indirect overhead and general and administrative costs), and operating expenses by task. c. Explains why the hours proposed for personnel and subcontractors are reasonable to accomplish the activities in the Scope of Work. d. Explains how the applicant will maximize funds for technical tasks and minimize expenditure of funds for program administration and overhead.

Maximum Points	Technical Scoring Criteria
15	Funds Spent in California a. Applicants must indicate that the amount of EPIC funds to be spent in California. The Energy Commission solicitation will specify the points to be awarded based on the percentage of funds spent in California. b. "Spent in California" means that: (1) Funds under the "Direct Labor" category and all categories calculated based on direct labor in the B-4 budget attachments (Prime and Subcontractor Labor Rates) are paid to individuals who pay California state income taxes on wages received for work performed under the agreement; and (2) Business transactions (for example, material and equipment purchases, leases, rentals, and contractual work) are entered into with a business located in California. • Airline ticket purchases and payments made to out-of-state workers are not considered funds "spent in California." However, funds spent by out-of-state workers in California (for example, hotel and food) are considered funds "spent in California."
5	Ratio of Direct Labor and Fringe Benefit Rates to Loaded Labor Rates • The score for this criterion will be calculated from the Rates Summary worksheet in the budget forms, which compares the weighted direct labor and fringe benefits rate to the weighted loaded rate. This ratio, as a percentage, is multiplied by the possible points for this criterion.
100	Total Possible Points
70	Minimum Passing Score

Source: California Energy Commission

Match funding is required for TD&D projects in the amount of at least 20 percent of the requested EPIC funds. However, applicants that provide more than this amount will receive additional points during the scoring phase, similar to the process described in Table 31 or as delineated in the solicitation.

Points are assigned to each criterion based on the scoring scale and technical criteria (Table 29 and Table 35, respectively). Proposal scores are calculated as shown in Table 36. Passing proposals are those that achieve a minimum score, typically at least 70 percent of all points. All proposals are ranked and a NOPA is released, similar to Table 33. All passing proposals are ranked and funding is awarded to the top ranked proposal and then to the next ranked until all funds have been expended.

Table 36: Calculating the Proposal Score for Company A

Technical Scoring Criteria	Table 35 A Maximum Points	Table 29 B Evaluator Applies Scoring Scale	A x B Total points
Technical Merit	20	80%	16.0
Technical Approach	20	80%	16.0
Impacts and Benefits to California Ratepayers	20	80%	16.0
Team Qualifications	10	90%	9.0
Budget Cost Effectiveness	10	80%	8.0
Funds Spent in California	15	70%	10.5
Ratio of Direct Labor and Fringe Benefit Rates to Loaded Labor Rates	5	80%	4.0
Total	**100**	**10**	**79.5**

Source: California Energy Commission

Table 37 summarizes the three-year funding for TD&D projects. This table also shows the estimated minimum and maximum project award per recipient, on average. Some initiatives may exceed the typical maximum project award per recipient. For example, S12.2: *Demonstrate Large-Scale Deployment of Integrated Demand Side Management and Demand Response Programs in Buildings* may provide up to $10 million to $20 million per award. Also, S15: *Demonstrate Advanced Energy Storage Interconnection Systems to Lower Costs, Facilitate Market and Improve Grid Reliability* may provide up to $10 million to $20 million per award. Each solicitation will state a minimum and maximum allowed per bid, along with minimum match.

Table 37: Summary of Three-Year Funding for Technology Demonstration and Deployment

3-Year Funding for Technology Demonstration and Deployment	Up to $145.02 million
Estimated Minimum/Maximum Project Award Per Recipient	$1 million to $5 million
Match Funding Requirement	20 percent of the requested EPIC funds. Those providing match funds in excess of 20 percent will receive higher scores during proposal evaluation
Estimated Funding to Match Federal Program Investments (3 years)	EPIC Program will allow technology demonstration and deployment strategic objectives to apply up to 10 percent of the funding to support federal cost share opportunities

Source: California Energy Commission

*Set aside funding to leverage federal program investments to promote continued national economic investments in California.

Market Facilitation Award Requirements

Projects under the market facilitation investment area will address funding gaps in market processes and includes a wide range of activities such as:

- Program tracking
- Market research
- Education and outreach
- Regulatory assistance/streamlining
- Workforce development or support clean energy technology deployment
- Evaluation

The overall goal is to help ensure that products or strategies make it all the way through the technology development cycle and are delivering benefits to consumers.

Market facilitation efforts support clean energy technology and strategy deployment. Though they can increase widespread application of technologies and strategies, there is not a clear business case for investing private capital, meaning that the amount of match funding in most cases will be low, if any. Similar to applied research, proposals will be initially screened to ensure compliance with the administrative requirements (Table 28). The proposals will then be evaluated using a scoring scale, such as the one shown in Table 29, and then evaluated against technical scoring criteria like those shown in Table 38. Specific evaluation criteria will differ in each solicitation, depending on the solicitation objective and expected products.

Table 38: Example Technical Scoring Criteria and Maximum Points for Market Facilitation Projects

Maximum Points	Technical Scoring Criteria
20	**Technical Merit and Need** a. Provides a clear and concise description of the goals, objectives, technological or scientific knowledge advancement, and innovation in the proposed project. b. Explains how the proposed project will lead to technological advancement and breakthroughs that overcome barriers to achieving the state's statutory energy goals. c. Summarizes the current status of the relevant technology and/or scientific knowledge, and explains how the proposed project will advance, supplement, and/or replace current technology and/or scientific knowledge. d. Justifies the need for EPIC funding and why the proposed work is not adequately supported by competitive or regulated markets. e. Discusses the degree to which the proposed work is technically feasible and achievable. f. Provides a clear and plausible test plan that describes how energy savings and other benefits specified in the application will be determined and measured.
20	**Technical Approach** a. Describes the technique, approach, and methods to be used in providing and performing the work described in the Scope of Work. b. Describes how tasks will be executed and coordinated with various participants and team members. c. Identifies and discusses factors critical for success, in addition to risks, barriers, and limitations. d. Describes how the knowledge gained, experimental results, and lessons learned will be made available to the public and key decision-makers.

Maximum Points	Technical Scoring Criteria
20	**Impacts and Benefits to California IOU Ratepayers.**[133] a. Explains how the proposed project will benefit California Investor-Owned Utility (IOU) ratepayers with respect to the EPIC goals of greater reliability, lower costs, and/or increased safety). b. Provides clear, plausible, and justifiable **quantitative** estimates of potential benefits for California IOU electricity ratepayers, including annual energy savings, peak load reduction, energy cost reductions, greenhouse gas emission reductions, and other benefits. c. States the timeframe, assumptions, and calculations for the estimated benefits, and explains their reasonableness. d. Identifies impacted market segments in California, including size and penetration or deployment rates, with underlying assumptions. e. Discusses any qualitative or intangible benefits to California IOU electricity ratepayers, including timeframe and assumptions. f. Provides a cost-benefit analysis that compares project costs to anticipated benefits. Explains how costs and benefits will be calculated and quantified, and identifies any underlying assumptions.

133 All of the scoring criteria will evaluate benefits to ratepayers. For example, technical approach and team experience will lead to higher probability of success while cost criteria ensure ratepayer value at lower costs.

Maximum Points	Technical Scoring Criteria
10	**Team Qualifications, Capabilities and Resources** a. Describes the organizational structure of the applicant and the project team. b. Identifies key team members, including the project manager and principal investigator. c. Summarizes the qualifications, experience, capabilities, and credentials of the key team members d. Explains how the various tasks will be managed and coordinated, and how the project manager's technical expertise will support the effective management and coordination of all projects in the application. e. Describes the facilities, infrastructure, and resources available to the team. f. Describes the team's history of successfully completing projects (for example, RD&D projects) and commercializing and/or deploying results/products. g. Identifies past projects that resulted in a market-ready technology. h. References are current, meaning within the past three years. i. Identifies any collaboration with utilities, industries, or others. Explains the nature of the collaboration and what each collaborator will contribute. j. Demonstrates that the applicant has the financial ability to complete the project, as indicated by the responses to the following questions: • Has your organization been involved in a lawsuit or government investigation or audit within the past ten years? • Does your organization have overdue taxes? • Has your organization ever filed for or does it plan to file for bankruptcy? • Has any party that entered into an agreement with your organization terminated it, and if so for what reason? • For Energy Commission agreements listed in the application that were executed (for example, approved at a Commission business meeting and signed by both parties) within the past five years, has your organization ever failed to provide a final report by the date indicated in the agreement? k. Support or commitment letters (for match funding, test sites, or project partners) indicate a strong level of support or commitment for the project.

Maximum Points	Technical Scoring Criteria
10	**Budget and Cost Effectiveness** a. Justifies the reasonableness of the requested funds relative to the project goals, objectives, and tasks. b. Justifies the reasonableness of costs for direct labor, non-labor (for example, indirect overhead and general and administrative costs), and operating expenses by task. c. Explains why the hours proposed for personnel and subcontractors are reasonable to accomplish the activities in the Scope of Work. d. Explains how the applicant will maximize funds for technical tasks and minimize expenditure of funds for program administration and overhead.
15	**Funds Spent in California** a. Applicants must indicate that the amount of EPIC funds to be spent in California. The Energy Commission solicitation will specify the points to be awarded based on the percentage of funds spent in California. b. "Spent in California" means that: (1) Funds under the "Direct Labor" category and all categories calculated based on direct labor in the B-4 budget attachments (Prime and Subcontractor Labor Rates) are paid to individuals who pay California state income taxes on wages received for work performed under the agreement; and (2) Business transactions (for example, material and equipment purchases, leases, rentals, and contractual work) are entered into with a business located in California. c. Airline ticket purchases and payments made to out-of-state workers are not considered funds "spent in California." However, funds spent by out-of-state workers in California (for example, hotel and food) are considered funds "spent in California."
5	**Ratio of Direct Labor and Fringe Benefit Rates to Loaded Labor Rates** • The score for this criterion will be calculated from the Rates Summary worksheet in the budget forms, which compares the weighted direct labor and fringe benefits rate to the weighted loaded rate. This ratio, as a percentage, is multiplied by the possible points for this criterion.
100	**Total Possible Points**
70	**Minimum Passing Score**

Source: California Energy Commission

For market facilitation there is no match requirement. However, applicants that provide match funding will receive additional points during the scoring phase, similar to the process described in Table 31 or as delineated in the solicitation.

Proposal scores are calculated as shown in Table 39. Passing proposals are those that achieve a minimum score, typically at least 70 percent of all points. All proposals will be ranked and a NOPA will be released, similar to Table 33. Funding will be awarded to the top ranked proposal and then to the next ranked until all funds have been expended.

Table 39: Calculating the Proposal Score for Company A

Criteria	Table 38 A Maximum Points	Table 29 B Evaluator applies Scoring Scale	A x B Total points
Technical Merit	20	80%	16.0
Technical Approach	20	80%	16.0
Impacts and Benefits to California Ratepayers	20	80%	16.0
Team Qualifications	10	90%	9.0
Budget Cost Effectiveness	10	80%	8.0
Funds Spent in California	15	70%	10.5
Ratio of Direct Labor and Fringe Benefit Rates to Loaded Labor Rates	5	80%	4.0
Total	100		79.5

Source: California Energy Commission

Table 40 summarizes the three-year funding for market facilitation. This table also shows the estimated minimum and maximum project award per recipient, on average. Some initiatives may exceed the typical maximum project award per recipient. Each solicitation will state a minimum and maximum allowed per bid, tailored to the individual solicitation.

Table 40: Summary of Three-Year Funding for Market Facilitation

3-Year Funding for Market Facilitation	$53.26 million
Estimated Minimum/Maximum Project Award Per Recipient	$25,000 to $3 million
Match Funding Requirement	None. Those providing match funds will receive higher scores during proposal evaluation.

Source: California Energy Commission

Two-Phase Application Process

Some solicitations may use a two-phase selection process. The first phase involves preparation of a brief abstract to determine technical merit. The abstract will be evaluated on a pass/fail or scoring scale (similar to Table 28) basis according to specific criteria, such as those listed in Table 41. 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 according to the scoring scale in Table 29, and the applicable technical scoring criteria for Applied Research and Development, Technology, Demonstration, and Deployment, and Market Facilitation, Tables 30, 35 and 38, respectively.

Table 41: Example Pass/Fail Scoring Criteria for Evaluation of Phase One of a Two-Phase Application Process

Pass/Fail	Example Scoring Criteria
Pass/Fail	**Application Completeness** The application is complete and includes the following sections: a) Application Form includes all required information and is signed by an Authorized Representative. b) Project Summary c) Identification of Research Target Areas d) Time Frame for the Project e) Funding request f) Letter of Support
Pass/Fail	**Abstract Project Summary** • Purpose and scope of the project is clear • Technical and implementation issues or barriers discussed • The summary justifies the need EPIC funding • Project is unique and not duplicative of existing technology • The summary explains how the project will: (1) provide California electricity IOU ratepayers with greater reliability, lower energy costs, and/or increased safety; and (2) lead to technological advancements and breakthroughs that overcome barriers to achieving the state's statutory energy goals • Project is supported by major laws of physics (for example, law of gravity, conservation of mass and energy, and laws of thermodynamics) •
Pass/Fail	Addresses Targeted Funding initiatives • Project meets the eligibility criteria specified in the solicitation manual.
Pass/Fail	Time Frame for the Project • The project end date does not extend past the date specified in solicitation.
	Funding Request • The funding requested falls within the minimum and maximum range specified in the solicitation manual
	The abstract includes one or more support letters that meet the requirements of the solicitation.

Source: California Energy Commission

Proposal Preparation

Each proposal submitted will be screened and scored according to criteria described earlier in this chapter. At a minimum, proposals must be organized in a way that facilitates scoring, such as:

- Incorporating the scoring criteria within the proposal project narrative.
- Discussing the project in sufficient detail.
- Identifying and quantifying rate-payer benefits from the project with clear justification on all assumptions.

- Discussing the projects market connection and the market size.
- Identifying and discussing the match funding and the source.
- Outlining project risks and measures to mitigate risk.
- Discussing project team qualifications and structure.
- Providing a detailed project scope of work, budget and schedule.
- Discussing private partnerships and plans for technology transfer.

After the scoring is completed, a NOPA will be released by the Energy Commission that identifies recipients for which EPIC funding is proposed (see Table 33). For each recipient receiving funding, a grant agreement or contract will be developed and approved by the Energy Commission. For recipients not awarded funding, there will be a specified debriefing process as described in each solicitation.

Other Solicitation Criteria

EPIC Funds Spent in California

The Energy Commission under the EPIC Program will strive to maximize funds spent in California and will provide higher scores to those that clearly illustrate direct economic benefits to ratepayers, as indicated in Tables 30, 35 and 38. Examples of direct benefits can include applicants (prime contractor and subcontractors) using researchers, manufacturers, suppliers, and other labor forces located in California. Proposals with fewer funds and direct benefits for California ratepayers will receive lower scores.

Loaded Rates

Another area of emphasis will be ensuring reasonable overhead and general administrative costs. There are two scoring criteria that address budget, cost effectiveness and overhead/administrative costs. One criterion requires that each applicant justify the reasonableness of costs for direct labor, non-labor (for example, indirect overhead and general and administrative costs). The other criterion will evaluate the non labor costs charged. One example of the latter is to compare the weighted direct labor and fringe benefits rate of the applicant's team to the total weighted loaded rate of the team. This ratio as a percentage will be multiplied by the possible points for this criterion (please refer to the draft PON template in the appendix).

Loaded rates include direct labor, fringe benefits, overhead, general and administrative costs, and profit (refer to solicitation for restrictions). Completing the required budget templates will automatically calculate the ratio and an applicant's score for these criteria.

Match Funds for Federal Awards

A portion of EPIC funds will be set aside to leverage federal funds and boost research investments and economic benefits to California. The following criteria will be used to evaluate potential requests to provide cost share to match federal funds from the U.S. DOE and others:

- The research projects goals/objectives are aligned with those in this *2015-2017 EPIC Investment Plan*.
- The EPIC funds will be spent in California to benefit electric ratepayers.
- The potential recipient receives a federal award.

This will be similar to the approach the Energy Commission took with the American Recovery and Reinvestment Act funding. Under the American Recovery and Reinvestment Act of 2009, the Energy Commission successfully leveraged more than $500 million in federal stimulus funding while providing $21 million in match funding for projects that are consistent with the Energy Commission's research program and state's policy goals. Depending on the research goals and work scope, EPIC funds may come from the Applied Research and Development or the Technology, Demonstration, and Deployment funding to provide as match share to the federal grant. EPIC match funds will be capped at no more than half the required match in the federal award. It is anticipated that the selection and evaluation of proposed bidders requesting EPIC funds to match federal awards will be through a competitive process similar to that described in this *2015-2017 EPIC Investment Plan,* but emphasizing the criteria described in this section. Refer to strategic objective S11: *Provide Federal Cost Share for Applied Research Awards* and S17: *Provide Federal cost Share for Technology Demonstration and Deployment Awards*.

Integrating Source(s) of Funding in a Solicitation

The typical solicitation will be EPIC funding only. However, the Energy Commission recommends allowing a combination of funding sources in the same solicitation when it adds value to the ratepayers. For example, some barriers and solutions may benefit from an integrated electricity and natural gas approach. It could be beneficial to include EPIC funding and natural gas funding together in the same solicitation because some initiatives (for example, HVAC or building envelope) can have both electric and natural gas savings. Having a joint solicitation will capture the synergy associated with both fuel savings. Any such use of multiple funding sources will be clearly identified in the funding opportunity notice and all proposals will be required to demonstrate how the proposed project will provide benefits to both electric and natural gas ratepayers.

As an example, one of the proposed initiatives in this *2015-2017 EPIC Investment Plan* is to develop and test advanced building envelope systems, materials, and components to improve building efficiency. This initiative could result in technologies that could affect both air conditioning and heating in buildings. Since most buildings in California use electricity for air

conditioning and natural gas for heating, this research could result in envelope systems that could reduce demand for both energy sources. In this case, the project could be funded with both EPIC and natural gas funds. Gas and electric funds, as well as benefits, would be tracked and reported separately.

Contracting

The Energy Commission will use either grant agreements or contracts for recipients receiving funding under the EPIC Program. Both grants and contracts will identify the task requirements, schedule, and budget for the funded effort.

The mechanism for awarding most contracts or grants will be a competitive process. Noncompetitive awards may be granted in selective circumstances as discussed in a later section. All procedures will follow applicable requirements of the State Contracting Manual, State Public Contracts Code, and Public Resources Code.

Agreement Terms and Conditions

Each solicitation will identify the terms and conditions to be used in the solicitation. These terms and conditions set forth the recipient's rights and responsibilities. When submitting a proposal, the applicant must sign the Application Form. By signing the form, each applicant agrees to use the version of the grant terms and conditions that corresponds to its organization, without modification: (1) University of California terms and conditions; (2) National Laboratory terms and conditions; or (3) general terms and conditions. The terms and conditions are shown on the Energy Commission's website: www.energy.ca.gov/research/contractors.html.

Research Centers (University of California and National Laboratories)

Under EPIC, the Energy Commission plans to establish a competitive process for investments in research centers. The Energy Commission previously funded research centers via interagency agreements to target research on technologies and analyses most needed to advance evolving energy policies, public interest research not addressed elsewhere, and as a cost-beneficial method to bring together researchers, industry, manufacturing and policy experts, universities and national laboratories. These research centers have been very effective at turning innovative technologies into products that become part of California's markets or advancing science to support decisions by policy makers. Additionally, research centers located at universities provided teaching laboratories for students, thus educating the future workforce. Many of the research centers leveraged state funding and secured private and federal funding.

An example of a research center funded with research, development, and demonstration (RD&D) funds is the California Lighting Technology Center. The California Lighting Technology Center at the University of California, Davis, has accelerated the development and

commercialization of energy-efficient lighting technologies by connecting private industry, state regulatory agencies, and utility emerging technology programs.

One of the technologies developed through previous research funding was adaptive smart lighting. This technology involves the integration of energy efficient light sources (for example, light emitting diodes, induction, and fluorescent) with smart controls that turn lights on and off depending on occupancy and/or daylighting. The initial research helped develop the technology and provided monitoring and verification to demonstrate the actual energy savings that can be achieved and convince building owners/operators of the benefits of such systems. As a result, the technology was used in utility emerging technology/incentive programs and has now progressed to being included in codes and standards. Without initial public research investment, this technology would not have been able to complete the innovation cycle in this time frame, if at all. Building owners and operators that use these technologies can anticipate reduced energy costs for lighting. This technology has been deployed in many buildings located in the IOU service territory, including UC campuses in Santa Barbara, Irvine, and Davis.

Some of the strategic objectives outlined in Chapters 3-5 may be best implemented through a solicitation targeted to research centers. Under EPIC, the Energy Commission will pursue opportunities to advance these highly cost-effective technological and analytical innovative incubators. Research centers, however, will still be required to compete for funding. Solicitations will be developed to provide multiyear funding for research centers that meet a specific set of criteria depending on targeted outcomes. Examples of criteria that could be included in a solicitation are:

- Unique research that addresses a major energy using/technological area with fast changing and evolving technology.
- Proven track record of providing explicit California electric ratepayer benefits. This can include developing technologies and strategies that have had an impact on reducing energy costs, improving public health, increasing energy reliability, creating jobs and other benefits to California ratepayers.
- Successfully using state research funds to leverage other private and public funding, such as from industry, manufacturers, utilities, and the U.S. DOE. The preference is not to have EPIC funds be the only source for the center.
- Strong private, industrial, manufacturing, and utility partnerships with demonstrated need for goods and services.
- Demonstrated successful "path to market," such as market penetration of goods and services or significant analyses that inform policy. One of the best ways to make certain that the products and services developed are needed and used, is to ensure that there is a partner who will use the results. This will help guarantee resulting research will not languish but will actually be used or commercialized.

- Portions of the budget dedicated to performing the work are significantly greater than the costs for overhead.

Noncompetitive Awards

Senate Bill 96 states that the Energy Commission may use a sole source or interagency agreement method 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 Energy Commission, at least 60 days prior to making an award pursuant to this subdivision, 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.

Public Resources Code Section 25711.5 states that it is the intent of the Legislature to ensure legislative oversight for EPIC awards made by the Energy Commission on a sole source basis or through an interagency agreement.

The Energy Commission anticipates some limited circumstances where interagency agreements or sole source agreements will be justified although those cannot be specified at this time. The Energy Commission will adhere to the direction provided in Senate Bill 96 and well as the CPUC Decision.

Project Management

A project agreement establishes a business relationship between the Energy Commission and the recipient of EPIC funds. The EPIC project management process will include checkpoints for reviewing the progress of the project. Standard template language for all contracts and grants will require awardees to participate in kick-off meetings to establish deliverable expectations, roles and responsibilities, accounting procedures, and reporting requirements; monthly or quarterly progress reports to ensure the contractor is complying with the task schedules specified in the contractual agreement; regular critical project reviews to monitor progress and make necessary corrections to ensure project success; and final documentation in the form of data, engineering plans, final construction and operation of facilities, or final reports documenting research results and other contractual deliverables.

Energy Commission Project Manager

Each project that is funded will be assigned a single Energy Commission project manager. The project manager will be responsible for coordinating with funding recipients, providing project oversight, and serving as the Energy Commission's point of contact for stakeholders interested in receiving more information about the project.

Critical Project Reviews

Research agreements will include critical project reviews at pre-designated milestones in which the Energy Commission project manager will review the progress to date and determine whether progress to date justifies proceeding to the next project phase. This is an important management tool for research projects that do not always meet their initial goals and decisions need to be made whether to terminate or rescope a project based on research findings.

Technical Advisory Committee and Project Advisory Committee

EPIC research projects will typically include technical or project advisory committees. These committees will be composed of diverse professionals and can provide valuable perspective as the project matures. The number and composition of the committee members can vary depending on potential interest and time availability. The committee members serve at the discretion of the Commission project manager.

The committee may be composed of qualified professionals in the following disciplines:

- Researchers knowledgeable about the project subject matter.
- Members of the trades who will apply the results of the project (for example, designers, engineers, architects, contractors, and trade representatives).
- Public interest market transformation implementers.
- Product developers relevant to project subject matter.
- U.S. DOE, academia, and other governmental research managers.
- Public interest environmental groups.
- Utility representatives.
- Members of relevant technical society committees.

The role of the advisory committee will be to:

- Provide guidance in research direction. The guidance may include reviewing scope of research, research methodologies, timing, and coordination with other research to maximize synergy and avoid duplication. Guidance may be based on:
  - Technical area expertise.
  - Knowledge of market applications.
  - Links between the agreement work and past, present, or future research (both public and private sectors) in a particular area.
- Review deliverables and provide specific suggestions and recommendations for needed adjustments, refinements, or enhancement.
- Review and evaluate tangible benefits to California of the research and provide recommendations as needed.
- Provide recommendations regarding information dissemination, market pathways, or commercialization strategies relevant to the research products.

Outreach

Advancing pre-commercial energy technologies and approaches can only reach its full potential if information about funded activities and improvements is efficiently and actionably available to the appropriate audiences, stakeholders, and users. The types of stakeholders that will be engaged through outreach include state legislators, government officials, utilities, investors, the California ISO, consumer groups, environmental groups, agricultural organizations, academics, the business community, the energy efficiency community, the clean energy industry, and other industry associations. The Energy Commission is committed to ensuring that information regarding EPIC-funded projects and activities is available to these groups, and will employ a variety of techniques to disseminate information. Through coordination among its Energy Research and Development Division, Media and Public Information Office, Office of Governmental Affairs, and leadership offices, the Energy Commission will ensure that its implementation and administration of EPIC-funded innovations results in effective information sharing. The following avenues for outreach are not intended to be a complete or exclusive list of the Energy Commission's work to this effect, but rather a summary of main foci. These activities will also reflect and adhere to all applicable state policies regarding the sharing of information as well as guidance from the Legislature regarding the inclusion of women-, minority-, and disabled veteran-owned businesses, small businesses, and disadvantaged groups in energy innovation.

Outreach through Partnerships and Coordination

Energy Commission staff's deep knowledge of energy innovation will be linked with the expertise of its partners, funded researchers, industry, and policy decision makers to ensure the results of EPIC-funded work are applied. Our outreach work will directly complement and advance the technical and market facilitation projects that are funded by EPIC- for example, with the development of the innovation hubs to facilitate entrepreneurship as described in the *2012-2014 EPIC Investment Plan*. The Energy Commission will also use professional industry networks and forums to share project highlights and significant findings. Technical Advisory Committees and Project Advisory Committees will provide recommendations for information dissemination and technical transfer priorities that are specific to each project and their industry. The Energy Commission will use these expert recommendations to maximize the strategic and meaningful distribution of project findings. Energy Commission collaboration with local, state, and federal agencies will also help ensure that information about innovation advancements is shared with the appropriate regulatory and energy authorities.

Dissemination via Media Awareness, Public Information, and Education Efforts

The Energy Commission will employ the best practices of media outreach to disseminate information about EPIC- funded innovations. Its Media and Public Communications Office will work with the Energy Research and Development Division and Commission leadership to facilitate media inquiries, share newsworthy and timely advancements with appropriate media outlets, and spread updates via social media channels. EPIC projects that are of interest to the scientific community will be featured in scientific journals or trade publications. While these feature articles are not guaranteed, the Energy Commission will seek every opportunity to highlight EPIC-funded projects to drive industry forward and extend the reach of R&D efforts. These articles will provide more depth and project detail than fact sheets and describe the project's influence on policy development or industry momentum.

Project Fact Sheets and Reports

The Energy Commission will develop fact sheets for each project funded through EPIC. Fact sheets will be posted on the Energy Commission website and provide the public, stakeholders, and decision makers with current information on projects funded through EPIC. Projects can take several years from start to conclusion. The fact sheet, a one- to two-page summary, is a useful tool to keep all interested parties informed. For longer-term projects or those that are of particular interest to the general public or industry stakeholders, the Energy Commission will update fact sheets to reflect interim and final research findings. For non-research projects, like local government planning and permitting and workforce development activities, project fact sheets will describe project outcomes and identify lessons learned as well as best practices.

Projects funded through EPIC will also conclude with the production of a final technical report that thoroughly describes the issue or problem addressed by the research, the approach and analysis, any findings, and recommendations for follow-up activities. In some of the longer-

term or higher-profile projects, interim reports will be required to describe analysis and results to date.

Innovation Forums

The Energy Commission will periodically host technology/innovation forums to showcase and share project results. All program administrators will be invited to participate.

Energy Commission Website

Project fact sheets, final reports, and other documents related to, or supported by, EPIC funds will be publicly accessible on the Energy Commission website to maximize transparency and increase value for the program and its projects. The Energy Commission website will also serve as a resource for Energy Commission proceedings related to the development of the *2015-2017 EPIC Investment Plan*. On the website, interested stakeholders will be able to navigate to EPIC policy documents, past workshop presentations, funding solicitations, annual EPIC reports, and other resources that will facilitate active participation in the program. In the future, there are plans to develop a searchable database for all EPIC funded projects. The EPIC website is: http://www.energy.ca.gov/research/epic/.

Intellectual Property

Intellectual property (IP) refers to products of the mind protected by law such as copyrights, trademarks, and patents. The treatment of IP rights under an RD&D program will affect its success. Correct handling of IP rights encourages participants in RD&D programs and advances the commercialization of new technologies, while incorrect handling can have the opposite effect. To ensure EPIC is successful in this regard, IP rights under EPIC RD&D should result in the following:

1. Provide tangible benefits to the ratepayers who pay for the RD&D.
2. Foster and not hinder the commercialization of new technologies, including advances in existing technologies.
3. Advance the collective knowledge of energy RD&D.

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 no longer have the impetus for developing new technology.

Although it is important that IP rights lead to the commercialization of new technologies, IP rights must also allow the sharing of new scientific knowledge which fosters further advances and prevents duplication of efforts by others, which in turn preserves RD&D funds for new efforts.

Intellectual Property Rights Under EPIC

Details of the standard IP rights under EPIC can be found in the Electric Program Investment Charge (EPIC) Standard Grant Terms and Conditions, Sections 21 and 22 (http://www.energy.ca.gov/research/contractors.html). These were developed with the directions in the CPUC's Decision 13-11-025 and Public Resources Code Section 25711.5. The following are some key areas:

1. As directed by statute, the Energy Commission consulted with the California State Treasurer's Office in developing the IP terms.
2. 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.
3. In general, the rights of IP developed under EPIC will be held by the entity developing it. The Energy Commission and the Public Utilities Commission have licenses to use the IP to benefit EPIC ratepayers. The Energy Commission also has the ability to grant a license to Load-Serving Entities, which are companies or other organizations that provide electricity to EPIC ratepayers.
4. The EPIC Program will have march-in rights to take IP that entities who accept EPIC funds develop but do not use. This will protect the ratepayers' investment in the IP and ensure that the benefits from the developed IP are received.
5. IP derived from general energy research that is geared towards new knowledge rather than product development should be put in the public domain, made publically 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 duplicate research.
6. Royalties will be collected as indicated in Section 22 of the terms and conditions. The requirements can be found at: http://www.energy.ca.gov/research/contractors.html.

CHAPTER 8: Assessing EPIC Program Benefits

Assessment Process

All energy research and development (R&D) programs using ratepayer dollars must demonstrate a reasonable probability of achieving ratepayer benefits in selecting those R&D projects. For EPIC, the Energy Commission is using a program-wide approach to assess ratepayer benefits including integrating benefit and cost assessment elements into solicitation planning, project implementation, and project evaluation.

The Energy Commission will implement prospective and retrospective benefits assessment. Prospective assessments that are targeted and integral to the planning and project process can estimate potential benefits based on size of the sector, magnitude of the barrier, and solutions that are targeted. Retrospective assessments will be conducted at project closeout to capture achieved benefits and projected future benefits.

In the solicitation-planning phase, the Energy Commission will define the problem and solutions targeted for each competitive solicitation within the scope of the *2015-2017 EPIC Investment Plan*. The *2015-2017 EPIC Investment Plan* lists benefits targeted by each proposed initiative. Additional detail will be provided in each solicitation reflecting the most current available information on trends, gaps, and needs addressed by the solicitation. Potential benefits evaluation will be part of the selection criteria.

Solicitations instructions will require bidders to provide data to support potential quantitative and qualitative benefits including information on the location of the research or project and the geography of the expected benefits. Senate Bill 96 added Public Resources Code Section 25711.5, subparagraph (c), which directs the Energy Commission to require each applicant for EPIC funding to report how the proposed project may lead to technological advancement and potential breakthroughs to overcome barriers to achieving the state's statutory energy goals.

Where applicable, the bidder will be required to submit a proposal that includes an estimate of the potential energy savings and cost savings of the research if adopted by the market. The bidder will also be required to provide the basis of or assumptions used in the energy or cost savings calculations, including projections of market penetration of the technology and the size of the market. For environmental or market facilitation research, bidders will typically provide qualitative benefits evaluations explaining why this research is necessary and include which policy and regulatory drivers are being addressed and how the research will fill knowledge gaps or facilitate adoption of clean energy technologies.

A bidder must also discuss why the desired research or project outcome would not occur without EPIC funding or why it might not occur as quickly or in a way beneficial to California ratepayers without EPIC funding.

The Energy Commission staff will evaluate and score potential awards based on a bidder's reasonable probability of achieving California ratepayer benefits and other factors such as match/leveraged funds, research or market facilitation activities conducted in California, and administrative/financial capability.

Additional information on what the Energy Commission will measure, how it will collect benefit data and forecast impacts, and where information on EPIC project benefit assessments will be available, specifically,

- Energy Commission staff will select metrics and areas of measurement to assess benefits and costs for each project as required by the CPUC and the Legislature.
- Projects will be required to provide data and estimates of potential markets for each project phase. Where applicable, staff will provide conservative estimates of future market penetration.
- Metrics and benefit assessments will be included in solicitation planning, solicitation and agreement development, project management, and project closeout. The EPIC annual reports will include information on metrics and benefit assessments at each of these project phases.

Throughout the program, Energy Commission will consult with interested stakeholders to vet funding initiatives and market facilitation activities and seek feedback ensuring that the R&D, TD&D, and market facilitation activities to provide clear electricity ratepayer benefits.

Metrics and Areas of Measurement

The CPUC (Decision 12-05-037) 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:

a. Providing benefits to ratepayers.
b. Achieving greenhouse gas (GHG) emissions mitigation and adaptation in the electricity sector at the lowest possible cost.
c. Sustaining the Loading Order.
d. Advancing low-emission vehicles/transportation.
e. Supporting economic development.
f. Using ratepayer monies efficiently.

The CPUC Decision 13-11-025 modifies the EPIC Administrators' investment plans by adopting a list of proposed metrics and potential areas of measurement[134] "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."[135] The decision notes that the list of proposed metrics "includes metrics for public and worker safety, as recommended by Energy Division staff" at the January 17, 2013, workshop.[136] The decision states that EPIC 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."[137] The following proposed measurement areas are identified in the list adopted by the CPUC for the EPIC Program:

1. Potential energy and cost savings.
2. Job creation.
3. Economic benefits.
4. Environmental benefits.
5. Safety, Power Quality, and Reliability (Equipment, Electricity System).
6. Other Metrics (to be developed based on specific projects through ongoing administrator coordination and development of competitive solicitations).
7. Identification of barriers or issues resolved that prevented widespread deployment of technology or strategy.
8. Effectiveness of information dissemination.
9. Adoption of EPIC technology, strategy, and research data/results by others.
10. 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 Energy Commission 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, and the specific project funded, and the project's development stage in the energy innovation pipeline.

134 Decision 13-11-025, ordering paragraph 26.

135 Decision 13-11-025, Attachment 4.

136 Decision 13-11-025, page 67.

137 Decision 13-11-025, ordering paragraph 27.

The Energy Commission staff notes the close connection of energy savings, cost savings, job creation, and economic benefits. For example, the cost savings accrued to ratepayers resulting from EPIC-funded research on energy efficiency will have a multiplier effect on California's economy, creating jobs. The Energy Commission has expanded upon these measurement areas and mapped them onto the EPIC guiding principles (Table 42 and Table 43). The Energy Commission staff will determine which benefits and metrics are applicable to the evaluation of each proposal and project based on the research stage, segment of the electricity system value chain, industry or ratepayer class, and purpose.

Table 42: Potential Metrics and Areas of Measurement for Each Guiding Principle

Ratepayer Benefits		
Measurement Area	Categories	Metric
Lower Costs	Utility Bill Savings	$
	Fuel Switching Savings	$
	Other Cost Savings	$
	Least-Cost GHG Mitigation	$/metric ton CO_2e
	Least-Cost RPS Compliance	$/MWh
Greater Reliability	Reduced Frequency of All Service Interruptions	SAIFI
	Reduced Frequency of Momentary Interruptions	MAIFI
	Reduced Total Duration of Interruptions	SAIDI
	Faster Outage Restoration Time	CAIDI
	Reduction in Unserved Demand	kWh
	Improved Grid Resilience to Climate Change	(qualitative)
	Reduction in System Harmonics	Distortion Factor
	Reduced Power Losses	%
Improved Safety	Reduced Probability of Hazardous Event (%)	%
	Improved Indoor Air Quality (ppm)	ppm
	Reduced Morbidity and Mortality	QALY

Source: California Energy Commission

Table 43: Potential Metrics and Areas of Measurement for Each Guiding Principle

Complementary Guiding Principles		
Measurement Area	Categories	Metrics
Economic Development	Job Creation	PY, FTE, hours, wages
	Economic Growth	Gross State Product
	Reduced Energy Imports	GWh, mmBtu
	Reduced Exposure to Energy Commodity Prices	%
Environmental Benefits	GHG Emission Reduction	metric tons CO_2e
	Avoided Economic Damage from Climate Change	$
	Criteria Air Pollutant Emission Reduction	metric tons NO_x, SO_x, PM, CO
	Reduced Water Consumption	acre-feet
	Reduced Water Use	acre-feet
	Reduced Water Pollution	metric tons
	Reduced Land Use	acres
	Habitat Protection	(qualitative)
	Reduced Landfill Disposal	metric tons
Public Health	Reduced Morbidity and Mortality	QALY
	Adverse Health Events	Incidence, Prevalence
	Avoided Healthcare Costs	$
Improved Quality of Life	Protection of Cultural Resources	(qualitative)
	Protection of Recreational Resources	(qualitative)
	Protection of Visual Resources	(qualitative)
	Improved Consumer Appeal of Clean Tech	(qualitative)

Source: California Energy Commission

Data Collection and Availability

Over the last 20 years the Energy Commission staff has ensured all research results and information have been transparent, open and coordinated. This has helped eliminate duplication and made certain results have been publicly available and shared. The CPUC Decision 13-11-025 includes specific requirements for the sharing of data collected from EPIC-funded projects. For example, Ordering Paragraph 13 states: "Except when valid reasons exist for confidentiality, the California Energy Commission, Pacific Gas and Electric Company, Southern California Edison Company, and San Diego Gas & Electric Company must make available upon request all data, findings, results, computer models and other products developed through the Electric Program Investment Charge program, consistent with the treatment of intellectual property requirements." Ordering Paragraph 14 adds: "The California Energy Commission, Pacific Gas and Electric Company, Southern California Edison Company, and San Diego Gas & Electric Company must include with their Electric Program Investment Charge annual report a final report on every project completed during the previous year. The final project report must provide a comprehensive description of the project, present detailed findings and results, including a summary of all data collected and how the data may be accessed."

Also, Ordering Paragraph 29 of Decision 13-11-025 states the Energy Commission must give the CPUC, at the CPUC's request, "full access rights to all EPIC research, development, and demonstration, reports, Intellectual Property (IP), and data to which the CEC has access, with appropriate protections for proprietary data and IP against public disclosure;" and "Grant the [CPUC] all appropriate rights to publicly report (for example, to the Legislature) on the EPIC RD&D, reports, IP, and data developed with EPIC funds, again with appropriate protections for proprietary data and IP."

Data collection begins with proposals for EPIC funding. Bidders must provide information on metrics identified in the solicitation as part of the criteria used to assess the potential for the proposed project to successfully address the barriers to clean energy targeted by the solicitation to provide ratepayer benefits.

In the agreement development phase, the Energy Commission will incorporate the benefits to be measured in the proposed scope of work. Where applicable, the agreement will include some or all of the following information to measure benefits during the project management and closeout phases:

- Quantitative and qualitative benefits.
- Methods to measure benefits.
- Issues or barriers to be resolved.
- Test results.
- Critical project review (Chapter 7).

During the project management phase, the Energy Commission staff will use its knowledge and experience from other Energy Commission programs to manage EPIC Program agreements. The Energy Commission project manager will review all the responsibilities with the contractor, visit the project site, review all reports, and be in regular communication with the contractor to actively follow and shape the project to a successful conclusion. The Energy Commission will work closely with the researcher or award recipient to verify and capture all potential benefits.

Energy Commission staff will oversee projects and evaluate benefit assessments, as needed, through regular communications, critical project review meetings, monthly or quarterly reports, and final reports. If the contractors are not meeting the projected benefits, the Energy Commission will advise an appropriate course of action. The agreement manager will draw on internal and external experts to review project results during critical phases. During the project closeout phase, the Energy Commission will capture achieved research results, along with the targeted market potential. For a portion of projects, the Energy Commission will conduct in-depth post-project benefits assessment audits.

Publishing Research Results

Each EPIC recipient agreement will include specific deliverables to document ratepayer benefits, including:

- Fact sheets.
- Project interim reports.
- Sharing technology information via workshops/conferences.
- Project final reports.
- Post-program follow-up data sharing.
- Other information.

The Energy Commission staff will work with the researcher or award recipient to prepare a fact sheet that identifies the energy issue(s)/barriers that are preventing product deployment, the planned research or investment initiative, and the potential benefits to share information with the public through the Energy Commission's website.

Through the life of the agreement, the Energy Commission will work with the researcher or award recipient to assess and report benefits through project interim reports and stakeholder workshops or conferences. Also, the Energy Commission will work with the researcher or award recipient to publish a final project report that includes the research and/or project results, including the quantitative/qualitative benefits, methods used to measure the benefits and the issues/barriers resolved.

The Energy Commission will strategically focus on a sample of closed projects that merit consideration for follow-up interviews to determine represented quantitative and qualitative benefits. Additionally, the Energy Commission will validate the researcher's or award recipient's method(s) to measure benefits. The Energy Commission will share the benefits information in published project fact sheets, project final reports, annual reports to the CPUC, and through other avenues such as published technology brochures and trade journals.

In all cases, the Energy Commission will document the steps of benefits assessment and transparently present the uncertainties in the benefits calculations. Moreover, the Energy Commission will evaluate the EPIC Program benefits assessment processes by working with other benefits assessment practitioners, including government and other research organizations, to continually evaluate and improve the EPIC Program benefits assessment process.

CHAPTER 9:
Next Steps

Through the public workshops held in February and March 2014, the Energy Commission gained valuable stakeholder input for this *2015-2017 EPIC Investment Plan*. Public comments received during the workshops helped to shape the investment initiatives presented in this proposed draft *2015-2017 EPIC Investment Plan*. The Energy Commission plans to consider adopting the proposed final *2015-2017 EPIC Investment Plan* at a Business Meeting in April 2014. The schedule calls for submitting a proposed Investment Plan to the CPUC on May 1, 2014. As stated in the CPUC's EPIC Phase 2 decision (D. 12-05-037), the anticipated schedule calls for the CPUC to consider the Energy Commission's *2015-2017 EPIC Investment Plan* and the EPIC investment plans of the three investor-owned electric utilities from May 2014 through November 2014. The anticipated schedule calls for CPUC approval of the 2015-2017 EPIC investment plans in December 2014.

After Investment Plan approval, the Energy Commission will prepare and issue solicitations to fund the initiatives outlined in this *2015-2017 EPIC Investment Plan*. The four administrators, including the Energy Commission and the three utilities, will file annual reports to the CPUC each February through 2020, consistent with CPUC EPIC Decision 13-11-025. The Energy Commission will also provide an EPIC annual report to the Legislature each April, beginning in 2014, including the information required by Public Resources Code section 25711.5.

The Energy Commission looks forward to implementing the EPIC Program and seeing these projects come to fruition for the benefit of ratepayers who fund this program.

APPENDICES

Appendix A: Summary of Stakeholder Comments and Energy Commission Staff Responses on the February 7 Workshop

Appendix B: Summary of Stakeholder Comments and Energy Commission Staff Responses on the March 17 and 21 Workshops

Appendix C: Summary of Stakeholder Comments on the *Electric Program Investment Charge Proposed 2015-2017 Triennial Investment Plan*

Appendix D: Links to EPIC Program Solicitations

These appendices are available as a separate volume, publication number:

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