For public review and comment:

Attached is the Energy Commission staff's working draft of the proposed initiatives and strategic objectives for *2015-17 Electric Program Investment Charge (EPIC) Program - Second Triennial Investment Plan*. These initiatives and objectives have been the focus of staff workshops over the last two months. Written comments on these proposed initiatives and strategic objectives are due to the Energy Commission staff Friday, March 28, 2014.

Background on EPIC

The California Public Utilities Commission (CPUC) (Decision 12-05-037) established the EPIC Program to fund investments for clean technologies in three areas: applied research and development, technology demonstration and deployment, and market facilitation. This research and development program uses ratepayer funds from California's major investor –owned electric utilities: Pacific Gas and Electric Company, Southern California Edison Company and San Diego Gas and Electric Company. The Energy Commission is administering 80 percent of the approved EPIC funds ($162 million annually) with the remaining 20 percent administered by PG&E, SCE and SDG&E. The CPUC provides program oversight.

Proposed Initiatives Advance Energy Policy Goals

The draft proposed funding initiatives are intended to fund projects that will provide the highest value back to the electric ratepayers. The draft proposed funding initiatives 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 by the CPUC, specific guiding principles, the electricity value chain, and policy and other ratepayer benefits, as directed by the CPUC.

Questions for Stakeholders

1. Are critical research initiatives missing? If so, provide examples and explain why.
2. Can some initiatives be dropped because of progress made to address these issues?
3. What issues are deserving of significant funding due to their high potential for ratepayer returns?
4. Are there initiatives that should be combined? Please explain why.

Written Comments

Written comments should be submitted by 5:00 p.m. on Friday, March 28, 2014. Written comments can be mailed, e-mailed, or submitted in person to the address below.
The Energy Commission encourages comments by e-mail. Please include your name

and any organizational affiliation name. Comments should be in a downloadable, searchable format such as Microsoft® Word (.doc) or Adobe® Acrobat® (.pdf). Please include the docket number 12-EPIC-01 and indicate "EPIC Second Investment Plan" in the subject line. Send comments to: docket@energy.ca.gov and include in the CC line: Lorraine.Gonzalez@energy.ca.gov

Additionally, written comments may be posted to the Energy Commission's website for the proceeding. Please note that your written and oral comments, attachments, and associated contact information (e.g. commenter's address, phone, email, etc.) become part of the public record. This information may become available via Google, Yahoo, and other search engines.

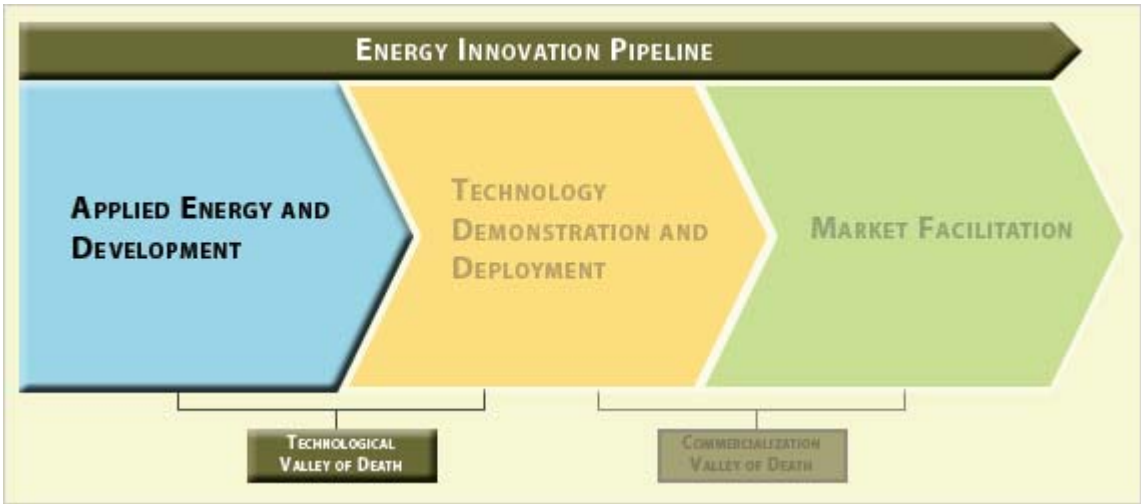
If you prefer, you may send a paper copy of your comments to:

California Energy Commission
Dockets Office, MS-4
Re: Docket No. 12-EPIC-01
1516 Ninth Street
Sacramento, CA 95814-5512

Next Steps

The Energy Commission will release the proposed *2015-17 Electric Program Investment Charge (EPIC) Program - Second Triennial Investment Plan* for public review and comment in early April and will consider the plan for adoption at an Energy Commission Business meeting on April 22, 2014. Once adopted, the Energy Commission will submit the Plan to the CPUC by May 1, 2014. The CPUC will conduct a formal proceeding, starting in May, to consider this proposed Plan, with anticipated adoption in December 2014. The Energy Commission is coordinating with the investor owned utilities as they develop their own investments plans to fund technology development and deployment initiatives.

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 investment plan, the Energy Commission will provide funding for applied research and development (R&D) 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 1: Proposed Funding Allocation for the Applied Research and Development Program Area by Strategic Objective

Funding Area	Amount (Millions)
Energy Efficiency and Demand Response	TBD
S1 Strategic Objective: Improve Energy Efficiency Technologies and Strategies in California's Buildings, Industries, Agriculture and Water Sectors.	TBD
S2 Strategic Objective: Enable Cost-Effective Demand Response for California Electricity Customers.	TBD
Clean Generation	TBD
S3 Strategic Objective: Develop Innovative Solutions to Increase the Market Penetration of Distributed Renewable and Advanced Generation.	TBD
S4 Strategic Objective: Improve Power Plant Performance, Reduce Cost, and Accelerate Market Acceptance of Existing and Emerging Utility-Scale Renewable Energy Generation Systems.	TBD
S5 Strategic Objective: Reduce the Environmental and Public Health Impacts of Electricity Generation and Make the Electricity System Less Vulnerable to Climate Impacts.	TBD
Smart Grid Enabling Clean Energy	TBD
S6 Strategic Objective: Advance the Use of Smart Inverters for Grid Support in California.	TBD
S7 Strategic Objective: Develop Advanced Distribution Modeling Tools for the Future Smart Grid.	TBD
S8 Strategic Objective: Advance Customer Systems to Coordinate with Utility Communications.	TBD
S9 Strategic Objective: Efficient Integration of Plug-In Electric Vehicles to the Electricity System.	TBD
Cross-Cutting	TBD
S10 Strategic Objective: Advance the Early Development of Breakthrough Energy Concepts.	TBD
S11 Strategic Objective: Provide Federal Cost Share Applied Research Awards.*	TBD
Applied Research and Development Program Area Total	**TBD**

*S11 funds are drawn from allocations in S1 – S10.

Source: California Energy Commission.

The proposed funding allocations for the Applied Research and Development Program Area by Strategic Objective provided in Table were developed based on the priorities defined in the CPUC EPIC decision and the expected level of effort of applied research and development needed to fully address each of the specific strategic objectives. These funding levels are estimates and may change based on the number of successful responses received from competitive solicitation awards and the amount of leveraging of the EPIC funds from other parties that can be obtained by strategic objective. For S11, Provide Cost Share for Federal Awards, up to 10 percent of the funding allocated for the applied research and development strategic objectives can be applied to providing cost share for these types of competitive federal awards.

Through this plan, the Energy Commission intends to issue solicitations in all strategic objectives. Proposed initiatives identified in this 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 Buildings, Industries, Agriculture and Water Sectors.

Table 2: Ratepayer Benefits Summary for Strategic Objective 1

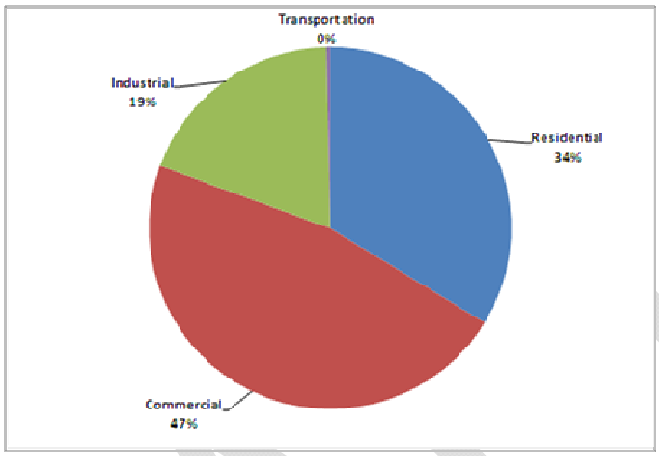
	Promote Greater Reliability	Lower Costs	Increased Safety	Societal Benefits	GHG emissions mitigation and adaptation	Lower emission vehicles/ transportation	Economic Development	Public Utilities Code Section 740.1	Public Utilities Code Section 8360
S1.1 Advancing Efficient Solutions for Lower Energy Buildings.		X		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	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	X
S1.4 Develop And Evaluate Strategies to Improve Indoor Air Quality in Energy-Efficient Buildings.	X	X	X	X	X			X	X
S1.5 Develop and Test Advanced Industrial, Agricultural, and Water Technologies and Strategies to Reduce Energy Use and Costs.	X	X	X	X	X		X	X	X
S1.6 Advancing Strategies to Reduce California Buildings' Impact on the Water-Energy Nexus.	X	X	X	X	X		X	X	X

Source: California Energy Commission.

Barriers and Challenges: Energy efficiency is a primary strategy to reducing the state's energy use and costs, as well as greenhouse gas (GHG) emissions. Electricity used in homes, commercial buildings, industrial, and agricultural processes, and water and wastewater activities consume nearly 258 billion kWh/year in annual electricity use. As shown in Figure 4, the commercial sector and the residential sector combined use more than 80 percent of statewide average electricity use in California. 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. Efficiency improvements are also needed in the process

operations associated with the industrial, agriculture and water sectors which use nearly 20 percent of the statewide average electricity use and are also faced with economic and environmental challenges.

Figure 1. Statewide Average Electricity Use by Sector in California



Source: United States Energy Information Administration (EIA), 2010

Though significant progress has been made in some areas, there is still a need to reduce the cost of these technologies, to provide verification that the actual benefits will accrue to electric ratepayers and look for ways to best integrate and apply these technologies in the most cost effective manner. Additionally, achieving the State's zero net energy building goals for all buildings and ensuring that existing buildings and facilities are cost effectively retrofitted to maximize energy efficiency will be crucial.

Achieving the transformational goals will involve novel research that includes developing and testing advanced energy efficiency technologies, services, and products; encouraging their use through utility incentive programs or building and appliance energy efficiency codes; and understanding and evaluating the behavior of energy users. Concurrently, the effects of these new technologies will need to be evaluated both on performance and to assess potential unintended effects, such as indoor air quality.

Additionally, water and energy are linked. Inefficient water use results in 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 user group in the State, consuming nearly 20 percent of California's electricity (or approximately 48 billion kWh/year). Peak electricity demand by water agencies and end-users is estimated to be

approximately 9,000 MW.[1] Water deliveries to buildings and industrial facilities are often treated, pumped and used within the facility and then disposed. With the State's dire water situation, new strategies, technologies and tools are needed to optimize the water/wastewater processes and develop technologies and techniques to maximize savings associated with how water is used by homes, businesses and industries.

Investments in first plan addressing barriers and challenges: The first 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 zero net energy buildings and energy retrofits in existing buildings. The focus will be on advancing technologies, addressing data gaps that hinder large scale demonstrations or prevent achievement of the state's policy goals for energy efficiency. Consumer behavioral research will be integrated into the technologies analyzed to gauge their potential acceptance by consumers, such building owners, occupants, engineers, designers, and installers. With the first investment plan, the strategy was to lay the foundation for future deployment and large scale technology demonstrations.

As it is uncertain how many of building technology areas will be funded through the solicitations from the first investment plan, it may be necessary to emphasize some areas more or less in future solicitations resulting from this second investment plan. As a result, the second investment plan will continue to focus on new technologies and strategies, addressing data gaps to help inform future building and appliance energy efficiency code changes, strategies for zero net energy buildings, and maximizing energy efficiency in existing buildings.

New areas to be included in the second investment plan include research initiatives to advance energy efficiency technologies for the industrial, agriculture and water sectors to reduce energy use and cost, and advancing strategies and technologies pilots to increase end-use water efficiency in buildings.

1 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.

S1.1 Proposed Funding Initiative: Advancing 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 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 continue further advancements of technologies to reduce cost and gain more widespread acceptance in new and existing buildings along with help inform future codes and standards. The following are the five areas covered by this initiative:

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 with improved energy efficiency and customer satisfaction. Examples of potential areas include:

- Develop and test advanced lighting technologies, controls, and integrated systems that achieve improved performance (lighting quality, energy savings, reliability, etc.), minimize installation costs, reduce energy costs and meet customer's operational needs.
- Evaluate 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 with the goal of providing cost-effective 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, DOE, researchers (academia, national labs, etc) and IOUs.

Background: Lighting offers significant opportunities for energy savings and peak demand reductions. Many new products that promise more efficient lighting, 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, will create opportunities for faster acceptance of new technologies and systems that can accelerate reductions in energy consumption and greenhouse gas (GHG) emissions.

Lighting research focuses on advancing the Energy Commission and state energy policies by accelerating the development and commercialization of technologies. This initiative will complement past and current lighting research.

2. **HVAC: develop and test innovative HVAC systems**

Purpose: Research in this area focuses on improving the energy efficiency of existing and emerging HVAC systems, developing new or innovative approaches or techniques to maximize the efficient use of energy in HVAC systems and testing and piloting candidate HVAC technologies and controls. Examples of potential areas include:

- Improve the energy efficiency and cost-effectiveness of existing HVAC systems, such as use of fault detection and diagnostic tools and test protocols and use of plug-n-play emerging energy management systems and HVAC sensors and controls for small and medium sized commercial buildings.
- 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 and ground source heat pumps, miniaturized heat pumps; refrigerant-free technologies; radiant cooling; innovative ways for incorporation of HVAC systems into building structures.
- Optimize integration of HVAC and refrigeration systems in grocery stores, food service and other similar applications.
- Develop night- or pre-cooling strategies to minimize or even potentially eliminate the need for mechanical cooling.

- Develop simulation models, performance modeling rule sets to promote utility incentives and compliance credit for innovative systems; test protocols to detect refrigerant issues (for example, leakage, contamination, and flow restrictions), and appropriate design guides.
- 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 over the weekend).
- Engage local experts and other stakeholders through public workshops to identify research priorities and needs associated with HVAC and refrigeration-related research and development with the goal of providing cost-effective benefits to California ratepayers.

This initiative will be coordinated with other ongoing CPUC/IOU activities/studies. This will ensure that the research and work scope will a) benefit and inform CPUC/IOU efficiency policy and b) be consistent with energy, monitoring and verification frameworks, standards, and the *California Energy Efficiency Strategic Plan*'s *HVAC Action Plan*.[2] Additionally, this initiative will coordinate with basic research conducted by the U.S. Department of Energy through their research programs 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 and utilities.

Background: HVAC and refrigeration systems are among the largest consumers of electricity in residential and commercial buildings and are therefore one of the primary targets for reducing energy consumption. Reductions in HVAC energy consumption have also been targeted by the CPUC in its IOU energy efficiency portfolio and are a component of utility incentive programs.[3] [4] The IOUs, HVAC designers and contractors, and regulators also need better and simpler simulation tools to help design and evaluate high efficiency systems, justify incentive levels, and determine the amount of credit for use in 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

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

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

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

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 move these technologies to the next level, potentially integrate them with other HVAC systems such as thermal energy storage or demand response, and provide standardization and validation of energy and other benefits. This initiative will further develop and pilot test advanced HVAC technologies and controls to improve their performance and cost-effectiveness, and move them closer to wide-scale deployment and commercialization.

The 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. Department of Energy's building efficiency research staff, and public comments on the draft EPIC investment plan.[5]

3. **Building envelope: develop and test next generation systems**

Purpose: Research in this area focuses on improvements to building envelope performance, systems, materials, and components, develop or modify existing simulation tools to ease their successful entry into the market, and to advise future building energy efficiency standards. Potential research areas include:

- 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 will be accomplished by using research and product developments discovered during assessments and targeting other ongoing complementary research.
- Evaluate new materials and components for building envelopes and evaluation of 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

5 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

panel systems (SIPS), insulation with high R-value per inch (such as R-8 per inch or greater), and advanced framing methods.

- Assess the most effective ways to measure the performance and address regulatory barriers associated with fire, moisture, structural and seismic that may prevent the use of new building envelope systems, materials and components. 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 research and development with the following goals: providing cost-effective benefits to California rate payers in the form of lower energy bills, healthier, more durable, and more comfortable residential and commercial structures.

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

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. 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 (LBNL) Windows and Facades Test bed 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. Assessments of the benefit of these windows, and development of manufacturing approaches, which can reduce their cost, are needed to ease their market entry.[6] 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. [7] Further research is

6 http://buildings.lbl.gov/

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

required to develop more robust daylight discomfort glare models to enable improvement in automated controls.[8] 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 the demand for high efficiency buildings.[9]

- 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, and efforts are underway to more effectively integrate solar photovoltaic cells into roofing materials.[10] Other envelope improvements, such as insulation at the roof plane and sealed attics, are also 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 use of in-shop manufacturing and quality control for entire wall sections, can reduce waste and construction defects that typically plague site-built structures. Past research has funded the improvement of roof and wall insulation in manufactured housing. The research is underway and benefits and costs of the techniques from this project have yet to be determined. However, research is needed to assess these new building techniques and, materials, and components to determine technical and economic feasibility and 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 and office electronics and the electronic infrastructure that supports the communication of these devices. Potential research includes:

- Improve and develop efficiency improvements to existing and future plug-load devices, such as develop and test low cost components, low cost energy reporting technologies, and integration of smart controls via an integrator or network.

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

9 Ibid

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

- Address consumer behavioral patterns for equipment use and potential acceptance of new technologies and operating strategies.
- Develop and implement pilot programs for candidate technologies and inform future energy efficiency codes and standards, as applicable.
- Develop competition mechanism for one or more plug load devices to encourage the market to go well beyond existing efficiencies in contrast to incremental change.
- Engage local experts and other stakeholders through public workshops to identify research priorities and needs associated with plug load-related research and development with the goal of providing cost-effective benefits to California ratepayers.

The efforts will complement and coordinate with other past and current research being undertaken by UC Irvine-Cal Plug Center, national laboratories, and others.

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.

Background: Plug loads devices contain internal or external AC-DC power supplies, such as computers, televisions, and cell phones. 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.[11] Current estimates indicate that plug loads are contributing about 15-20 percent of residential and 10-15 percent commercial electrical use, and this use could nearly double by 2030.[12] 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 net-zero energy building goals.[13]

Past research focused on set top boxes, computer enabling rates, initial research on 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

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

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

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

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 supply and battery chargers.[14]

The UC Irvine's CalPlug Center has performed research on set-top boxes (STB) and was instrumental in bringing a large group of stakeholders to identify ways to make STBs more efficient. Input from these stakeholders was subsequently considered in the voluntary agreement with manufacturers and the U.S. Department of Energy to reduce STB energy.[15][16] Preliminary estimates by UC Irvine's CalPlug Center indicate that California may be able to save about $400 million per year through set-top box efficiency improvements.

The 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, and public comments received on the second 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:

- Identify and pilot innovative advanced approaches, strategies, and technologies to bring energy efficiency retrofits solutions to the following sectors: low-income, market-rate residential builders/owners, the multifamily market, commercial builders, and institutional facilities (e.g., K-12 schools). Technologies and approaches can include single technology or integration of multiple technologies to capture opportunities for improving energy efficiency and indoor environmental quality (IEQ) at various points of a building owner's decision-making process to upgrade equipment or buildings. Technologies can include

14 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.

15 www.nrdc.org/energy/files/settopboxes.pdf.

16 http://www.energy.gov/articles/us-energy-department-pay-television-industry-and-energy-efficiency-groups-announce-set-top

advanced HVAC, lighting, building envelope, plug load efficiency strategies, equipment controls, 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, determine the impacts of various advanced/emerging energy efficiency measures, make recommendations for building improvements, and generate performance and cost/benefit data for decision makers regarding building retrofits.

This initiative will coordinate with ongoing activities and studies by the CPUC, IOUs, and the Energy Commission related to Proposition 39 (2012), SB 73 (Committee on Budget and Fiscal Review, Chapter 29, Statues of 2013), and AB 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, governmental agencies, utilities, and national labs.

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 increasing in age, but have lacked technical knowledge and funding to identify and implement the needed energy efficiency upgrades and solutions to their indoor environmental quality (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: Developing 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: This initiative will develop an integrated approach to building design to meet zero net energy building goals that will have acceptance among consumers and builders, and have similar costs to standard construction. Potential research includes:

- Develop and test standard prescriptive design packages for zero net energy residential, multifamily and commercial buildings in various climate zones that can be easily implemented with reliable energy savings, have costs comparable to standard construction and have consumer acceptance.
- Develop a design optimization competition for prospective developers to design zero net energy residential, multifamily/low income, or commercial buildings/communities/centers that incorporate a set of prescriptive energy efficiency/generation measures. The goal is to apply the design in a full build-out and deployment in the technology demonstration phase of multiple buildings (e.g., subdivision, business park, etc.). Potential areas of emphasis could include development of standard designs that meet minimum performance and quality construction goals, are likely to be replicable in multiple climate zones, cost effective (zero adder compared to standard construction), capable for large-scale or subdivision/community scale deployment, and have high potential for customer (owner, builder, installer) acceptance and market demand.

Additionally, behavioral elements and motivations for owners/occupants to transition to ZNE will be assessed as well as 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. Due to this, very few designers, builders, or contractors have the expertise or experience to construct ZNE buildings cost-effectively.

The *California Energy Efficiency Strategic Plan* and the Energy Commission's *Integrated Energy Policy Report* have established ZNE goals for residential and commercial new and retrofit construction. In addition, the CPUC has completed two studies with Pacific Gas & 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. This initiative will build on these reports and other current research to achieve California's ZNE goals in all the different 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				X

Source: California Energy Commission.

Purpose: This initiative focuses on improving the understanding of consumer activities associated with energy consumption to identify strategies for: 1) improving and adapting devices to maximize efficiency based on real world applications, 2) identifying opportunities for savings due to behavior change, and 3) communicating with, motivating, and rewarding consumers for their 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.
- 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 research and development process—particularly as funded through public investment—could include social science research components that anticipate end-user needs, expectations, understandings and capabilities.

Stakeholders: California ratepayers; future homebuyers; 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 more to the large variation in consumption levels observed between households and between similar commercial buildings, even when engineering and demographic factors are taken into account. Historically, "behavior" research and efficiency programs have reflected a "rational choice" framing of the problem, and of the solution opportunities—to disappointing effect. From this 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".[17] Consequently, most programs have been designed to either reduce first costs (rebates), to offset the higher cost of more efficient devices or provide information on the value of future savings so consumers can make more "optimal" 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 (i.e. reducing the "transaction costs") the process of providing subsidies, and even doing the math for consumers—essentially teaching them how to make "rational" choices (e.g. EnergyGuide labels, by their presence, shows that one should consider operating costs along with purchase price).

The use of other academic traditions with well-developed frameworks for understanding and explaining human behavior to help address the problems has been growing. Psychology, sociology, anthropology and their sub-disciplines (e.g. economic sociology; social anthropology) as well as their applied offshoots (marketing; program evaluation) have contributed theoretical framings, data collection methods, and analytical approaches. The history of these efforts is heavily represented in three different collections of research literature, conference presentations, and evaluation research.[18][19][20] More recently, work funded through the PIER program and by the CPUC has sought to document behavior research efforts and organize the application of multiple methodologies and theoretical frameworks to future research, program development, and evaluation.[21][22][23] This initiative will build on these reports and other current research.

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

18 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

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

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

21 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

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

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

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 zero net energy building and developing strategies to ensure adequate indoor air quality in these buildings. Data gaps include collecting and analyzing data on building characteristics that affect indoor air quality for low-energy or net zero energy buildings; identifying and quantifying sources of indoor pollutants and developing approaches to reduce the pollutants; determining impacts of human behavior on Indoor Air Quality (IAQ), on the factors that influence human behavior that affects IEQ and the impacts of poor IEQ on occupants; and identifying, developing and demonstrating metrics for tracking and comparing IAQ in buildings.

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

Background: The California Energy Commission (Energy Commission) is required to set standards for energy efficiency for both new and existing buildings and for new appliances.[24] It must consider indoor air quality impacts in setting these energy efficiency standards.[25] Further, it must comply with the California Environmental Quality Act (CEQA) by considering potential impacts of such standards on human health and safety and by mitigating any significant adverse impacts.[26] Climate change legislation and California's AB 32 Global Warming Solutions Act of 2006[27] is one of the main drivers for more efficient buildings. Green buildings with

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

25 AB 4655 (Tanner; PRC 25402.8).

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

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

increased energy efficiency were identified as a major target for reducing greenhouse gas (GHG) emissions in the AB 32 Scoping Plan.[28][29]

The Energy Commission has funded several landmark studies of indoor environmental quality and related factors in California, including studies of new residential buildings, small and medium commercial buildings, pollutant emissions from office equipment and studies of building heating, ventilating, and air conditioning (HVAC) and air leakage that are pertinent to indoor environmental quality. Studies have also focused on retrofits of low-income apartments, exposures from unvented combustion appliances, and healthy zero energy buildings. *Indoor Environmental Quality: Research Roadmap 2012-2030: Energy-Related Priorities* has been developed to guide future research.

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 present in a variety of structures such as schools, office buildings, and homes and investigates a variety of approaches to ameliorate mold problems in residences and office buildings. The U.S. DOE's indoor air quality research and development focuses on developing new ventilation strategies that simultaneously improve indoor air quality and reduce the energy impact of increased ventilation.

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**		**X**

Source: California Energy Commission.

28ARB, 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.

29ARB, 2011.Green Building Strategy. http://www.arb.ca.gov/cc/greenbuildings/greenbuildings.htm.

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

- Industrial and agricultural: Energy efficiency process improvements for energy intensive industries (e.g., glass, pharmaceuticals, petroleum, advanced metals, coatings, manufacturing and fabrication processes, data centers), development of technologies that substitute or materially change the underlying process (e.g., development of lower weight cement mix, substitutions for electrically intensive materials such as aluminum), and load reduction through demand response technologies.
- Water or wastewater sectors: Evaluate and fill data gaps such as in the following areas:
    - Extent of deployment of alternative water disinfection systems, such as ozone and ultraviolet light disinfection/oxidation technologies, the barriers to their adoption and their longer-term energy and cost savings.
    - Document extent of deployment and energy savings associated with membrane filtration technologies, such as advanced microfiltration, ultra-filtration, nano-filtration, reverse and forward osmosis membranes.
    - Extent of market penetration 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.
    - Advance the science of water and wastewater related energy efficiency (pumps, efficient canal technologies, water recycling technologies, desalination technologies, leak detection tools, process improvements).
- Identify opportunities to operate equipment or alter processes to provide load reduction on demand, evaluation of other opportunities, such as fast response, and limited duration load reductions that assist system operators in integrating intermittent, variable renewable resource and maintaining power quality across the grid.
- Engage experts and other stakeholder through workshops or technical advisory meetings to identify research priorities and needs to achieve reductions in electric energy use in the industrial, agriculture and water end use sectors.

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

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 only offers funding after a successful field demonstration. Over the past 5 years the Energy Commission's IAW research program has funded many demonstration projects to prove their efficacy and cost effectiveness. In the first investment plan, the emphasis was on large scale deployment of technologies. As a result, the emphasis of this investment plan will be applied research that will help support demonstrations in future investment plans.

In addition, multiple stakeholder workshops have been held to further 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 (ETCC) and other venues such as the Emerging Technologies Summit.

S1.6 Proposed Funding Initiative: Advancing Strategies to Reduce California Buildings' Impact 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: The purpose of this initiative is to 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 with the goal of potentially saving Californians 30 percent of its current urban water use with cost-effective water-saving solutions.[30] Potential research areas:

- Increase end-use water efficiency: Develop and test water efficient fixtures (e.g., shower heads, faucets, toilets) and plumbing to verify energy/water savings; develop cost effective

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

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 (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.

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 California Water Plan Update 2009 states, "California is facing one of the most significant water crises in its history"—one that is hitting hard because it has many impacts and consequences. 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 Delta by about 20 to 30 percent. In some areas of the state, our 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 the health, economy, and ecosystems[31].

The Department of Water Resources (DWR) estimates that the population will grow to 45 million by the year 2020. With an increasing population, climate change, and a multi-year drought, the state must take action to promote water efficiency to preserve our limited water supply. Landscape irrigation uses a significant amount of water. An estimate of residential

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

water use for 2005 is 5.9 million acre feet, of which an estimated 3.2 million acre-feet is outdoor water use. There is considerable potential for water savings through irrigation system improvements and behavioral change. Substantial amounts of water can be saved using existing technology and management techniques. 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. [32]

"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 this use through conservation and efficiency. The bad news: California's urban sector currently 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, where around 20 percent of the state's water is used to meet commercial, industrial, institutional, and residential needs. The best way to save is to reduce waste in the system, using proper pricing and economics, educating the public, and improving water efficiency and conservation efforts.

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

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

Table 3: 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: Demand response (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 mitigate net load 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 load-balancing services to integrate higher levels of renewable energy resources that will be necessary to meet California's long-term (2050) greenhouse gas emission reduction goals.

Customer participation opportunities are limited—both in CAISO 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.

Because communication, automation, and end-use control technology has been rapidly evolving—along with other microelectronic, telecommunication and internet-based technologies—the institutional frameworks for utilizing those advances has 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 probalistic 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 a number of underlying technology, application and customer awareness barriers that need to be addressed through research.

Investments in first 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 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 first investment plan focuses on research and development that helps organize and operationalize DR for existing market and program opportunities. The second 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, and 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 generation while maintaining grid reliability and integrating intermittent and highly variable renewable resources. This will be done by developing and testing of DR technologies to assess and evaluate performance as well as collecting and evaluating performance data from different programs to increase reliability of DR impact estimates and improving forecasting techniques. Potential research areas include:

- Develop, test and advance DR technologies: Building on the technology development research under the first investment plan, this initiative will develop the ability to combine end-use DR technology—switches and control logic and communications—with management systems. The purpose is to develop and test load reduction capabilities at all hours of the year, and 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:
  - 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.
- Evaluate the potential development of control and monitoring hardware and software systems that will provide enhanced, highly reliable DR (and storage) performance forecasting and allow increased system utilization of DR as a reliable substitute for generation resources.
- 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: Utilize 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 that the real-time performance impacts can be documented.

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

Background: Policies designed to reduce GHG emissions will increase renewable energy generation and increase electricity consumption. 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 (LSEs). In addition, these shifts in demand and supply balance have the potential to alter the historical relationship between 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 in the absence of sufficient attention and oversight by regulatory authorities to protect ratepayer interests.

Demand response, along with distributed generation and storage, is a critical component in balancing renewable intermittency. The extent of DR participation by consumers will ultimately have a strong impact 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 currently 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. To increase the effective utilization of existing participating resources and to realize the savings opportunities inherent in the large-number-of-small-loads model requires further development and research. Research is needed on low-cost automation technologies, dependable and end-user-friendly control strategies, communications technologies and performance measurement strategies that provide sufficient information to system operators, and the expansion of market opportunities for small users.

Clean Generation

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

Table 4: 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 Lower-Cost, Efficient, and Sustainable 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 Generating 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 to small-scale and localized power generation from renewable resources that are typically close to electricity loads. Such generation reduces the demand for transmission and distribution infrastructure and large-scale centralized power generation. It is a key goal under Governor Brown's Clean Energy Jobs Plan, which calls for adding 12,000 MW of distributed renewables by 2020 and supports the mandated 33 percent renewable electricity by 2020 under the state's Renewable Portfolio

Standard. Common barriers among renewable DG systems include relatively high overall cost depending on the technology and resource, intermittency and reliability.

Permitting processes and utility interconnection requirements also pose major challenges in many situations and can add to costs and results in lengthy delays to individual distributed generation projects, although efforts continue to streamline these processes and requirements. For a number of emerging DG technologies, lack of sufficient performance data and bench and pilot scale verification complicates permitting processes and hinders the needed investment confidence needed for full market deployment of the technology. This Strategic Objective aims to provide ratepayer benefits by addressing the research and development needs of different forms of renewable and advanced DG, such as biomass, solar, and small hydro, and other potential resources that are currently underutilized 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 renewables, 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 has not focused on this niche of the market due to the need for technological breakthroughs to make it economical. There is a need to highly improve and integrate state-of-the-art technologies in order to maximize exploitation of energy. For example, conventional photovoltaic (PV) systems utilize 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 is generated by almost every energy conversion process that could, instead, be utilized to further augment energy supply. Emerging technologies may be able to utilize previously untapped renewable resources to augment renewable energy capacity and/or reduce demand-side load.

Investments in first plan addressing barriers and challenges: This strategic objective builds on initiatives started in the first investment plan to address barriers and challenges related to distributed renewable energy by leveraging technical advancements expected from awarded projects. One of the proposed initiatives also addresses barriers and challenges for small hydropower which was not included in the first investment plan. Finally, this strategic objective also includes initiatives addressing the barriers and challenges for breakthrough energy generation sources that were not included in the first investment plan.

S3.1 Proposed Funding Initiative: Lower-Cost, Efficient, and Sustainable 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: 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 greenhouse gas emissions and providing additional co-benefits. These co-benefits include prevention of catastrophic wild fires and reduction of material sent to landfills. The goal of this initiative is to advance innovative approaches that show the greatest potential to reduce system costs, increase energy conversion efficiency, and improve environmental performance. This initiative will conduct applied R&D in the following areas:

- Advanced Biomass-to-Energy Conversion Technologies: Biomass conversion technologies funded through this initiative 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, 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 will include developing technologies and strategies for the sustainable utilization of forest residue and thinning to generate clean electricity, while reducing catastrophic fire hazards, and utilization of municipal waste, agricultural residue and food processing waste. The target will be to generate electricity and useful thermal energy 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: Through this initiative, research 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. Research will be conducted to develop tools and techniques to evaluate environmental and economic impacts of proposed technology solutions.

Stakeholders: Ratepayers in rural and urban communities, industrial and commercial food processing facilities, dairy and agriculture facilities, and wastewater treatment facilities; California Department of Food and Agriculture; 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, US Forest Service.

Background: This initiative will address challenges identified in the *2009 Integrated Energy Policy Report*, the *2011 Bioenergy Action Plan*,[33] and the *Renewable Energy in California: Status and Issues* report. This initiative also leverages the biomass activities specifically identified in the first 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

33 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 go to: http://www.energy.ca.gov/bioenergy_action_plan.

three processes: thermochemical, biochemical, and physicochemical. Thermochemical, such as by combustion or gasification, and biochemical, commonly by anaerobic digestion, are the dominant processes for biomass-to-electricity generation (also referred to as biopower) and are the main focus of this initiative. Most solid biomass power plants, which convert biomass from forestry, agricultural residue (such as prunings, old trees) and urban wood wastes to electricity in a thermochemical process, use only about 5 million bone dry tons (BDT) per year of biomass in California compared to estimated biomass technical potential of more than 36 million BDT tons per year. Similarly, only a small proportion of food and other organic wastes, including only one percent of the manure produced from the dairy farms, are captured as resource for biopower through anaerobic digestion. Furthermore, a major portion of the biogas produced by the anaerobic digesters and waste water treatment plants is flared. Reciprocating engines, which are the more dominant technology in biogas to electricity systems, are currently challenged with meeting state and local air emission requirements. Air pollutant emissions control devices for this type of engine can be relatively expensive, posing a major barrier to expansion of utilization of the biogas. Other generation technologies like microturbines and fuel cells have lower emissions profiles but are currently more costly, require more stringent quality of biogas, and are relatively more complicated to operate.

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.[34] USDA is funding bioenergy with a focus on the environmental and policy issues. The conversion technology research funded through this effort 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.

This initiative will coordinate with other Energy Commission renewable energy commercialization activities (AB 118).

34 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, facilitate the adoption of building-integrated PV and hybrid PV/T 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, and 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 conduct applied R&D to improve the performance and value of distributed PV systems, such as:

- Hybrid solar PV/T 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 have a need for 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 Zero Net Energy 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 in concert with other energy components within the building to advance California's ZNE buildings goals, as indicated in 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. CSI RD&D will invest up to $50 million by 2016 pursuant to Public Utilities Code Section 2851. [35] 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 SDG&E as described in Decision 06-12-033.[36] Through this proposed 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 has 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.

As California strives to meet its zero-net energy 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 research and development 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 facilitate the widespread deployment of these technologies. Additional cost savings may be realized by identifying opportunities for hybrid photovoltaic and thermal (PV/T) technologies to provide power and heat to California's buildings.

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35 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…"

36 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.

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.[37] 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, further cost reduction opportunities exist that are essential to the long-term viability of distributed PV in California.

S3.3 Proposed Funding Initiative: Generating 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 hydropower turbines and generators. Demonstration of pre-commercial turbines and generator may be conducted up to the pilot scale which includes demonstration of an individual unit within an actual conduit. This initiative will also address the development of testing protocols or

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

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.

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

Background: In-conduit hydropower is where electricity is generated from the force of moving water that is flowing in tunnels, canals, pipelines, aqueducts and other structures without the need for a large dam or reservoir. Significant small hydropower generation potential exists at existing canal drops and pipeline pressure relief valves within the state. A California Energy Commission study in 2006 estimated that 250 MW is available on existing open channel drops of nine feet or more.[38] It is likely that significant greater 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.

Conduit projects often qualify as small hydropower under the state's Renewable Portfolio Standards; avoid environmental concerns associated with in-stream hydropower generation and exploit synergies with infrastructure already in place 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. In-conduit hydropower is the least expensive renewable generation technology available and offers all the benefits of distributed and self generation. Although a host of turbine technologies have been developed for in-conduit hydropower[39], the major barriers to greater deployment of this technology is seen as permitting requirements, cost of interconnections and a lack of standardized testing protocols and guidance for equipment selection[40]. The California's Renewables Portfolio Standard (RPS) Participating Facilities[41] list

38 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.

39Inventory of Current In-Conduit Small Hydroelectric Generation Technologies. 2013. Cooperman, Aubryn and J.P. Delplanque. California Small Hydro Collaborative. August.

40 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.

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

identifies less than 40 in-conduit generation installations, within the state. The majority of these facilities are less than one megawatt and representing just a small fraction of the available sites in California. Recent federal legislation has significantly relaxed permitting requirements, but interconnection costs remain an impediment.

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 currently utilized 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 distributed generation technologies.

Potential applied R&D topics funded under this initiative may include but not limited to:

- High-efficiency waste heat conversion technologies to augment electricity generation. Technologies such as this can help to increase existing electricity generation utilizing 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 individual devices to power themselves based on ambient electromagnetic, thermal, or mechanical energy in the surrounding environment. Technologies such as this could help facilitate a reduction in

plug-load demand using energy resources that are renewable, consistent with California's energy loading order.

- Thermoacoustic engines for electricity generation. Technologies such as this 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 that are used in nature could be applied to optimize existing energy systems or develop altogether new approaches to electricity generation.
- Application of advanced printing techniques for electricity generation. This could include printing processes for ultra low-cost photovoltaic panel manufacturing or evaluating potential applications of 3D 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 separate renewable energy generators that can be hybridized in a way that increases overall conversion efficiencies and provides other potential benefits.
- Novel technological solutions to enable increased deployment of clean and advanced distributed power generation. This will support new designs, materials, and control systems that have potentials to significantly reduce the cost, improve the durability and increase the reliability of renewable and advanced distributed generation technology. Potential projects may include areas that address new materials and system design for turbines or fuel cells, enabling control systems to better integrate renewable distributed generation with the grid and user requirements, for instance, to better response to load changes or ramping requirements.

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

Background: In 2012, the Energy Commission released a solicitation titled Community Scale Renewable Energy Development, Deployment and Integration. One of the research areas was for "Breakthrough Renewable Energy Generation Technology Development."[42] This research

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

area sought proposals to develop renewable energy technologies with breakthrough potential in the commercial energy market, and will provide a significant contribution 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 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 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 underutilized applications to cost-effectively increase renewable energy capacity and/or reduce demand-side load. Projects supported under this funding initiative should be consistent with the recommendations from recent California Energy Commission assessment of piezoelectric materials for roadway energy harvesting. Notably, 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 its power generation. The initiative will also support assessment of piezoelectric system applications in other opportunity areas with little public data to determine technical and economic feasibilities, particularly determining projected power output, lifetime and durability, costs, and marketing potentials.

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

Background: Unlike the photovoltaic semiconductor which generates electricity with the application of light, piezoelectric materials generate electricity with the application of stress. Such phenomenon offers a wide opportunity to harvest energy where stress or vibration is generated and yet currently remained largely untapped. Potential sources of vibration include humans walking, machinery, or cars moving on a roadway. The application of piezoelectric technology is not entirely new. For instance, it has been used in sonar and touchscreen 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.[43]

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 (LCOE) for the piezoelectric systems to be between $0.08-$0.18/kWh, although it is strongly dependent 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.[44]

43 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/

44 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 5: 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 Boosting 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 Upgrading 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 standalone generation facility that is directly connected to the grid and is 20 MW or greater in capacity. The distinction of having 20 MW in capacity is somewhat tentative, systems as low as 10 MW have also been considered utility-scale in other utility generation policy and planning documents. The key distinction is being standalone and having direct connection to transmission and distribution 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 Renewable Portfolio Standard (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, remain a common challenge across different 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 in comparison to photovoltaic and conventional natural gas fired generation sources remains a significant barrier to greater penetration of this technology. For both 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 (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. For geothermal, the cost of 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 needs to be implemented in consideration of 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 tax incentives. 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 research and development on utility-scale renewable energy systems.

Investments in first plan addressing barriers and challenges: The first 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 first investment plan, particularly in the area of solar and wind forecasting, to further increase the accuracy of solar and wind generation forecasts, and the value they provide to California IOUs and the CAISO. Research on concentrating solar power, wind repowering and geothermal technologies will

address technological barriers and challenges that are not addressed in, but are leveraging the results from, the first EPIC Investment Plan.

S4.1 Proposed Funding Initiative: Boosting 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 concentrating solar power (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 improving the solar transmissivity of the mirrors to reduce the levelized cost of energy, developing lighter weight reflective surfaces to reduce manufacturing costs; developing reflector coating to reduce maintenance costs and improving reflectivity assessments to improve maintenance and reduce costs. Also, research to support microdefect detection and accelerated aging tests is included under this initiative. This initiative also addresses research on increasing the efficiency of absorbers to operate at higher temperatures and to allow higher radiation fluxes. For linear absorbers, there is a need for the development of absorbers that can work with alternative heat transfer fluids and the development of 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 first EPIC investment plan.

Stakeholders: Technology developers and providers, federal, state and local agencies, academic institutions, IOUs, CAISO, Western Electricity Coordinating Council (WECC)

Background: Concentrating solar power (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 facilitating greater use of thermal storage with this technology. CSP technologies have different system configurations, and all use different designs of mirrors or reflectors and receivers or absorbers, to concentrate sunlight to heat a fluid and produce steam that drives a turbine to produce electricity.

According to the Department of Energy's Sunshot Initiative, mirrors represent 40 percent of the total system costs for CSP plants, while receivers represent another 15 percent. The Sunshot Initiative is seeking to reduce the levelized cost of electricity generated by CSP to $0.06 per kilowatt hour (kWh) or less, without any subsidy by the year 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 set temperature, thermal cycling and efficiency, cost and durability goals.

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

NREL is undertaking research to improve the 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 parabolic trough 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 complimentary 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 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 a number of the research opportunities posed by the 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:

- Expand and extrapolate on past renewable forecasting efforts, including investments made as a result of the first Triennial EPIC Investment Plan, to result in higher accuracy, more reliable forecasts that grid operators and IOUs can utilize for planning processes 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 mitigate 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 IOU and CAISO needs are adequately addressed.

Stakeholders: Electric IOUs, CAISO, Forecast Providers, Western Electricity Coordinating Council (WECC)

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. Recent research is evaluating the feasibility of integrating these three tools into one seamless forecasting tool, and additional applied research and development activities will be funded by the first Triennial EPIC Investment Plan. Future research activities 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 (NOAA) 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, 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 (MWD) 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 our 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. Additionally, newer binary power plants are able to utilize moderate and lower temperature resources which were formerly impossible or uneconomic to exploit for electricity production. Applied research and development 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 are 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: Upgrading 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, academia

Background: California was one of the first locations for utility-scale wind development, meaning some existing equipment currently in operation dates 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.

Additionally, 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 approximately 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, EERE 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 6: 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 Implementing Roadmap to Address Public Health Effects From Energy Technologies.			X	X					
S5.2 Developing Environmental Tools and Information for Future Renewable Energy Conservation Plans.		X	X	X			X		
S5.3 Improving Science for Water Management in Power Generation: Hydropower Forecasting and Hybrid Cooling Towers.	X		X	X					
S5.4 Providing 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 first 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.

Investments in first plan addressing barriers and challenges: The first 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 first investment plan, which leaves ample room for new more specific research initiatives for the second investment plan. However, the same overall need of environmental protection still drives the proposed suite of research areas for the second investment period. In some cases, the first investment period will only be able to partially address the research needs in a given area (e.g., 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 that will be continued in the second investment period. In the public health area, the first investment period will cover the development of a roadmap of research while this investment period will fund priority projects identified in the roadmap.

S5.1 Proposed Funding Initiative: Implementing 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 NO_2 to NOx in exhaust from biopower and potentially also at power plants. This work will further characterize 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 the poor air quality in California, California has strict emissions requirements that could inhibit the adoption of biogas in power generation if emissions are not adequately controlled.

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

Stakeholders: Ratepayers, utilities, non government organizations (NGOs), California Air Resources Board (ARB), U.S. Environmental Protection Agency (U.S. EPA), Air Quality Management Districts.

Background: Air quality model results can be very sensitive to the assumed ratio of NO_2 to NOx 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 NOx 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 particulate matter (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 Electric Program Investment Charge is expanding to include health impacts of producing and using electricity, the first 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 renewable 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: Developing 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 California 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 (e.g., 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), 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, NGOs, U.S. EPA, state and federal wildlife agencies, renewable energy developers.

Background: Utility-scale renewable energy developments that are crucial to achieving California's Renewables Portfolio Standard (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 facilities for distributed generation can encounter land-use conflicts with terrestrial resources and land uses such as agriculture. Several new, or revitalized, energy technologies (hydraulic fracturing, enhanced geothermal energy, geologic carbon sequestration, and compressed air energy storage) pose an unknown level of risk of inducing seismic events that could harm people or property. Key barriers and challenges include:

- A lack of baseline data, tools, and methodologies 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 (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; 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 DRECP, as identified in the *2009 Integrated Energy Policy Report*. The DRECP will guide renewable energy siting and conservation in the Mojave Desert and Colorado Desert of California 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 facilitate 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: Improving Science for Water Management in Power Generation: Hydropower Forecasting and Hybrid Cooling Towers.

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 initiative is to develop tools, technologies, and information that will improve the management of water in electricity generation as well as reduce associated impacts of this use. The focus of this initiative will be on the following topics that were identified in the first EPIC investment plan, but were not funded:

1. **Developing and Demonstrating 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 through developing 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 is dependent, 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 now, new sensors and wireless capabilities that can be used to substantially develop improved hydrological forecasts, but the demonstration of these tools is not sufficient at the present time. 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 a number of 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 individual 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 its 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, may reduce the amount of expensive offsets needed to be purchased.

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

Background:

Hydropower

Depending on precipitation, over the last decade hydropower has contributed from 8 to 17 percent[45] 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.[46] 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. Given the role this high elevation hydropower system has within the state's electricity system, it is important to utilize this system as efficiently as possible.

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

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

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 is dependent 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 the accuracy of streamflow forecasts only in the order of 40 percent. 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 Demonstration* Project[47]. The probabilistic forecasting system in INFORM was coupled with a decision support system to assist reservoir operator to utilize 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 to 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.

47 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.

Degraded Water Sources for Cooling Tower Make-up

Although all electricity generating technologies utilize 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* [48] 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.

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*[49] 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.

48 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

49 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

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 grown and may not result in PM emissions.

Significant portions of Southern California have been classified by the U.S. Environmental Protection Agency 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: Providing 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

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 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 California for the energy sector: Under the first EPIC investment period researchers will develop improved downscaling techniques and develop climate and sea-level rise scenarios designed for the energy sector. Under the second triennial Investment Plan for EPIC, researchers will use these scenarios to develop

probabilistic climate projections using numerical experimentation, paloeclimatic information, and expert elicitation.

Potential impacts of climate change to renewable sources of energy: Climate change will not only increase ambient temperatures, but also may change wind regimes, cloudiness and therefore solar radiation reaching ground level, and the availability of biomass. 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.

Long-term evolution of the energy system taking climate change into account: Continuation of ongoing research developing potential energy scenarios for Californians but, this time, with more in-depth consideration on reducing the climate vulnerability of the energy system and the examination of unexplored issues such as large scale deployment of microgrids, dynamic rating of transmission and distribution lines, and consideration of weather related extreme events.

Identification of cost-effective compliance mechanisms for the electricity sector for the cap-and-trade program: Compliance with greenhouse gas regulations may affect the price of energy in California. These impacts can be reduced by finding innovative approaches to comply with cap-and-trade limits such as helping energy users reduce GHG emissions below their cap, which free some of their allowances, or purchasing lower cost emission offsets from sources not included in the GHG cap. Currently, only a limited number of offset protocols have been approved. In order for there to be sufficient offsets by 2020 and after 2020, additional types of offsets will have to be identified. While the cap and trade program allows offset projects to take place anywhere in the country, this initiative will focus on California-based offsets so that local communities, particularly low-income ones, benefit from accompanying environmental and health co-benefits. These offsets would, as much as possible, be associated with the energy sector.

Barriers to adaptation to the energy 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 energy system.

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.

Measuring adaptation progress and effectiveness: This study involves the development of practical metrics to measure adaptation progress and effectiveness. The goal is to develop metrics that energy agencies can use in an operational mode (e.g., Integrated Energy Policy Report).

Other related areas of work may be supported depending on the results of the first investment period.

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 to the state. 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 utilize 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 technology by improving regulatory decision-making and informing policy.

Energy Commission environmental research seeks to advance scientific knowledge or protocols used to gain that knowledge. Success is measured by the direct result of research informing the improvement of energy facility permitting (regulatory) processes; advancing knowledge, such as findings referenced in peer-reviewed literature or regional land use plans; informing policy, such as findings being adopted by the Integrated Energy Policy Report, Energy Action Plan, or Legislation (e.g. California's Global Warming Solutions Act of 2006); and better defining an environmental impact or mitigation measure. New technologies and energy infrastructure, however, are affecting new geographic areas, potentially changing the kind of environmental and public health impacts that have been the focus of studies in the past.

Environmental research is based on knowledge of the relevant issues through collaboration with stakeholders, policymakers, and the scientific community. Given the rapidly evolving technological advances and energy needs of California, staying up to date on the multitude of environmental issues associated with such rapid development can be a challenge, and unexpected issues arise. Previous Energy Commission small grants programs have offered the flexibility needed to stay informed about cutting-edge concepts, allowing for a higher risk based approach to solve evolving energy-related environmental concerns.

Smart Grid Enabling Clean Energy

S6 Strategic Objective: Advance the Use of Smart Inverters for Grid Support in California.

Table 7: 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 utilizing advanced inverter capabilities to optimize system performance.

Under the joint leadership of the CPUC and the Energy Commission, the Smart Inverter Working Group (SIWG) comprised 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 also reduce the amount of equipment on the distribution system.

Investments in first plan addressing barriers and challenges: The first Investment Plan did not contain any funding initiatives addressing the barriers and challenges described above. Funding Initiative S6.2 from the first Investment Plan included enhancements to existing distribution management systems (DMS) to monitor and control smart inverter activities, but did not include applied research on improvements to smart inverters themselves.

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: The purpose of this initiative is to explore the capabilities for smart inverters to support the grid. 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 first Investment Plan.

Stakeholders: Utilities, smart inverter manufacturers, and DER 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 some initial inverter functions to the CPUC regarding autonomous DER functions for inverters. 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 8: 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.

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 their 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.

Investments in first plan addressing barriers and challenges: The first Investment Plan did not contain any funding initiatives addressing the barriers and challenges described above. During the development of the first 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 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: The purpose of this initiative is to 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 that maximize the use of multiple processors.

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

Background: Modeling software for power systems is undergoing significant development to address an increasingly complex electric grid. The rapid increase of penetration of solar photovoltaic (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.

While not considered simulation, data analytics is expected to play a role in utility planning. Data analytics is the study and extraction of useful, but frequently unobvious information from large volumes of data. Dramatically increasing data will be available in the future from distribution systems as DERs are continually added at various points on distribution feeders and smart grid monitoring and communication systems are deployed.

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

Table 9: 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 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 currently communicate with their respective utility systems.

Investments in first plan addressing barriers and challenges: In the first 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 second Investment Plan will address communication interfaces for smart inverters instead of the first 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: The purpose of this initiative is to develop customer energy management systems that coordinate various energy devices and equipment capable of demand response, renewable energy generation, and electric vehicle charging. This initiative will allow customer energy management systems to manage customer resources behind the meter and coordinate with utility communication and controls.

Stakeholders: Utilities, CPN software vendors

Background: Network-enabled devices such as programmable thermostats, plug modules, water sensors, lighting controls, and security devices are currently available for customer use. However, these types of devices currently available in the market use different communication protocols such as ZigBee, ZWave, WiFi, and Bluetooth. Network hubs communicate over multiple protocols so that all devices in a single location can be controlled by an energy management system. Information about the performance of these devices could be useful for demand-side management and improve coordination with utility operations.

S9 Strategic Objective: Efficient Integration of Plug-In Electric Vehicles to the Electricity System.

Table 10: 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 Advancing Electric Vehicle Charging and Grid Services to Maximize Renewable Resources and Improve Grid Flexibility.	X	X		X	X	X			
S9.2 Advancing Vehicle-Grid Integration Technologies and Methods for Broader Use and Benefit for Residential, Private, and Public Users.	X	X		X	X	X			
S9.3 Advancing Technologies and Methods to Enable Safe, Efficient, Smart Recycling of Electric Vehicle Batteries.		X	X	X					

Source: California Energy Commission

Barriers and Challenges: Plug-in Electric Vehicles (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. 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 continue to advance the capabilities of PEVs. Actions 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, are all barriers that should be addressed and examined further. For example, continued demonstration of vehicle grid integration needs to be pursued in order to ensure wider adoption of this technology that expands beyond military bases and government fleets. Additionally, lithium is 100 percent recyclable, however producing battery-grade lithium from current recycling processes is about five times more costly than production from new materials resulting in un-recycled yet useable materials ending up in landfills as opposed to new batteries. Research investments that address

these issues will continue to be explored in order 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 SX, the Energy Commission met with stakeholders through advisory board meetings and technical working groups on smart grid and electric vehicle infrastructure research needs. Energy Commission staff also incorporated comments from the workshops held on its draft 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 first plan addressing barriers and challenges: The first Investment Plan did not contain any funding initiatives addressing the barriers and challenges described below with the exception of SX.X (Battery Recycle). The initiative was not pursued because two projects were funded in this area with PIER electric funds and it was determined that the second EPIC investment plan would better leverage findings and results from these efforts.

S9.1 Proposed Funding Initiative: Advancing Electric Vehicle Charging and Grid Services to Maximize Renewable Resources and Improve Grid Flexibility.

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 Plug-In Electric Vehicles (PEVs) that help mitigate intermittency issues associated with renewable generation allowing for a higher mix of renewable resources such as wind and solar into the grid. This research will look for opportunities to utilize the distributed battery capacity of an electric vehicle fleet as grid storage, and create opportunities for rapid response and operational flexibility to provide regulation and load-following capabilities.

Stakeholders: Ratepayers, utilities, electric vehicle 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 electric vehicle charging infrastructure is designed to capture renewable benefits, for example by encouraging charging during times of high wind and low load.[50] 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, either for the individual electric vehicle 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, though it is critical to move towards a range of alternative and complementary options such as energy storage and demand response. To enable further deployment of a mix of renewable generation, methods to address intermittency need to be explored and demonstrated.

S9.2 Proposed Funding Initiative: Advancing 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 VGI (Vehicle Grid Integration) projects that developed the communication and protocols to enable bidirectional power flow to perform vehicle-to-grid and vehicle-to-building strategies. The research will further advance the development of VGI technologies and methods by expanding beyond military bases and government fleets, and into residential and private/public fleet applications. The research will also leverage findings from ongoing Department of Defense military installation VGI projects,

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

including continuing to determine cost benefits of VGI through demand response or load shifting, and to determine impacts VGI may have on PEV batteries. Examples of proposed research topics include:

- Understanding vehicle use profiles, EV cost benefits, and battery life challenges with VGI under residential and private/public fleet applications
- Assessing VGI grid impacts for different VGI applications and technologies
- Developing VGI business models for residential and private/public fleet applications
- Identifying research gaps for further study and in support for scale-up efforts

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

Background: The interest in validating the benefits of Vehicle Grid Integration (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 by 2025, and a large portion of these vehicles will be plug-in electric vehicles (PEVs). Managing the aggregated load to the power grid for PEVs requires innovative methods to support the growth of these vehicles in California while also 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 variations in power generation. Additionally, 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 findings are not yet available but will guide future research and development.

To provide guidance for VGI, the California ISO took the lead in drafting a VGI Roadmap in coordination with the Governor's Office, the California Energy Commission, the California Public Utilities Commission and the California Air Resources Board. The effort included a comprehensive stakeholder review process to ensure the roadmap captured the ideal course of actions. The resulting Vehicle-Grid Integration (VGI) Roadmap maps a way to develop solutions that enable electric vehicles (EV) to provide grid services while still meeting consumer driving needs.

S9.3 Proposed Funding Initiative: Advancing Technologies and Methods to Enable Safe, Efficient, 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, as well as advance existing methods for battery production and recycling. Disposal impacts as well as advance tools and methods necessary for large-scale battery pack recycling should be investigated further, and additional research on recycling efficiency should also be explored. As the number of electric vehicles in California's transportation grows, it is essential that efficient, safe, environmentally sound, and cost effective recycling systems are developed for recycling large format lithium ion batteries.

Stakeholders: Vehicle OEMs, Existing and Start-up companies, investors

Background: Recycling can provide financial value and thereby contribute to overall affordability and sustainability of PEVs, can provide material resources, and can reduce the costs and environmental concerns of battery component disposal at end of life. Battery production and disposal impacts could have land use impacts that negate the many benefits of PEV use. Specifically, battery disposal could have significant land use impacts if batteries are sent to landfills instead of recycled. Research is needed to address these issues, and determine the economic and environmental impacts of recycling, and to explore new and advanced methods for doing so.

In December 2012 the Energy Commission released a solicitation that made $1 million available for the development of technologies, tools, methods, and scientific knowledge that is needed to enable large scale battery recycling. Through the solicitation, two projects were awarded funding. The first project is to develop an advanced recycling method that can reclaim high value materials that can be used to develop new large format lithium ion batteries. The second recycling project awarded to Lawrence Berkeley National Laboratories focuses on the development of battery recycling scenarios for California.

While battery recycling for PEVs was listed as an initiative for the first EPIC Investment Plan, funding was not allocated to this initiative pending results of the ongoing projects mentioned above. Results from research currently under way can support future funding opportunities under EPIC by building on existing research, or identifying the remaining gaps and barriers that need to be addressed in order to advance recycling strategies.

Cross-Cutting

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

Table 11: 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	X
S10.2 Conduct Incentive Based Competitions to Foster Breakthrough Ideas for Clean Energy Solutions.	X	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 like 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."[51] 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 individual innovators collaborating across disciplines and

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geographic scales to address major challenges in the energy sector. However, funding opportunities to design, develop and prove out potentially breakthrough concepts are limited.

Investments in first plan addressing barriers and challenges: The Energy Commission's first EPIC investment plan did not include seed-stage funding for energy technologies.

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 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 impact.

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

Background: Through the PIER program, the Energy Commission provided funding for the Energy Innovation Small Grant (EISG) Program. The EISG Program provided up to $95,000 for research that established the feasibility of new, innovative energy concepts that provide potential benefits to electric ratepayers. At the Federal level, the U.S. Department of Energy's Small Business Innovation Research provides small business 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 Incentive Based 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 incentive based 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:

- Zero-net Energy Buildings
- Home Fuel-cells
- Portable waste-to-energy technologies

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 incentive based competitions and crowd sourcing can offer a number of benefits to conventional research and development 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 prizes is that they allow for outside innovators to provide solutions to traditionally industry-specific problems."[52] In addition to XPRIZE, the Defense Advanced Research Projects Agency (DARPA) has utilized prize 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 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 prize.

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

Table 12: 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 (entrepreneurs, small businesses, and research institutions) have not fared as well as expected when competing with other states for

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

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 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 first plan addressing barriers and challenges: The first investment plan included cost share for federal funding opportunities related to the initiatives in the Energy Commission's EPIC investment plan for 2012-2014. This initiative focuses on the initiatives included in this investment plan for 2015-2017.

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

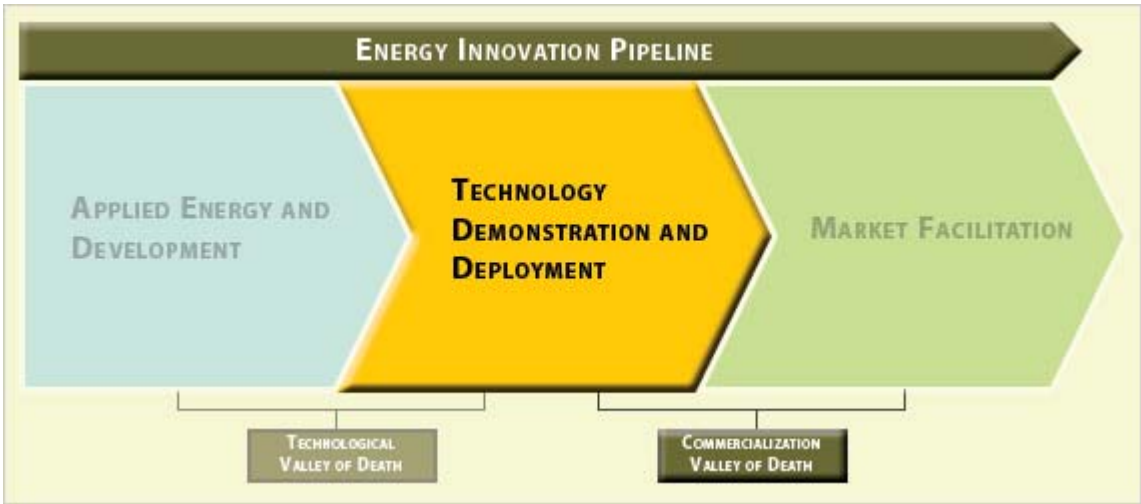
Source: California Energy Commission

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 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 pre-defined or pre-approved in the investment plan.

Stakeholders: Research Institutions, companies, U.S. DOE, U.S. DOD, 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 ARRA awards. 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 currently 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 the transition of 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 currently planning its first regional roll out of electric vehicle 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. Additionally, California companies that can become part of the regional roll out in California will have business opportunities throughout the nation and the world as the U.S. DOD completes its system-wide transition to electric vehicles.

Technology Demonstration and Deployment



Source: California Energy Commission.

The applied research and development stage develops novel clean energy technologies and strategies, evaluates technical performance, and tests promising prototypes. The next step, technology demonstration and development, 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 provide funding for 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 sufficiently large and in conditions sufficiently reflective of anticipated actual operating environments to enable appraisal of the operational and performance characteristics and the financial risks. For this three-year investment plan, the Energy Commission will provide funding for technology demonstration and deployment 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 facilitate the achievement of the states' energy policy priorities, including the "loading order." Demonstration projects funded in this category will also serve as a test bed to explore opportunities to make the whole better than the sum of individual parts through a holistic approach to integrating efficiency, renewables, and clean transportation. 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 be conducted in investor-owned utility (IOU) service territories. However, projects located outside IOU service territories may be considered, if there is a strong case that the project demonstrates IOU electricity ratepayer benefits. The demonstration and deployment strategic objectives discussed below outline a set of proposed initiatives focused on a particular proposal area.

Proposed initiatives identified in this 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.

Table 13: Proposed Funding Allocation for the Technology Demonstration and Deployment Program Area by Strategic Objective

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

Source: California Energy Commission.

The proposed funding allocations for the technology demonstration and deployment program area provided in Table 13 were developed based on the priorities defined in the CPUC EPIC decision and the expected level of effort needed to fully address each of the specific strategic objectives. These funding levels are estimates and may change based on the number of successful responses received from competitive solicitation awards and the amount of leveraging of the EPIC funds from other parties that can be obtained by strategic objective.

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

Table 14: 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, they must be fully demonstrated and deployed in actual commercial applications to document benefits and savings in real world conditions. This includes independent documentation of real world conditions to validate energy, water and cost savings, environmental benefits and overall life cycle economics. Without an independent assessment of their technical and economic viability, these technologies and strategies do not make it past the commercialization valley of death. Additionally demonstrations and large-scale deployments are needed to overcome the barriers associated with emerging technologies, such as technical feasibility, reliability, regulatory and permitting, economic feasibility and long term viability and persistence of benefits.

In addition, demonstrations of integrated multiple demand side management technologies to maximize overall building and facility energy efficiency are needed to document the synergies of combining technologies and identifying the correct mix that would result in the most ratepayer benefits. These demonstrations are especially needed. However, based on past experience, a one-size fits all process will not work since the reason for upgrading and implementing retrofits varies with facility operators.

Investments in first plan addressing barriers and challenges: The first Investment Plan addressed three demonstration strategies associated with individual technologies (S12.1), technology integration (S12.2) and zero net energy buildings and communities (S14.1).

The Energy Commission will release solicitations in fiscal year 2014 and 2015 that focus on these areas. The bulk of the individual technology demonstrations will focus on the industrial, agriculture and water sector. As it is uncertain how many of these areas will be funded through these solicitations, we will continue to focus on additional demonstrations in this area and also for the building sector, especially on technologies that went through bench scale testing as part of applied research portion of the program (S1 from 2012-2014 Investment Plan), with an emphasis on large-scale deployment. With more demonstrations and deployments, it is anticipated that there will be increased electric ratepayer acceptance of technologies and integrated approaches so that the value and the benefits 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: This initiative will demonstrate pre-commercial technologies that are past the "proof-of-concept" stage in existing and new buildings. These demonstrations will be partially funded by EPIC and the applicants will need to provide a required level of match funding. The objective is to produce independent technical and economic performance data, which could make the technologies eligible to participate in the utility energy efficiency rebate programs and could facilitate the successful deployment of the technologies into the marketplace, particularly technologies developed in Strategic Objective S1. Utility rebates can expedite customer acceptance and market development for the demonstrated technologies and also provide the data needed to inform future building efficiency codes and standards. For instance, results from

several advanced light demonstrations were used in developing the 2013 building energy efficiency standards for commercial interior/exterior lighting.

Examples of technologies include, but are not limited to the following; advanced lighting, advanced HVAC systems and controls, advanced building envelopes, cost-effective retrofit strategies, indoor air quality improvement strategies, and other cost-effective technologies. Technologies, systems and strategies would be retrofit to existing buildings and could include both commercial and 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, home performance contractors and building managers/operators.

Background: This initiative will build and expand upon energy efficiency research efforts to demonstrate advanced technologies:

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 has resulted in widespread application and installation of emerging technologies, especially lighting improvements and HVAC controls, in several University of California and state buildings and has saved an estimated 61 million kWh/year and 4.2 million therms/year, resulting in $12 million per year in savings. The efforts of SPEED have also resulted in many of the developed lighting technology being included in the 2013 Title 24 code update. Additionally, other efforts also resulted in demonstrations of whole building energy efficiency concepts in limited residential and commercial buildings in a few climate zones. This initiative will expand these commercial demonstrations and emphasize large-scale demonstration and deployment of advanced technologies to private and other publicly owned buildings.

Multiple stakeholder workshops were held to further identify specific research needs and emerging technologies ready for demonstration at commercial facilities scale. Additionally, input from the IOUs and other stakeholders are received through participation in the Emerging Technology Coordinating Council (ETCC) and other venues such as the Emerging Technologies Summit. Both of these venues have participation by the IOUs and the Sacramento Municipal Utility District.

Research areas that are not being considered in this initiative are those that are exclusively renewable energy or combined heat and power (CHP) projects since these are covered mainly by S13. Though these types of projects could be associated with commercial and residential

buildings (e.g. Zero Net Energy buildings, micro-grids and community scale grids), they do not result in any energy efficiency benefit and is more appropriately handled in the other initiatives.

There is a need for public funding for demonstrations of emerging technologies to bridge the commercialization "valley of death." The private sector, for the most part, does not conduct basic 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. through bench scale activities. Typically, the private sector only offers funding after a successful field demonstration.

The focus will be on large-scale demonstrations and deployment and could involve multiple residential and commercial building owners/developers, IOUs, major manufacturers, regulators and other research organizations. These larger scale activities can *result in quicker market adoption of the technology*.

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: This initiative will focus on demonstrations and large scale deployment of an integrated suite of pre-commercial demand side management and other "smart" technologies that maximize energy efficiency and/or achieve zero net energy buildings and/or communities.

Potential research areas include:

- Demonstrate and deploy an integrated suite of pre-commercial demand side management technologies, including energy efficiency, demand response, and other "smart" technologies such as energy management systems. The objective is to facilitate large-scale deployment and market acceptance of integrated designs, technologies and

approaches that maximize energy efficiency (beyond the Title 24, 2013 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 which could be used to support future revisions to Title 20 and 24 building standards.

- Demonstrate and deploy integrated zero net energy turnkey package designs in multiple residential, multifamily and commercial developments. The objective is to demonstrate a variety of designs and approaches that incorporates high levels of energy efficiency (e.g., beyond the Title 24, 2013 building energy efficiency standards), demand response, localized renewable energy generation and storage technologies, and "smart" technologies. The goal is to demonstrate technology/designs that result in little or no cost adders when compared to conventional construction and to 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, will increase homebuyer awareness of ZNE homes and inform future revisions to Title 20 and 24 building standards.
- Integrate social science behavioral research into the development and implementation phases of the demonstrations to make sure that the demonstration designs consider the fact that people 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 potential design changes.

This initiative will coordinate and complement existing CPUC/IOU activities associated with integrated DSM pilots and ZNE building studies and demonstrations. This will ensure consistent and coordinated definitions of ZNE buildings and communities and help leverage synergies and avoid duplication.

Stakeholders: Electric ratepayers who own and operate buildings, developers, design professionals, equipment manufacturers, engineers, contractors and 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."[53] The intent was to achieve maximum savings while avoiding duplication of efforts, reducing transaction costs, and diminishing customer confusion.[54] In this same decision, the IOUs were directed to fund pilot projects to achieve integrated DSM.

The *California Energy Efficiency Strategic Plan* also sets retrofit targets for reduction of 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."[55] The IOU 2010-2012 portfolios made notable steps towards this undertaking, but more needs to be done to expand deep retrofit programs in multifamily and nonresidential buildings and address cost-effectiveness issues, and incorporate financing into retrofit project transactions.[56]

This initiative will coordinate with on-going and planned CPUC/IOU activities associated with both integrated DSM and deep retrofits of residential and commercial buildings and complement the work undertaken through the Energy Upgrade California Program, other Energy Commission building efficiency retrofit programs and AB 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 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. In addition, early adopter institutions, facilities, and neighborhoods in California are implementing zero- or near-zero energy approaches at the community scale. San

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

54 Ibid.

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

56 Ibid.

Diego Gas & Electric (SDG&E) currently operates an energy smart community demonstrating state-of-the-art technologies at Borrego Springs. The UC 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. "Significant additional resources will be required to scale these efforts up for full-scale production at affordable prices"[57]

The primary barriers to ZNE buildings and communities is the cost of required technologies and components and whether these added cost can be recovered at the time of sale and customer acceptance and demand for ZNE buildings. Also, the deployment of distributed renewables, 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. While ZNE communities are technically possible at this time, previous demonstration attempts have encountered a number of issues that hinder their success.

The inadequate supply of builders and developers that have the skills and experience to create ZNE buildings and communities and enunciate the benefits are barriers. Many design challenges and site-specific considerations are required to meet the energy needs of a building and the surrounding community efficiently. Designers must apply holistic design principles and take advantage of the free, naturally occurring assets available, such as passive solar orientation, natural ventilation, daylighting, thermal mass, and nighttime cooling. Without properly trained builders and developers to create ZNE buildings and communities, new technologies will never reach market maturation due to the lack of exposure or poor performance related to incorrect designs and installations.

Lack of a long-term financing mechanism, such as the Property Assessed Clean Energy (PACE) program in California, which allowed current building owners to pass forward loan payments for energy retrofits to new owners when homes are sold, can be a barrier to the goal of ZNE buildings. 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 retrofitting a building.

57 *California Energy Efficiency Strategic Plan.*

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

Table 15: 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.[58, 59] 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. For purposes of this strategic objective, the focus will be limited to electricity and heat generation as the main product. There are two main pathways for converting biomass to electricity; the thermochemical pathway, which occurs at elevated temperature and, generally, a faster

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

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

conversion rate than the biological pathway, which is more commonly identified as anaerobic digestion. Each of these pathways has a distinct set of deployment 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 air emissions, cost, and reliability of downstream gas treatment and catalyst systems. Thermochemical conversion processes are expensive due to the low energy conversion efficiencies and need research and full-scale demonstration to help drive down costs and improve efficiency. On the other hand, anaerobic digestion systems, which convert wastes (i.e., 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 one 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. These technologies will also 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 (AB 341) recycling goals.

Investments in first plan addressing barriers and challenges: The first Investment Plan contains 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 advancements made as result of projects awarded under the first investment plan.

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. The types of 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 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. Some of the possible technology demonstration and deployment 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 the 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 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; local air quality districts; California Air Resources Board (ARB); CalFire; California Department of Resources Recycling and Recovery; Department of Transportation; U.S. Department of Agriculture (USDA); U.S. EPA; bioenergy developers; 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 California Air Resources Board (CARB) 2013 targets for NOx and 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 to 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. [60]

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

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 EPIC can leverage funding to resolve outstanding bioenergy issues.

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. The types of 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 distributed generation 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. Some of the possible technology demonstration and deployment 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, and low-cost, sustainable fuel and effluent handling and processing systems, biogas cleanup technologies and upgrading systems to increase electricity generated from biomass waste resources. Eligible projects under this initiative will reduce the waste products while providing additional co-benefits to electricity ratepayers and facility operators.

Stakeholders: Ratepayers in rural and urban communities, industrial and commercial food processing facilities, dairy and agriculture facilities, and wastewater treatment facilities; California Department of Food and Agriculture; local air quality districts; California Air Resources Board (ARB); CalFire; California Department of Resources Recycling and Recovery; Department of Transportation; U.S. Department of Agriculture (USDA); U.S. EPA; bioenergy developers; 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.[61, 62]

Recently, a federal grant was provided to assess the feasibility of a centralized dairy digester model. This study advances this conceptual model and lays the foundation for development of centralized dairy digester projects in California. The feasibility study reports 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" GHG capture and destruction. Dairy biogas to transportation fuel projects also provides significant criteria air pollutant benefits when used to displace heavy-duty vehicle diesel use.[63]

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

61 *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.

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

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

US DOE Biomass Research and Development Initiative, that this EPIC initiative can leverage to accelerate the deployment of bio-digester and clean generation technologies.

S14 Strategic Objective: Taking Microgrids to the Next Level: Maximizing the Value to Customers

Table 16: 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 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.	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, demand response, storage, and renewable energy resources have not been widely adopted because they are seen as complex, require specialized dedicated staff, and are only cost effective for large single owner facilities. Furthermore, ideal configurations of these technologies have not yet been determined, and they would be difficult to demonstrate on the larger grid. 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, demand response opportunities, storage, locally available renewable energy resources and the full range of emerging clean energy technologies for the facilities they serve.

Microgrids with their controls for renewables, demand response, CHP using biomass, 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 commercially available and emerging technologies and strategies to supply multiple benefits to the facilities they serve as well as the larger grid.

Investments in first plan addressing barriers and challenges: This initiative continues the activities of S14.2 of the first 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: 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.

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 demand response, CHP using biomass, 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.

This initiative requires renewables and mandatory demand response participation either in the current IOU programs or in emerging CAISO 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 first Investment Plan. Projects will also identify installation issues and other barriers, such as permitting requirements, and participation potential for demand response 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 demand response. 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.

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 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 zero net energy communities when incorporated with energy efficiency and demand response.

In response to the San Onofre Nuclear Generating Station (SONGS) outage, the CAISO is currently pursuing creating a capacity market, "a voluntary preferred resource capacity auction to advance state-preferred resource policy goals, enable the procurement of preferred resources

in the local areas affected by the loss of SONGS, and assure that preferred resources are configured to meet ISO reliability needs."[64] The CAISO plans to implement this market in two phases. Phase one will consider an auction (like bidding into ancillary services) that will include only demand response resources. Phase two will consider additional resources such as storage, CHP and resources other than demand response. Microgrids with renewables and the ability to participate in demand response can help alleviate the loss of SONGS.

S15 Strategic Objective: Demonstrating Advanced Energy Storage Systems to Lower Costs and Improve Grid Reliability.

Table 17: 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 Demonstrations of Advanced Energy Storage Technologies 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: Despite many recent advances in the development of various energy storage technologies and systems, capable of providing numerous services and benefits throughout the electricity system, utilities often cite lack of operational experience for using energy storage, high cost of energy storage systems, lack of commercially available energy storage 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 needed to manage high penetration of variable and intermittent renewable generation. While inefficient, highly polluting conventional "flexible" resources (i.e., peakers, gas turbines, engine generators) are currently used along with nearly 4 GW of pumped hydro energy storage for grid stability and reliability, advanced energy storage technologies

64 CAISO website.

and systems that have a good potential for operational cost savings and emission reductions are not being utilized.

Energy storage provides additional flexibility to the electricity system needed to maintain system stability and reliability. It also reduces the system requirements to manage high penetrations of intermittent and variable solar and wind generation. It 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. Furthermore, energy storage provides flexibility and reliability benefits for grid infrastructure and critical facilities and other deployment sites. Advanced energy storage systems can also facilitate the integration of higher penetrations of intermittent and variable output renewable resources, demand-side management, load following, electric vehicle 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 California Public Utilities Commission (CPUC) established the Assembly Bill 2514 (AB 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 San Diego Gas and Electric (SDG&E) – 165 MW. The total MW target is differentiated by three points of interconnection: transmission (700 MW), distribution (425 MW) and customer-side (200 MW). The 2014 energy storage procurement applications were due by March 1, 2014. Also, 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 GW of nuclear power generation in southern California. Also, AB 2514 requires the publicly owned utilities in California to develop their own energy storage procurement targets and plans by October 1, 2014 and begin procuring energy storage by 2016. Meeting these targets will require a rapid development of commercially available and cost-effective energy storage systems.

However, 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.

Investments in first plan addressing barriers and challenges: These initiatives build on the activities of about 25 funding initiatives of the first Investment Plan addressing the barriers and challenges described above.

S15.1 Proposed Funding Initiative: Demonstrations of Advanced Energy Storage Technologies 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 grid-scale energy storage systems (Batteries, Flywheels, Adiabatic Compressed Air Energy Storage, Advanced Pumped Hydro, Flexible capacity output gas turbines, Thermal Energy Storage, etc.) connected to transmission, distribution, and customer side. Transmission connected advanced energy storage systems will be demonstrated at full-scale to assess and verify their capability for firming solar and wind generation (that is often variable and intermittent) and providing critical support services for renewable integration and grid stability and reliability. The purpose of this initiative also includes to demonstrate, at full-scale, various advanced distributed energy storage (DES) systems connected to sub-station and distribution system for distribution system support services such as distribution reliability, power quality, VAR support, frequency regulation, load following and demand management, and sub-station system requirements and options. This also includes facilitating market deployment of various advanced energy storage technologies and systems, particularly opportunities for streamlining regulatory processes and project permitting, 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 technical problems identified during 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, CAISO, USDOE, 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 demand response 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 greenhouse gas emission reductions by renewables. Also, additional flexible resource capacity is needed because of permanent shutdown of nearly 2GW nuclear generation in southern California and this deficit will be filled with preferred but unpredictable resources including renewables. The CPUC AB 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, a condition that will be satisfied more often once plant-level energy storage technologies are developed and demonstrated further by technology demonstration activities under the EPIC Program. This will also build confidence among utilities and energy storage vendors regarding technical and economic performance of energy storage systems.

Investor Owned Utilities, currently, have a few energy storage projects at pilot scale demonstrations in California. These projects are demonstrating Lithium-ion (Li-ion) and Sodium-Sulfur (Na-S) 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.

At this time, local electricity ratepayers cannot capture the substantial benefits and monetary value provided by distributed energy storage (DES) systems. This makes the value of DES systems makes such systems appear artificially uneconomic to utilities and their customers. The CPUC AB 2514 energy storage procurement target decision requires 425 MW of distribution connected energy storage by 2020, beginning 2014 and all operational by 2024.

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

quality needs. New business models for electrical energy storage (EES) and thermal energy storage (TES) are also developing. However, this is dependent on some 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 electric vehicles 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 electric vehicle population increase, there will be more opportunities to integrate energy storage systems and their applications to realize the full potential of energy storage systems at customer sites. The CPUC AB 2514 energy storage procurement target decision requires 200 MW of customer-side connected energy storage by 2020, beginning 2014 and all operational by 2024.

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

Table 18: 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 Distributed Electric Vehicles To Provide 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 application for either 1-directional controllable "smart" charging (V1G) or 2-directional charge/discharge capability (V2G) is in vehicle fleets where the PEVs are co-located geographically as one resource and are owned and controlled by the same entity.

Although fleet vehicles represent the technical and economic "low-hanging fruit", the number of fleet PEVs will be very small in comparison to non-fleet PEVs. Therefore, a next step is to develop the more complex but far wider-ranging applications where 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.

Investments in first plan addressing barriers and challenges: This strategic objective continues to expand the established benefits of V1G and V2G applications, collectively called "vehicle-grid integration", addressed in the first investment plan. However, this strategic objective expands the possible use cases by calling for demonstrations of geographically-distributed PEVs that are aggregated by a utility or third-party aggregator such that the PEVs appear as a single, larger resource.

S16.1 Proposed Funding Initiative: Demonstrate the Ability of Distributed Electric Vehicles To Provide 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 geographic size and vehicle quantity. This initiative calls for the demonstration of more complex but wider-ranging use cases where geographically-distributed PEVs are aggregated by utilities or third parties into resources large enough to participate in utility or independent system operator markets. The demonstrations will take place in investor-owned utility service territories.

Qualitatively, the grid benefits to the aggregation approach are the same as for simpler vehicle-grid integration use cases involving PEV fleets. However, proposed demonstrations under this initiative will address the additional technical and regulatory challenges encountered by geographically-distributed PEVs. 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 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 owners 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 19: 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 first plan addressing barriers and challenges: The first investment plan included cost share for federal funding opportunities related to the initiatives in the Energy Commission's EPIC investment plan for 2012-2014. This initiative focuses on the initiatives included in this investment plan for 2015-2017.

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

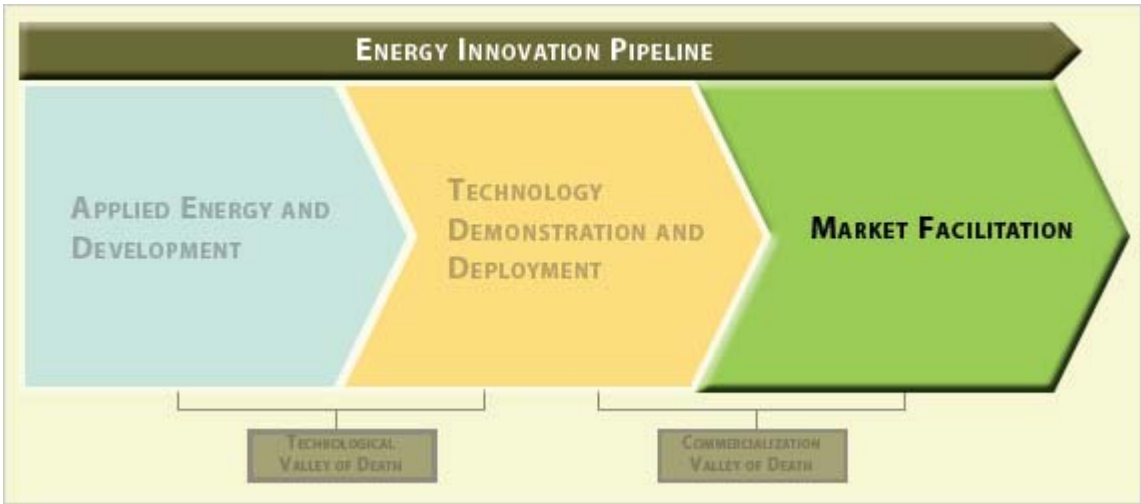
Purpose: This initiative will provide EPIC funds as cost share to leverage federal investments for projects that (a) meet the guiding principles of the decision; and (b) are aligned with the strategic objectives listed in the technology demonstration and deployment program area of this investment plan. 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 technology demonstration and deployment 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.

Market Facilitation



Source: California Energy Commission

Through the Market Facilitation program area, the Energy Commission will address funding gaps in market processes that drive clean energy investment within investor-owned utility (IOU) service territories.

Through this plan, the Energy Commission intends to issue solicitations in all strategic objective areas. Proposed initiatives identified in this 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 proposed funding allocations for the Market Facilitation program area provided in Table 20 were developed based on the priorities defined in CPUC EPIC Decision 12-05-037 and Decision 13-11-025 and the expected level of funding needed to address each of the specific strategic objectives. These funding levels are estimates and may change based on the number of successful responses received from competitive solicitation awards and the amount of leveraging of the EPIC funds from other parties that can be obtained by strategic objective.

Table 20: Proposed Funding Allocation for the Market Facilitation Program Area by Strategic Objective

Funding Area	Amount (Millions)
S18 Strategic Objective: Foster the Development of the Most Promising Energy Technologies into Successful Businesses.	TBD
S19 Strategic Objective: Facilitate Emerging Energy Technologies into the Procurement Process of Large Purchasers.	TBD
S20 Strategic Objective: Accelerate and Optimize the Deployment of Energy Technologies Through Innovative Local Planning and Permitting Approaches.	TBD
S21 Strategic Objective: Inform Optimal Decision-Making Through Market and Technical Analysis.	TBD
Market Facilitation Program Area Total	**TBD**

Source: California Energy Commission.

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

Table 21: 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 Foster Successful Clean Energy Entrepreneurship Through Commercialization Assistance and Services.	x	x	x	x	x	x	x	x	x
S18.2 Facilitate a Clean Energy Network to Provide Market Intelligence and Feedback to Entrepreneurs.	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 or who their potential customers are and what they need. In addition, many if not all are under financial and time constraints and don't have the means to purchase and permit the equipment and facilitates needed to develop, test, validate, and certify 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."[65]

Investments in first plan addressing barriers and challenges: This initiative expand 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*. Proposals must explain how they avoid duplication and create synergies with opportunities available through S10.

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

S18.1 Proposed Funding Initiative: Foster Successful Clean Energy Entrepreneurship Through Commercialization Assistance and 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	X	X	X

Source: California Energy Commission

Purpose: This initiative will provide services, tools, and other resources to help entrepreneurs and start-ups successfully transition good innovations from laboratory concepts to commercially viable clean energy products and services. Possible activities funded by this initiative include:

- Providing funding for incubators, accelerators, and other similar types of programs that provide entrepreneurs with knowledge, training, expertise and resources to successfully commercialize their innovations. This includes activities such as developing market strategies and business models, providing mentoring assistance and training, formulating commercial scale-up plans, and facilitating matchmaking with customers.
- Developing a suite of commercialization tools that helps entrepreneurs pull together information and resources needed to figure out how to successfully commercialize their innovations.

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

Background: There are currently a number of efforts in California and throughout the U.S that are attempting to provide commercialization assistance to clean energy entrepreneurs. Most of these efforts have focused on developing incubators and decision-support tools. Over the past couple years the U.S. Department of Energy has focused on early commercialization and has launched several programs in this area including the Innovation Ecosystem Initiative which focused on creating regional partnerships to advance to new energy technologies to market. More recently, the USDOE 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. The National Science Foundation (NSF) through their Innovation Corps (I-Corps) Teams and I-Corp Nodes help entrepreneurs commercialize NSF funded research. NSF I-Corps is helping to transition technologies out of the laboratory and recognizes that skills sets required for research are not the same required for a start-up environments.

At the state level, the New York State Energy Research and Development Authority (NYSERDA) has launched an incubator program called the New York Entrepreneurs in Residence (NEIR) Program, which offers one-on-one assistance to early stage companies from high-level businesses familiar with the business side of the clean energy technology arena. In addition, NYSERDA recently conducted a solicitation seeking proposals to develop a comprehensive self-guided program, called the Cleantech Commercialization Toolkit. The toolkit will provide resources, templates, and instructions necessary for cleantech companies to build the capabilities needed for commercialization; and will allow for progress tracking and document sharing through an interactive website.

In California, the California Innovation Hub (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, the state has a number regional technology organizations, such as CleanTECH San Diego, which offer mentoring resources for start-ups related to the green economy. CleanTECH San Diego's mentoring program was part of the Entrepreneurial Mentor Corps (EMC) pilot program run by the DOE and SBA. The "goal of EMC is to accelerate a startup company's path towards success, including targeted advice on revenue growth, employee growth, sourcing outside financing and avoiding pitfalls." . Another example is the Cleantech to Market (C2M) program at the Haas School of Business at University of California Berkeley which works with students and researchers to translate cleantech research into market opportunities.

S18.2 Proposed Funding Initiative: Facilitate a Clean Energy Network to Provide Market Intelligence and Feedback to Entrepreneurs.

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 help facilitate the creation a network of industry, investor, and customer stakeholders with the intended purpose of providing entrepreneurs with: intelligence and insights into specific market opportunities and customer needs; opportunities to engage with industry and investor stakeholders to receive market feedback and validation; matchmaking with potential customer and investors; and information on support services and resources available to them in the state. Potential activities funded from this initiative include:

- Developing an online portal that directs entrepreneurs to various resources available to them in the state including incubators, accelerators, testing centers, test beds, and other support services.
- Conducting technology forums, business plan competitions and other activities that allow for entrepreneurs to meet and engage with investors and customers in formalized settings.
- Convening a consortium of clean energy customers to define and articulate end-user needs for the electricity sector in IOU services territories. Information and intelligence from this consortium would be disseminated and deployed to the state network of incubators, accelerators, and other similar organizations working with entrepreneurs and start-up companies.

Stakeholders: Early-stage energy companies, entrepreneurs, and investors.

Background: Projects funded through this initiative would leverage resources and expertise available from existing clean tech accelerator, incubation, and support services and tools.

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 provides opportunities for

entrepreneurs to network with leaders in the public and private sector; receive go-to-market, business model, and other business acceleration coaching through incubators; gain access to testing and evaluation facilities for new products; connect with venture capital sources; and attend seminars and workshops led by university faculty and other experts. GO-Biz states that the iHub Program is the largest in-state innovation network in the country. The Innovation and Entrepreneurship unit also showcases successful California innovators on its "Innovation @ Work" webpage.

NYSERDA 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 geared towards helping cleantech companies not only develop and fund their technology, but also create a marketable product and effective business model. In addition, the DOE has organized a yearly regional and nationwide cleantech business competition which not only provides funding opportunities for top companies, but also exposes all attending companies and their technologies to a wide range of potential investors, business partners and customers. Groups such as Clean Tech Open, the National Renewable Energy Laboratory (NREL) and Ultra Light Startups act as accelerators for clean technologies by organizing dinners, ideas and product competitions, pitch events and conferences which help increase the visibility of cleantech companies, attract public and private funding and increase business connections. The goal of Clean Tech Open is to foster entrepreneurs with disruptive cleantech ideas by providing a global network of support for cleantech companies and holding events to enhance the interaction and visibility of cleantech companies and investors.

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**	**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. Potential activities funded under this initiative include:

- Providing funding for testing and verification centers. These centers should provide facilities, permitting, and testing equipment to enable companies to test and verify their technologies in controlled environments that approximate real-world conditions.
- Providing support for companies to demonstrate their technologies on test beds. California's IOUs currently have a number of test centers to evaluate electricity technologies in simulated scenarios, including PG&E's 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 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: The U.S. DOD is required to produce or procure 25 percent of facility energy consumption from renewable sources by 2025.[66] To support this effort, U.S. DOD has 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

66 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.

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 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 and an important certifier in the cleantech space. A certification from UL is a trustworthy impartial review that a company's product meets stringent safety ratings, energy efficiency ratings, and environmental ratings, and complies with national and international standards and governmental regulations.

S19 Strategic Objective: Facilitate Emerging Energy Technologies into the Procurement Process of Large Purchasers.

Table 22: 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: Pilot Innovative Procurement Strategies to Reduce Costs for Clean Energy Technologies.		X			X			X	X
Initiative S19.3: Create a "Test Drive" Program to Help New Energy Technologies Qualify for Large-Scale Procurement.	X	X	X	X				X	

Source: California Energy Commission

Barriers and Challenges: One of the key challenges for companies engaged in developing emerging technologies is in finding initial markets that will allow them to scale-up their innovations. Large procurers of energy technologies, such as military bases, government facilities, ports and intermodal transportation gateways, hospitals, and building developers, can help create the early market pull needed for companies to ramp up deployment and build economies of scale. Furthermore, these large procurers such as the Department of Defense are often motivated by additional non-cost factors when purchasing energy technologies. However, because these entities must operate and maintain essential services they require proven performance, cost-effectiveness, and reliability before purchasing energy-related services and equipment.

Port operators, builders, facility managers, and licensed contractors may be unfamiliar with emerging clean energy technologies and may not know how they can be incorporated into port infrastructure, new and existing homes, buildings, and facilities. They may also be risk averse due to different installation and operation requirements that could impact building occupant comfort. Before investing in large quantities of energy-related equipment, these groups need greater certainty on whether:

- The product/system is clearly cost effective from a life cycle perspective that takes into account all independently verified cost and benefits;
- The product can be incorporated into existing systems or construction processes;
- There are no impacts on the training and availability of skilled labor to install and maintain the equipment; and whether
- The new product or system affects land use or environmental permitting requirements.

Also, procurement processes can be slow, cumbersome, and resource intensive. The long lead time needed between design and completion of new housing developments, buildings, health-care, and other facilities slows the pace of adoption of clean energy innovations. There is a need to increase awareness and facilitate adoption of innovative strategies to streamline procurement practices, including facilitating aggregated procurement, identifying facilities that may be good candidates for rooftop solar or other clean energy technologies, creating standard specifications, and identifying pre-approved clean energy technologies and equipment. To this point, at the scoping workshop on February 7, 2014, for the Energy Commission's Proposed 2015-2017 Triennial Investment Plan for EPIC, participants discussed the need to come together and organize to achieve synergies, economies of scale, and feedback loops to drive good decision making.

And finally, lack of site-specific real-world testing in potential new and expanded target markets inhibits the widespread deployment of clean energy technologies that have been demonstrated in general application, but not in specific operating conditions for key market segments.

Addressing these barriers and challenges may expand opportunities to lower ratepayer costs, improve safety, and strengthen reliability, and accelerate achievement of California's clean energy goals. One example of a local initiative to address there barriers and challenges is the Silicon Valley Collaborative Renewable Energy Procurement (SV-REP) Project:

> "The SV-REP project was created to address three of the major challenges regarding public sector adoption of renewable energy in an era of diminished financial resources, including: high upfront costs associated with the purchase and installation of these technologies, the considerable transaction costs involved in conducting competitive bid processes and developing agreements, and the general lack of understanding of financing options and available incentives. The goal of the SV-REP project was to address these challenges via a regional collaborative effort utilizing a standardized Power Purchase Agreement (PPA) financing model, lease agreements and procurement process." [67]

The success of this and other collaborative purchasing agreements for solar PV could serve as a template for realizing similar benefits for other clean energy technologies, including highly efficient HVAC and other mechanical equipment, storage, and lighting. For example, the U.S. Environmental Protection Agency Green Power Partnership has already launched an effort for collaborative procurement of solar PV in the metropolitan Washington, D.C. area.

Investments in first plan addressing barriers and challenges: The first investment plan did not address barriers and challenges that limit the ability of large purchasers to procure advances in clean energy.

67 http://www.jointventure.org/index.php?option=com_content&view=article&id=189&Itemid=287

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 to develop tools and strategies to facilitate the adoption of emerging energy technologies into procurement processes and practices. Tools developed through this initiative would be designed to help builders, building owners, facility managers, and licensed contractors determine which clean energy technologies best meet their needs. For example, a tool could provide a best-in-class designation comparing performance, cost, reliability, and sustainability characteristics of competing emerging clean energy technologies based on quality assurance evaluations.

Stakeholders: Utilities, state and local government, providers of clean energy technologies

Background: Facility managers receiving unsolicited proposals from multiple clean energy technology vendors may not have the resources or expertise to assess equipment and services from different vendors against one another. For example, there is a need for a tool to help builders assess which types of clean energy technologies are most suited for the location of a project based on site characteristics and available resources. Also, a tool, such as the best-in-class designations, to quickly assess which products offer the best value can provide facilities managers with the information needed to consider adopting cost-effective demand management, renewable generation, and other clean energy technologies.

However, knowing the best in class may not be enough to overcome uncertainties that prevent adoption. For those seeking additional information, grants awarded through this proposed initiative could develop additional tools on how to incorporate clean energy technologies into facilities design, project development, and maintenance operations. Specifically, these tools in addition to the best-in-class designations could also include construction price catalogs for services and equipment and industry specific case studies.

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 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. Proposed funding initiative S20.1 would complement and avoid duplicating the work of this network.

S19.2 Proposed Funding Initiative: Pilot 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 innovative procurement strategies, including aggregated procurement of clean energy technologies.

The awardees would develop and implement innovative procurement strategies for clean energy, such as local or regional collaborative procurement programs to aggregate multiple buyers into group requests for proposals. This procurement strategy may attract volume discounts, lower administrative overhead, and reduce transaction costs of locating qualified vendors and cost-effective projects, making clean energy technologies more widely accessible.

Expansion of buyer-collaborative purchasing arrangements can further help achieve deep market penetration for clean energy technologies to meet renewable energy, clean transportation and green house gas policy goals. For example, this approach may be used to accelerate deployment of technologies for energy efficient HVAC systems and other mechanical equipment, distributed renewable energy generation, energy storage, and smart vehicle to grid charging devices.

Key elements of collaborative purchasing agreements include customization for specific markets and applications, and itemized scopes of works detailing how installations are to be performed. Another important element in developing cooperative purchasing agreements is accessing technical support and third party evaluation services to better compare proposals from a common set of analytics.

In addition to the above, better understanding the needs of target markets is also key for the widespread deployment of clean energy technologies. It is really important for entrepreneurs to begin engaging with customers, through surveys and other mechanisms, during product development to ensure that what they are trying to test and validate is actually what is needed and wanted by an industry. Therefore, early engagement with target markets, and assessing products not only on the technical level but also in regard to market acceptance is necessary. In summary, innovative procurement strategies and measures are needed to establish ready end use markets for emerging technologies.

This initiative is in the market facilitation stage of the energy innovation pipeline, focusing on demand-side management and generation categories of the electricity system value chain.

Stakeholders: Utilities, state and local government, providers of clean energy technologies.

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.[68]

For example, the Silicon Valley Collaborative Renewable Energy Procurement (SV-REP) Project has installed 12 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.

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

68 www.statesadvancingsolar.org/.

develop an effective and collaborative platform for deploying clean energy (predominately solar PV).[69]

S19.3 Proposed Funding Initiative: Create a "Test Drive" Program to Help New Energy Technologies Qualify for Large-Scale Procurement.

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 the adoption readiness testing is to support "test drive" opportunities for end users to learn first-hand how emerging clean energy technologies impact their processes and provide feedback to manufacturers before making a large, enterprise-wide procurement decision. By facilitating opportunities for new clean energy technologies to refine product design and reduce costs through economies of scale, this initiative can help overcome technical and economic barriers to the widespread deployment of clean energy technologies across a range of markets in California.

This initiative would award grants for a consultant or product manufacturer to evaluate whether a clean energy technology previously demonstrated to work under general operational conditions is ready for procurement in specific, highly risk-averse markets. Only the most promising technologies successfully demonstrated through EPIC or other programs will be eligible. This will allow selected would-be purchasers to assess whether the equipment improves energy affordability, reliability, and safety in their facilities while fitting in smoothly with their processes for procurement, installation, and operations. Also, the evaluation would allow the would-be purchaser to provide feedback to the manufacturer on changes needed before adoption could become feasible. This adoption readiness testing would be designed to help clean energy technologies become procurement eligible by large scale purchasers in target

69 U.S. Environmental Protection Agency, www.epa.gov/greenpower/initiatives/cecp/documents/MWDC_CleanEnergyProcurement_LocalAgencies.pdf.

markets. For example, field testing of clean energy technologies at intermodal transportation hubs and ports would help to tap into unrealized opportunities for large-scale purchasing of clean energy technologies at these facilities.

A broad range of adoption ready technologies would be considered under this funding initiative, including highly energy efficient technologies, renewable generation technologies, energy storage, and vehicle-grid integration devices. Only products that are production ready will be eligible for this independent evaluation, measurement, and verification testing. Products must have design specifications; all product features must have demonstration results showing they function as designed; and the product must have demonstration results showing it is usable in general conditions.

Eligibility is limited to technologies without access to similar testing opportunities through S12.1 *Identify and Demonstrate Promising Energy Efficiency and Demand Response Technologies Suitable for Commercialization and Utility Rebate Programs* in this investment plan or other programs.

Stakeholders: Utilities, state and local government, providers of clean energy technologies, port operators, intermodal transportation hub operators

Background: 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 government agencies and other large procurement entities. This means government and large commercial enterprises may be failing to capture opportunities to reduce costs and improve energy services. General demonstration testing cannot fully indicate whether a product is ready for adoption in specific markets. Customer interaction with the product is key for determining if the product is "adoption ready." In this context, adoption ready technology testing is designed to allow large-scale customers to see first-hand whether an emerging clean energy technology provides real world value for their facilities while minimizing risk and uncertainty.

By supporting the opportunity to "test-drive" clean energy innovations, this initiative would facilitate procurement of clean energy technologies and help to 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."[70] The testing would evaluate the performance of clean energy technologies under specific operational conditions to verify that it meets would-be purchasers' expectations for cost, performance, and reliability. In addition, to

70 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.

facilitate entry into targeted markets, adoption readiness testing is needed to allow a clean energy manufacturer to make necessary product changes based on results of on-site operation and feedback from real world customers in difficult-to-reach target markets.

At the adoption readiness test stage, the product will have already passed through the first-level, internal pilot-testing phase and demonstration or field testing phase and any glaring defects will have been corrected. Furthermore, product demonstrations will have documented that the product and features work as intended for general markets. The adoption readiness testing will determine how well a product works for specific customers with unusually cumbersome procurement processes under extended operational conditions of use.

Activities funded by this initiative will be similar to pre-deployment testing used by the Department of Defense (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,[71] found that this approach was also key to the innovation model used by the Department of Defense (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)."

71 http://bipartisanpolicy.org/sites/default/files/Energy%20Innovation%20at%20DoD.pdf

This initiative builds on the successful experience of DOD and Wal-Mart with pre-deployment testing by expanding this approach to a broader range of technologies for market readiness testing.

In summary, this initiative would not fund general demonstration projects. Instead, this initiative would focus on overcoming market barriers to utilization of clean energy technologies that have already been demonstrated in operational conditions, but are still considered too unproven to be eligible for procurement by specific markets such as large, risk-averse government agencies, builders, universities, and commercial enterprises. Applicants will need to explain why the time is right for pre-deployment testing of specific clean energy technologies at the facilities and enterprises they propose for funding. For example, applicants must show how the testing will help reduce the cost of deploying the technology, provide feedback to technology manufacturers if improvements are needed, and potential to advance the widespread deployment of the technology across its facilities.

Through funding of adoption readiness testing for clean energy technologies the Energy Commission seeks to support and accelerate the installation and management of smarter, cleaner, more resilient, and cost-effective electricity system for California. This includes technologies and strategies to advance energy efficiency, demand response, clean distributed generation, smart grid technology and energy storage.

S20 Strategic Objective: Accelerate and Optimize the Deployment of Energy Technologies in IOU Territories Through Innovative Local Planning and Permitting Approaches.

Table 23: 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 Support Local Governments in Deploying Energy Assurance Strategies to Maximize the Safety and Reliability Benefits of Clean, Smart Energy Technologies.	x		x	x			x	x	x
S20.3 Reduce Bioenergy Costs and Delays by Developing a Programmatic Environmental Impact Report for Solid Fuel Biomass.	x	x	x				x	x	x
S20.4 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 renewable 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 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 first plan addressing barriers and challenges: The first Investment Plan also addresses permitting barriers and challenges. Initiative S20.1 will build on Initiative S16.2, from the first Investment Plan. 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 investor-owned electric utility to prepare a distribution resources plan to identify optimal locations for distributed renewable generation resources, energy efficiency, energy storage, electric vehicles, and demand response technologies consistent with the goal of yielding net benefits to ratepayers. These plans are due to the California Public Utilities Commission 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 micro grids.

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 a competitive grant solicitation 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 micro grids. This will allow local governments to build on best practices and lessons learned from previous storage, micro grid and other clean energy research and demonstration projects in California and other states.

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, who own, operate or occupy buildings and facilities, utilities, clean energy equipment manufacturers, building designers, developers, contractors and consultants, distribution grid operators, local governments, preferred resource developers, environmental organizations.

Background: 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 Investor-Owned Utility prepare a distribution resources plan to identify optimal locations for distributed renewable generation resources, energy efficiency, energy storage, electric vehicles, and demand response 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.

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.[72]

S20.2 Proposed Funding Initiative: Support Local Governments in Deploying Energy Assurance Strategies to Maximize the Safety and Reliability Benefits of Clean, Smart 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 training and facilitation to assist leading local governments to become champions for emergency planning and identification of clean energy technologies and infrastructure as they develop energy assurance strategies. Energy assurance strategies form the foundation for a community's long-term plan and will reduce disaster losses and break the cycle of disaster damage, reconstruction, and repeated damage and are the first step in developing an Energy Assurance Plan. The planning process is as important as the plan itself and creates a framework for risk-based decision making to reduce damages to lives, property, and the economy from future disasters. These plans are living documents that require adjustments to maintain their relevance and remain a useful tool and resource. These plans

72 California Energy Commission, Renewable Energy and Conservation Planning Grants, Docket No. 12-GREP-1, http://www.energy.ca.gov/renewables/planning_grants/

coordinate with Climate Action Plans, Sustainability Plans, General Plans, Emergency Operation Plans, and other specific plans.

For example, some local governments need assistance to assess information on location and type of clean energy technologies installed and anticipated in their communities. Once local governments upload data, tools such as CaLEAP can help develop energy assurance strategies and process innovations to expedite deployment of clean energy technologies at critical facilities.

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. The grant awards will 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 grant will help build knowledge networks for deployment of micro grids, combined heat and power facilities, and new approaches to strengthening resilience and reliability of electricity systems.

Stakeholders: Ratepayers who will be purchasing clean energy technologies, utilities, local governments, environmental organizations, agricultural organizations.

Background: The CaLEAP and Cal-Adapt programs have been included in many state plans, including the 2013 Integrated Energy Policy Report[73] 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 California 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

73 *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

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.

S20.3 Proposed Funding Initiative: Reduce Bioenergy Costs and Delays by Developing a Programmatic Environmental Impact Report for Solid Fuel 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: Through a competitive selection process, this initiative will develop funding for the development of a programmatic Environmental Impact Report (EIR) for thermochemical conversion technologies using solid-fuel biomass, as recommended in the 2013 Integrated Energy Policy Report (IEPR).[74] The Environmental Impact Report should focus on streamlining the environmental review process for projects related to Senate Bill 1122 (Rubio, Chapter 612, Statutes of 2012).

The purpose of this program EIR is to develop background information on thermochemical conversion technologies using solid-fuel biomass for future policy considerations, potential environmental impacts, and mitigation measures. This information will assist state and local agencies in preparing site-specific environmental documentation that may be required for applications and/or permits submitted to state and local regulatory agencies.

The 2013 IEPR identified biopower thermochemical conversion project predevelopment costs are uncertain and can range from $168,000 - $765,000, which includes feasibility analysis and California Environmental Quality Act-related (CEQA) activities. CEQA-related costs can cause the greatest uncertainty. Obtaining funding for this range of costs is difficult for small

74 *2013 Integrated Energy Policy Report*, dated January 2013, CEC-100-2013-001-CMF, page 107: http://www.energy.ca.gov/2013publications/CEC-100-2013-001/CEC-100-2013-001-CMF.pdf.

developers and communities.[75] To address these concerns, stakeholders support developing a program EIR for pre-commercial solid-fuel biomass development.

Stakeholders: Ratepayers in rural and urban communities, foresters, agricultural facilities (orchards and nut growers), wastewater treatment facilities, CalFire, California Department of Food and Agriculture, local air quality districts, California Air Resources Board, U.S. Department of Agriculture, bioenergy developers, local governments, bioenergy and waste management industry groups.

Background: In September 2012, Senate Bill 1122 was enacted (Rubio, Chapter 612, Statutes of 2012) requiring an incremental 250 MW of renewable Feed-in Tariff (FIT) procurement from small-scale bioenergy projects that commence operation on or after June 1, 2013.

The statute requires that California's three large investor owned electric utilities (Pacific Gas & Electric Company, Southern California Edison Company, and San Diego Gas & Electric Company) must procure a share of the statute's 250 MW requirement based on the ratio of each utility's peak demand to statewide peak demand. Additionally, the statute orders the California Public Utility Commission to allocate the 250 MW procurement requirements among the following categories:

- 110 MW - biogas from wastewater treatment, municipal organic waste diversion, food processing, and co-digestion
- 90 MW - dairy and other agricultural bioenergy
- 50 MW – bioenergy using byproducts of sustainable forest management

CalRecycle and the Central Valley Regional Water Quality Control Board have developed a programmatic EIR for anaerobic digestion facilities. The programmatic EIRs intend to reduce the cost and timeframe needed to permit new anaerobic digester projects in California. In December 2010, a programmatic EIR was developed, *Dairy Manure Digester and Co-Digester Facilities*,[76] for the California Regional Water Quality Control Board, Central Valley Region, for dairy digesters in California's Central Valley. Another programmatic EIR, *Statewide Anaerobic*

75 *2013 Integrated Energy Policy Report*, dated January 2013, CEC-100-2013-001-CMF, page 90: http://www.energy.ca.gov/2013publications/CEC-100-2013-001/CEC-100-2013-001-CMF.pdf.

76 *Dairy Manure Digester and Co-Digester Facilities*, Final Program Environmental Impact Report, December 2010, http://www.waterboards.ca.gov/rwqcb5/water_issues/dairies/dairy_program_regs_requirements/dairy_peir_final_cert.pdf.

Digester Facilities for the Treatment of Municipal Organic Solid Waste,[77] was developed in June 2011. The development of these programmatic EIRs has helped to make the CEQA process more straightforward for small bioenergy developers in California.[78]

S 20.4 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

Purpose: This initiative will test and evaluate innovative strategies that local governments in IOU ratepayer territories can use to achieve Zero Net Energy (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 (e.g., a single substation) today, including advances energy efficiency, demand response, distributed renewable energy, storage, etc. This initiative seeks innovative answers to the question, "how

77 *Statewide Anaerobic Digester Facilities for the Treatment of Municipal Organic Solid Waste,* Final Program Environmental Impact Report, June 2011, http://www.calrecycle.ca.gov/swfacilities/compostables/AnaerobicDig/PropFnlPEIR.pdf

78 Transcript of Energy Commission Staff Workshop on the Status of Bioenergy Development in California, June 3, 2013, comments by Michael Boccadoro (Dolphin Group), p. 137.

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[79] 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*[80], and Governor Brown's *Clean Energy Jobs Plan*[81]. Separately, Governor Brown's Executive Order B-18-12[82] calls for all newly constructed state buildings and major renovations that begin design after 2025 be constructed as zero-net-energy facilities. The Executive Order also calls for achieving zero-net-energy for 50 percent of the square footage of existing state-owned building area by 2025."

The California Public Utilities Commission, *California Energy Efficiency Strategic Plan*, January 2011 Update[83], outlined several "big bold" goals related to ZNE buildings which included, all new residential construction in California will be zero net energy by 2020, and all new commercial construction in California will be zero net energy by 2030. The goals identified in the Strategic Plan provide long term targets for the CPUC and the Energy Commission, and are not mandated.

The California Clean Energy Future (CCEF), an inter-agency group consisting of the California Public Utilities Commission, Energy Commission, California Air Resources Board and the California Environmental Protection Agency, teamed up the California ISO and developed the

79 *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

80 California Air Resources, *Climate Change Scoping Plan: A Framework for Change*, 2008, http://www.arb.ca.gov/cc/scopingplan/document/adopted_scoping_plan.pdf

81 Clean Energy Jobs Plan, http://gov.ca.gov/docs/Clean_Energy_Plan.pdf

82 Executive Order B-18-12, April 25, 2012, http://gov.ca.gov/news.php?id=17508

83 *California Energy Efficiency Strategic Plan*, January 2011 Update, http://www.cpuc.ca.gov/NR/rdonlyres/A54B59C2-D571-440D-9477-3363726F573A/0/CAEnergyEfficiencyStrategicPlan_Jan2011.pdf

California's Clean Energy Future – Implementation Plan, in September 2010[84] to generate an implementation plan that meets the electric sector of the state. One of the purposes of the CCEF initiative was to provide the agencies with the ability to access data and analysis in a timely fashion, understand the interdependencies among initiatives, and jointly address implementation risks. The inter-agency team recommended that the agencies undertake a suite of activities that included ZNE.

S21 Strategic Objective: Inform Optimal Decision-Making Through Market and Technical Analysis.

Table 24: 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 Develop Roadmaps to Guide Future Investments.	X	X	X	X	X	X	X	X	X
S21.4 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[85] and the 2013 IEPR[86] suggest that the energy sector, in addition to reducing GHG emissions, should evolve in a way

84 *California's Clean Energy Future – Implementation Plan*, September 2010, http://www.cacleanenergyfuture.org/documents/CCEFImplementationPlan.pdf

85 CNRA. 2013. Safeguarding California: Reducing Climate Risk. http://resources.ca.gov/climate_adaptation/docs/Safeguarding_California_Public_Draft_Dec-10.pdf

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.

Investments in first plan addressing barriers and challenges: The first 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	x	x	X

Source: California Energy Commission

Purpose: This will be a three-part initiative to identify clean energy technologies, business models, and strategies under a range of conditions and scenarios. The first part will 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. In addition, this initiative will encourage modeling efforts that investigate the long-term system impacts of policies that promote technology development. The third part of this initiative will conduct a series of studies that 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 investor-owned utilities.

Studies suggest that low income communities may be least resilient to climate change impacts

86 California Energy Commission. 2013. 2013 Integrated Energy Policy Report. Publication Number: CEC-100-2013-001-CMF.

(Shonkoff et. al. 2011;[87] Cooley et. al. 2012).[88] 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.

- Development and deployment of PV units with low energy penalties with increased ambient temperatures without substantial cost penalties.
- Development of lower cost energy storage options. As we grow more reliant on intermittent renewable sources of energy, the ability to store energy so that it is available at times of peak demand will be key.
- Energy infrastructure capable of responding quickly to changes in energy load and generation will become increasingly important as the amount of self-generation, electric vehicle charging, and intermittent renewable resources increases. Recognizing these trends, this initiative may support studies to assess emission, ramping, and ancillary service characteristics needed to maintain system reliability and achieve California's goal to reduce greenhouse gas emissions to 80 percent of 1990 levels by 2050.
- Dynamic rating has been demonstrated successfully in Texas (Oncor 2013)[89] but no demonstration has occurred in California at the needed scale and sophistication to seamlessly integrate dynamic rating with the actual operation of the electricity system in California. Studies suggest that dynamic rating would facilitate the increase use of renewable generation (Seppa et. al. 2008)[90] and that it could be an excellent climate adaptation tool (Cradden and Harrison 2013).[91]

87 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

88 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

89 Oncor Electric Delivery Company. 2013. Final Report: Dynamic Line Rating Oncor Electric Delivery Smart Grid Program.Contract ID: DE-OE0000320.

90 Seppa, Tapani, et al. (The Valley Group, a Nexans company). 2008. Multi-Area Real-Time Transmission Line Rating Study. California Energy Commission, PIER Program. CEC 500-99-03 BOA 121-P-05.

91 Cradden, L. C., & Harrison, G. P. 2013. Adapting overhead lines to climate change: Are dynamic ratings the answer? *Energy Policy*, *63*, 197-206.

The following examples illustrate the type of studies envisioned for the second part of this initiative to investigate the system impacts of different technology options:

- 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).
- This initiative could fund evaluations of the potential impacts of breakthrough technologies on the costs of achieving California's climate goals under a range of climate and energy scenarios. This work will heavily leverage past and future work supported by EPIC initiatives designed to develop long-term energy scenarios for California and to investigate its potential environmental consequences.

For the third part of this initiative, studies exploring regulatory changes and business models to advance clean energy may assess technologies such as microgrids, zero-net energy buildings, whole building retrofits, second-use electric vehicle batteries, and electric vehicle charging across IOU territories.

Stakeholders: Ratepayers, clean energy entrepreneurs and start-up companies, investors, electric utilities, California ISO, electric utilities, policymakers, building developers, and local governments.

Background: Past research supported by the Energy Commission has developed multiple energy scenarios for California, 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, this work should be substantially enhanced, 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.

Recent studies suggest that multiple paths are available towards 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.

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.

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

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 research and development 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: Develop Roadmaps to Guide Future Investments.

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

Issue: 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.

Purpose: This initiative will develop advanced methods, tools, information, and data to develop and analyze future scenarios for the state's electricity system, and identify critical research gaps that must be addressed. 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 research and development investments. Activities funded under this initiative will include:

- Developing advanced methods to analyze integrated scenarios for the future electricity system.
- Identifying critical current and future research funding gaps to achieve IOU ratepayer benefits encompassed in state policy goals**.**
- Prioritizing 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.

To prioritize research activities future investment plans, scenario assessments and gap analyses are planned for the following research topics:

- Industrial, Agricultural and Waste Energy Efficiency
  - Data centers.
  - Petroleum refineries.
  - Electronics industry.
  - Food processing.
  - Industrial (e.g., cement, pharmaceutical, glass, etc.).
  - Water/wastewater (coordinated with Water Research Foundation roadmapping effort).
  - Food processing.
  - Pre-harvest agriculture (such as irrigation and sensors).
- Building Energy Efficiency
  - Lighting.
  - 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.
  - Offshore renewable energy.
  - Reducing environmental barriers to renewable energy permitting and Deployment (including water, habitats and species, and air quality).
  - ZNE communities (coordinated with energy efficiency efforts).

Stakeholders: Energy researchers, CPUC, IOUs, California ISO, ARB, U.S. DOE, U.S. DOD, Ocean Protection Council, other federal agencies, energy industry groups.

Background: 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.

S21.4 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	x	x	X

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.
- 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:
    - Current commercialization status of the technology.
    - 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.