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COMMISSION REPORT

Public Interest Energy Research 2015 Annual Report

Edmund G. Brown Jr., Governor
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California Energy Commission

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ABSTRACT

The California Energy Commission manages public interest energy research for electric and natural gas research programs, including the Public Interest Energy Research (PIER) Program. PIER supports energy-related research, development, and demonstration for research not adequately provided by competitive and regulated markets.

This report, prepared under Public Resources Code Section 25620.8, describes PIER electric research projects funded, or active, from January 1, 2015, through December 31, 2015. The report summarizes the projects, including ratepayer benefits and program updates. This is the final annual report for the PIER Electric program. The Energy Commission plans to release a compendium of the accomplishments of the PIER-Electric program in the summer of 2016.

Keywords: California Energy Commission, PIER, annual report, energy research, RD&D, energy efficiency, advanced generation, renewable energy, demand response, energy storage, buildings, distributed generation, transmission, smart grid, carbon sequestration, carbon capture, transportation, environmental, climate change, smart infrastructure, ratepayer benefits, public interest program, electricity, energy policy, loading order, jobs, clean energy, energy infrastructure, electric vehicles, greenhouse gas, Public Interest Energy Research Program, Renewables Portfolio Standard, building efficiency standards, California Public Utilities Commission

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EXECUTIVE SUMMARY

The California Energy Commission's Public Interest Energy Research (PIER) Program funds research, development, and demonstration (RD&D) projects as stipulated in Senate Bill 1250 (Perata, Chapter 512, Statutes of 2006) to "develop, and help bring to market, energy technologies that provide increased environmental benefits, greater system reliability, and lower system costs." Research priorities are guided by California's loading order of preferred energy resources, which prioritizes Energy Commission research investment, first in energy efficiency and demand response; second, in renewable energy and distributed generation; and finally, in clean fossil fuel sources and infrastructure improvements. Research priorities are also guided by legislative mandates such as the Clean Energy and Pollution Reduction Act of 2015 (Senate Bill 350, De León, Chapter 547, Statutes of 2015), and the Global Warming Solutions Act of 2006 (Assembly Bill 32, Núñez, Chapter 488, Statutes of 2006), by plans such as the Energy Commission's *Integrated Energy Policy Report,* and by stakeholder input.

California has adopted some of the most ambitious energy policy goals in the world. These policies provide a vision of California's energy future that includes increasingly cleaner, safer, and more affordable energy for all of California's electricity customers. In addition, this energy future envisions a new electric grid that will be more decentralized, will enable consumers to have greater control and more choices over their energy use, and will be more resilient to extreme weather events and other threats such as cybersecurity. Public interest energy research helps create the transformational technologies and science to make this vision a reality.

Through June 2013, the Energy Commission encumbered more than $779 million for energy research and development through the PIER Electric program, leveraging its investment to attract more than $1.2 billion in match funding. Authority to expend encumbered funds ends June 2017. Funded projects provide thousands of direct and indirect jobs to Californians, bolster California's status as a leader in energy innovation, and advance the state toward a clean energy future.

This annual report to the California Legislature, as required by Public Resources Code Section 25620.8, reports on the PIER Electric program in 2015, including specific information on award recipients, the amount of the awards, and the types of projects funded, along with an evaluation of the success of projects funded. This is the final annual report for the PIER Electric Program.

PIER Program Update

In 2011, the Legislature did not reauthorize the electricity research portion of the PIER Program and the mechanism under Public Utilities Code Section 399.8 that funds it, the Public Goods Charge. As a result, the PIER Electric program encumbered the final PIER electricity funds in June 2013. The Energy Commission continued to manage the remaining active projects through the end of 2015. The Energy Commission will release a final report,

which will showcase the benefits of the entire PIER Electric Program since the inception in 1997.

In December 2011, the California Public Utilities Commission (CPUC) adopted the Electric Program Investment Charge (EPIC), which authorizes collecting funds from system benefits charges for renewables and research, development, and demonstration purposes, filling the gaps in funding from the expiration of the Public Goods Charge. In November 2013, the CPUC approved the first triennial EPIC investment plan submitted by the Energy Commission and the three investor-owned utilities. The 2015-2017 triennial EPIC investment plan was approved by the CPUC in 2015. EPIC will be implemented consistent with program direction in Senate Bill 96 (Committee on Budget and Fiscal Review, Chapter 356, Statues of 2013).

CHAPTER 1:
Introduction and Overview

Background

In 1997, the California Energy Commission began funding research and development to address California's energy and environmental needs, technology opportunities, and system reliability through the Public Interest Energy Research (PIER) Electric program for "research, development, and demonstration programs to advance science or technology that are not adequately provided by competitive and regulated markets."[1] Subsequent legislation revised the program to reflect California's growing commitment to alternative transportation and give preference to California-based entities.[2] Under Senate Bill 1250 (Perata, Chapter 512, Statutes of 2006), the PIER Electric program funded research that:

- Supports technology development to enable future building and appliance efficiency standards.
- Increases energy efficiency in major energy end-use sectors, including buildings, industrial, agricultural, and water sectors.
- Develops and integrates renewable energy into the state's electricity and natural gas systems.
- Funds needed advancements in smart grid and energy storage technology.
- Supports energy-related environmental research and transportation energy research directly tied to energy generation, transmission, and use.

Since 1997, the PIER Electric program has responded to evolving policy goals and market needs. Through June 2013, the Energy Commission encumbered more than $779 million through the PIER Electric program. From July 2013 through June 2017, the program focus is on completing existing projects. The PIER Electric program prioritized funding allocation to align with California's loading order: investing first in energy efficiency and demand response and then renewables and distributed generation before conventional generation.[3]

The program initially focused on research involving individual components and progressed to emphasize integration of multiple energy technologies to solve complex, interrelated issues and to maximize synergies and benefits. For example, research in the earlier years of

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[1] Under Senate Bill 90 (Sher, Chapter 905, Statues of 1997) and AB 1890 (Brulte, Chapter 854, Statutes of 1996).

[2] Senate Bill 76 (Committee on Budget and Fiscal Review, Chapter 91, Statutes of 2005) added transportation research to the PIER Program. Assembly Bill 2267 (Chapter 537, Statutes of 2008) requires the Energy Commission to give preference to California-based entities in awarding PIER funding.

[3] http://www.energy.ca.gov/energy_action_plan/2003-05-08_ACTION_PLAN.PDF.

the PIER Electric program focused on reducing the costs of solar photovoltaic (PV) panels. As the costs of PV panels dropped, PIER-funded research began to focus on overcoming new barriers to solar energy, specifically technologies needed to enable large amounts of PV to be safely and cost-effectively added to the electric grid.

This annual report to the California Legislature, as required by Public Resources Code Section 25620.8, reports on the PIER Electric program in 2015, including specific information on award recipients, the amount of the awards, and the types of projects funded, along with an evaluation of the success of projects funded. Chapter 1 provides an introduction to the program and an overview of the policies guiding the Commission's public interest energy research. Chapter 2 lists the electricity-funded RD&D projects that were active or completed in 2015.

The Role of Public Interest Energy Research

California has adopted some of the most ambitious energy policy goals in the world. These policies, some of which are highlighted in Table 1, provide a vision of California's energy future. This energy future will provide increasingly cleaner, safer, and more affordable energy for all of California's electricity customers. In addition, this energy future envisions a new electric grid that will be more decentralized, will enable consumers to have greater control and more choices over their energy use, and will be more resilient to extreme weather events and other threats to cybersecurity.

Public interest energy research helps create the transformational technologies and science to make this vision a reality. New energy technologies go through several stages of development from initial concept to commercialization. The path from concept to commercial product is often referred to as the *energy innovation development pipeline*. Critical funding gaps within this pipeline are known as "valleys of death," where pervasive market barriers limit the ability of promising technologies to attract private sector investment. Without other sources of funding to bridge these gaps, technologies may fail to reach commercialization and leave potential benefits unrealized.

Public interest energy research provides funding at these critical stages to help early stage energy technologies overcome these valleys of death. More importantly, because the research results are made publicly available and shared widely, public interest energy research fills critical information gaps that help reduce the risk of these technologies to key stakeholder groups. Using this unbiased information, investors, customers, and policy makers can make informed decisions that promote new energy technologies that provide the greatest economic, environmental and public health and safety benefits to ratepayers.

Table 1: Select Policy Goals for California's Energy Future

Policy or Standard	Goal
Governor Brown's Clean Energy Jobs Plan	California should produce 20,000 new megawatts (MW) of renewable electricity by 2020, 12,000 MW of distributed energy, and 6,500 MW from CHP.
California's Loading Order, from the California *Energy Action Plan*	Prioritizes Energy Commission research investment first in energy efficiency and demand response; second, in renewable energy and distributed generation; and finally, in clean fossil fuel sources and infrastructure improvements.
Executive Order B-18-12 Greening State Buildings	Calls for efficiency improvements in new or renovated state buildings larger than 10,000 square feet; sets zero-net-energy (ZNE) and greenhouse gas (GHG) reduction goals.
Integrated Energy Policy Report	The Energy Commission's biennial energy forecasting and assessment report (required under Senate Bill 1389 of 2002) recommends policies to foster the development of energy efficiency, renewable energy, and more.
Assembly Bill 32 (2006) The California Global Warming Solutions Act	Requires the state to reduce GHG emissions to or below 1990 levels by 2020.
CPUC *Energy Efficiency Strategic Plan*	Sets efficiency goals, including ZNE goals for new homes by 2020 and for new commercial buildings by 2030.
Senate Bill 17 (2009)	Mandates implementing and planning a smart grid.
Governor Brown's Executive Order B-16-2012 and the *2013 Zero Emission Vehicle Action Plan*	The Governor's Executive Order sets a long-term target of reaching 1.5 million zero-emission vehicles on California's roadways by 2025 and directed state agencies to "encourage the development and success of zero-emission vehicles." The *2013 Zero-Emission Vehicle Action Plan* identifies specific strategies and actions to meet this goal.

Policy or Standard	Goal
Senate Bill 1250 (2006)	Made provisions for efficiency and renewables research, declaring that it is in the best interests of the people of California that environmentally sound, safe, reliable, and affordable energy services and products be developed and that the PIER Program makes research investments to this end.
Assembly Bill 2514 (2010)	Establishes an energy storage target of 1,325 MW by 2020 for investor-owned utilities.
Senate Bill 350 (2015)	By 2030, California should increase its electricity derived from renewable sources to 50 percent, and double energy efficiency savings in electricity and natural gas final end uses of retail customers through energy efficiency and conservation.

Source: California Energy Commission Staff

Policy, Planning, and Program Overview

As the state's primary energy policy and planning agency, the Energy Commission makes assessments and forecasts that aid in developing energy policies that conserve resources, protect the environment, ensure energy reliability, enhance the state's economy, and protect public health and safety

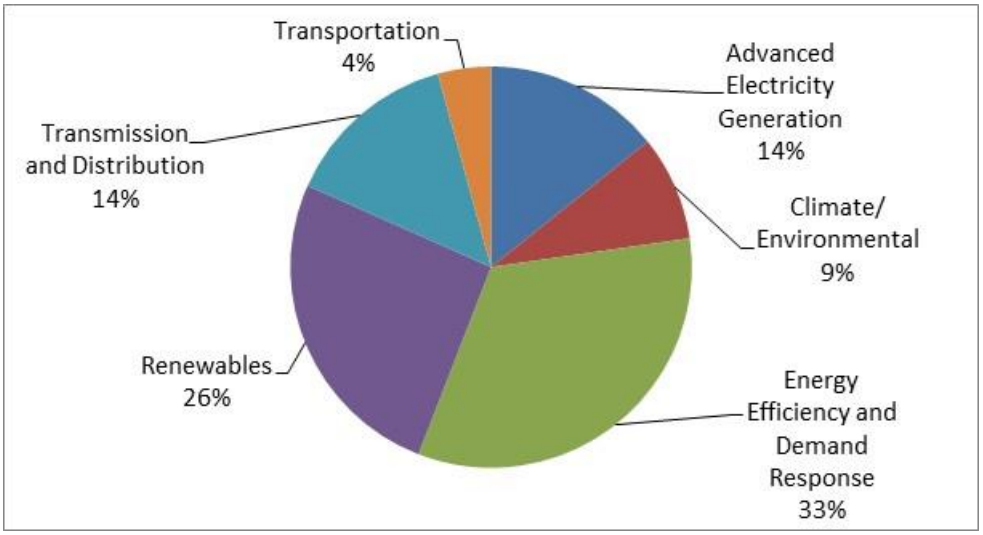
The Energy Commission's administration:

- Provides transparency and accountability for all funds and projects.
- Conducts coordinated research to avoid duplication.
- Provides independent and impartial evaluations of proposals and projects.
- Supports RD&D work with a policy focus dedicated to benefiting California ratepayers.
- Generates research opportunities for California-based companies that create jobs and stimulate the economy.
- Fosters critical relationships with California's universities, national laboratories, and high-tech companies that have diverse and substantial research capabilities.
- Leverages funds with private sources and the federal government.
- Works diligently to ensure the program is operating to fulfill statutory goals.

Program Funding Overview

PIER prioritized project funding to align with California's loading order. By consistently funding research based on the priorities of the loading order, the Energy Commission has ensured that energy investments are made where they are most needed to achieve electric system efficiency, generation, and delivery goals. Figure 2 illustrates PIER Electric funding encumbered from 1997 through June 2013, highlighting the alignment with California's energy policies.

Figure 1: Energy Commission PIER Electric Funding Aligns With California's Energy Policies



The Energy Commission encumbered more than $779 million for PIER Electric RD&D projects from 1997 through June 2013.

Source: California Energy Commission Staff

Highlights of PIER Benefits

Since 1997, the PIER Electric program has provided significant benefits to California and its electric ratepayers. The Energy Commission will release a final report that provides a comprehensive overview on the benefits of the PIER Electric program over the program lifetime. The following information highlights some of these benefits:

- Between 1999 and 2008, the Energy Commission invested $27.6 million in energy efficiency research projects that directly contributed to changes to California's Building and Appliance Energy Efficiency Regulations. These changes are estimated to result in more than $10 billion in net savings for California ratepayers between 2005 and 2025.
- *Demand response* refers to the practice of encouraging customers to cut their electricity use when needed using contractual or price incentives. While this is a proven approach to peak load reduction, the process can be highly complex and require advanced technologies. PIER funded the development of technologies that enable automated demand response – AutoDR and OpenADR – which are now

industry standards. These technologies avoided 260 megawatts of peak load and saved California electricity ratepayers an estimated $16.5 million in 2012.

- Research successes with synchrophasor technologies—highly complex tools that provide detailed electrical grid information to help avoid system problems—were advanced in 2012 with continued technology upgrades, and efforts to increase wider adoption of synchrophasors and to integrate the data they provide with other system tools. As a result of 2012 improvements, California's grid operator sees changes more clearly, compares data more effectively with interconnected systems outside the state, and is better capable of coordinated responses to any event or problem on the grid. By 2020, the effects of PIER synchrophasor research and related applications will save Californians an estimated $210 million to $360 million annually by improving reliability and avoiding costly outages and will provide $90 million per year in other economic benefits.
- Adaptive lighting technologies reduce energy use by automatically adapting lighting levels to occupancy and ambient light levels. Energy Commission staff estimates that adaptive lighting technologies fostered by PIER saved $10.7 million in 2014 from retrofits. By 2020, adaptive lighting retrofits are projected to save $66 million a year.
- PIER provided funding to Powerlight and SunPower to develop new products for the rooftop- and utility-scale PV markets, including the PowerGuard™, PowerTracker™ and SunTile™. In 2007, the two companies merged under SunPower. As of 2013, SunPower and its partners' operations were directly sustaining 4,055 California jobs in addition to 800 construction jobs created in school and similar-sized installations each year, and 1,350 temporary utility-scale construction jobs.
- Through June 2013, the Energy Commission encumbered more than $779 million for energy research and development through the PIER Electric program, leveraging its investment to attract more than $1.2 billion in match funding.

PIER Program Status

As stated, the Legislature did not reauthorize the electricity research portion of the PIER Program and the mechanism under Public Utilities Code Section 399.8 for funding it, the Public Goods Charge. All active PIER electric-funded projects were managed through 2015 as the program winds down and continues the transition to the Electric Program Investment Charge.

Recognizing the importance and benefits of public interest energy research, Governor Edmund G. Brown Jr. requested in 2011 that the CPUC take action to ensure that programs like those supported by the Public Goods Charge are instituted under CPUC authorities and take into account the constructive ideas for program updates that were identified during the legislative process. The CPUC adopted the Electric Program Investment Charge (EPIC) in December 2011, authorizing the collection of system benefits charges for renewables and research, development, and demonstration purposes. In November 2013, the CPUC approved the first triennial EPIC investment plan submitted by the Energy Commission and

the three investor-owned utilities. In 2015, the CPUC approved the 2015-2017 triennial EPIC investment plan submitted by the Energy Commission. EPIC is being implemented consistent with program direction in Senate Bill 96 (Committee on Budget and Fiscal Review, Chapter 356, Statues of 2013). The EPIC Program builds on many of the lessons learned from the Energy Commission's administration of the PIER Electric program. Table 2 highlights some of the lessons learned and how the Energy Commission has addressed those in the EPIC Program.

Table 2: Lessons Learned From the PIER Electric Program

Lesson Learned From PIER Electric Program	How the Energy Commission Applied the Lesson in the EPIC Program
Preference to award projects through a competitive solicitation process.	Through the end of 2015, all EPIC projects have been awarded through a competitive solicitation process.
Improve information dissemination of research projects	In December 2015, the Energy Commission held a symposium to highlight current EPIC projects and activities.
Reduce overhead and administrative costs charged by recipients.	EPIC solicitations include scoring criteria that provide higher scores to applicants that minimize their overhead and general administrative costs.
Preference for funds spent in California to increase the economic benefits returned to ratepayers.	EPIC solicitations include scoring criteria that provides higher scores to applicants that maximize funds spent in California.
Increase the diversity of applicants.	Under EPIC the Energy Commission has conducted outreach efforts to reach a broader and more diverse applicant pool in the state. This has included providing "How to Apply" training sessions throughout the state, holding pre-application workshops in different geographic locations of the state, and attending outreach events to inform potential applicants of EPIC funding opportunities.

Source: California Energy Commission Staff

As part of EPIC, the Commission submits an annual report to the CPUC and the Legislature detailing program activities and highlighting funded projects. The *2015 EPIC Annual Report* provides information on the first investment plan, as well as status updates on EPIC-funded activities.[4] The staff report was submitted to the CPUC on February 29, 2015. The report

[4] The EPIC Annual Report is available at http://www.energy.ca.gov/research/annual_reports.html.

was taken up at the Energy Commission's April 2015 business meeting and submitted to the California Legislature on April 30, 2015.

CHAPTER 2:
Project Descriptions and Updates

In calendar year 2015, the Energy Commission managed 81 projects that were either fully or partially funded from the PIER Electric program. The following tables provide information on each project including the names of the award recipients, the amount of awards, the types of projects funded, and an evaluation of the success of the funded projects.

Title:	Realizing Energy Efficient Lighting in California				
Agreement Number:	500-08-053	**Project Number:**	1	**Research Stage:**	Applied Research
Electricity Funding:	$5,011,481	**Match Funding:**	$870,000	**Natural Gas Funding:**	$0
Start Date:	6/30/2009	**End Date:**	3/30/2015	**Technology Topic:**	Lighting
Award Recipient	California Lighting Technology Center - University of California, Davis			**End-Market:**	Ratepayers

Description

In California, lighting accounts for 35 percent and 22 percent of commercial and residential electricity use, respectively. Numerous opportunities exist to reduce this use through improvements in source or system efficacy, reduction in operating hours and reduced reliance on grid-connected power sources. As part of the project, the California Lighting Technology Center addressed the application of light-emitting diode (LED) technology and advanced control systems as a primary method to achieve deep, sustained electricity savings. Project activities also included significant efforts to support market adoption of advanced technologies, including educational material and informing codes and standards.

Objectives:

Develop and assist in the development of products, technologies and strategies that will increase lighting energy efficiency with 25% target reduction in residential buildings and 50% in commercial buildings. To meet these ambitious goals California needs to develop new lighting technologies for new and retrofit applications, support market adoption and install in new and existing buildings.

Benefits:

The project resulted in commercially available products and energy-efficient design strategies for residential and commercial applications. Adaptive outdoor lighting solutions, for example, are now widely available from a variety of manufacturers. Over the course of the project, this technology matured from laboratory prototype to commercial technology. Demonstrated savings, as compared to traditional static solutions, range from 40 percent to 90 percent depending on the application. Market deployment activities resulted in outreach and technology transfer activities, in collaboration with utilities, industry, and academic and professional institutions.

Title:	Healthy Zero Energy Buildings Program				
Agreement Number:	500-09-049	**Project Number:**	1	**Research Stage:**	Policy/Regulation Support
Electricity Funding:	$3,400,000	**Match Funding:**	$0	**Natural Gas Funding:**	$0
Start Date:	8/9/2010	**End Date:**	3/15/2015	**Technology Topic:**	Indoor Air Quality
Award Recipient:	Lawrence Berkeley National Laboratory			**End-Market:**	Policymakers/ Regulators

Description:

The project conducted ventilation and indoor environmental quality (IEQ) research to assist the California Energy Commission in developing standards that simultaneously provide for occupant fresh air needs while minimizing energy demands.

Objectives:

1. Develop survey methods to measure ventilation, indoor and outdoor pollutant source contribution to indoor concentrations, building control system impacts on IEQ, and their combined impacts on building occupant health, comfort, performance, and productivity.
2. Assess how ventilation rates affect human outcomes in commercial buildings.
3. Quantify the energy costs of ventilation in California commercial buildings.
4. Develop a process for selection of thresholds for acceptability of human outcomes.
5. Develop recommendations on setting minimum ventilation rates for Energy Commission, standards bodies, and other stakeholders as appropriate.

Benefits:

This project resulted in the production of scientific information on ventilation rates necessary in commercial buildings to maintain the health, comfort, and performance of occupants. The key products of the research include:

- New techniques to measure ventilation, indoor air quality, building occupant health, comfort, and productivity.
- Development of a much-needed database of indoor air quality in commercial buildings in California.
- Understanding of the sources and dynamics of key indoor pollutants that are controlled through ventilation.
- Increased knowledge of the relationship between ventilation and human outcomes.
- New information on energy costs of ventilation in commercial buildings.

The findings assisted in developing science-based ventilation standards that support the health, comfort, and performance of building occupants while limiting unnecessary over-ventilation of buildings. This information helped inform policy and standards on the design and operation of energy efficient buildings, such as r use by Energy Commission Standards, ASHRAE, and other standards bodies for use in setting science-based

Title:	Integrated Retrofit Solutions for Untapped Markets				
Agreement Number:	500-10-028	**Project Number:**	1	**Research Stage:**	Applied Research
Electricity Funding:	$1,995,032	**Match Funding:**	$1,197,500	**Natural Gas Funding:**	$0
Start Date:	3/31/2011	**End Date:**	3/31/2015	**Technology Topic:**	Whole buildings
Award Recipient:	Regents of the University of California, Davis			**End-Market:**	Ratepayers

Description:

The project resulted in the development of technology and market-based approaches to increase deployment of energy-efficient technologies and reduce peak demand for existing multi-tenant, light commercial buildings in California. This project developed cost-effective, commercially viable, whole-building, integrated technology retrofit and financing solutions for existing buildings that address building envelop, lighting (interior and exterior), and heating ventilation air conditioning (HVAC) including integrated controls.

Objectives:

1. Create a cross-disciplinary research team, including manufacturers, designers, the building industry and California's major utilities.
2. Advance market adoption of research products through development of inter-linked projects that are technically feasible.
3. Provide a cost effective approach that is connected to the market through manufacturers, customers, builders, regulators and other market actors.
4. Support for major state policies and goals, such as zero net energy in commercial construction by 2030.

Benefits:

- Lower energy costs for owners and tenants of multi-tenant light commercial buildings.
- Potential to reduce cost of retrofits for this sector with development of cost-effective packages of appropriate and integrated technologies.

Title:	Public University Energy Efficiency Research Projects				
Agreement Number:	500-10-048	**Project Number:**	2	**Research Stage:**	Applied Research
Electricity Funding:	$1,986,500	**Match Funding:**	$0	**Natural Gas Funding:**	$1,992,090
Start Date:	3/31/2011	**End Date:**	3/31/2015	**Technology Topic:**	Whole buildings
Award Recipient:	Regents of the University of California, Davis			**End-Market:**	Ratepayers

Description:

The project resulted in the funding of 11 research projects to improve building, industrial and agriculture energy efficiency by developing and deploying new technology. The projects included advanced heating and cooling systems for building efficiency, advanced solar water heating technology to reduce cost, improve HVAC electric motors, wireless measurement tools, adaptive lighting, adaptive envelope systems, fuel flexible burners and gasification of biomass.

Objectives:

1. Improve heating and cooling systems while reducing cost.
2. Reduce non-renewable energy consumption in commercial buildings.
3. Improve HVAC electric motor systems
4. Develop adaptive lighting systems for the retail sector.
5. Promote better indoor environmental quality in buildings.
6. Promote adaptive building envelopes which actively manage ventilation and lighting.

Benefits:

- Increase energy efficiency in buildings and industries.
- Lower energy costs for facility operators.
- 3. Reduce greenhouse gas emissions.

Title:	Demand Response Research Center				
Agreement Number:	500-03-026	**Project Number:**	1	**Research Stage:**	Applied Research
Electricity Funding:	$19,749,970	**Match Funding:**	$0	**Natural Gas Funding:**	$0
Start Date:	4/1/2004	**End Date:**	3/31/2015	**Technology Topic:**	Load reduction
Award Recipient:	Demand Response Research Center			**End-Market:**	Ratepayers

Description:

The Energy Commission provided funding to create the Demand Response Research Center (DRRC). The purpose of the center was to develop, prioritize, conduct and disseminate research facilitating the near-term adoption of demand response (DR) technologies, policies, programs, strategies and practices. The research focus also included continuing to be connected with the DR market and policy makers through substantial stakeholder input. The DRRC worked with system developers, aggregators, program implementers, utilities, industry trade associations, state policy makers, researchers and utility customers to help direct their efforts.

Major accomplishments:

- Developed open automated DR, accepted by NIST as a national standard.
- Evaluated DR control strategies, developed measurement and verification methods, provided tools and guides for customers to evaluate DR opportunities.
- Assisted California utilities to deploy OpenADR.
- Demonstrated OpenADR in fast ancillary services projects.
- Any-time DR capability now available from 200-900MW.

Objectives:

1. Conduct research, development, demonstrations and technology transfer on DR topics.
2. Disseminate information on DR technologies to facilitate near term adoption.
3. Develop DR control strategies, tools and guides.

Benefits:

- Energy bill savings.
- Reliability benefits, such as peak shaving.
- System and network benefits, such as reduced congestion or low cost ancillary services.
- Market price reductions.
- Environmental benefits.

Title:	Central Valley Research Home Program				
Agreement Number:	500-10-014	**Project Number:**	1	**Research Stage:**	Applied Research
Electricity Funding:	$1,350,000	**Match Funding:**	$880,000	**Natural Gas Funding:**	$532,091
Start Date:	9/27/2010	**End Date:**	3/15/2015	**Technology Topic:**	Whole Building
Award Recipient:	Bruce Wilcox, Sole Proprietorship			**End-Market:**	Policymakers/ Regulators

Description:

This project developed cost effective retrofit packages for four different vintages of homes in Stockton, California to test and measure the effects of envelope and HVAC, duct reconfiguration and other measures to reduce heating and cooling energy use. The project also evaluated Home Energy Rating System (HERs) calculations and procedures used to estimate baseline and post-retrofit energy use and demand.

Objectives:

1. Identify and characterize alternative [conditioned air] distribution systems.
2. Produce a technology transfer plan.
3. Improve HERS software to produce better estimates of existing home pre and post retrofit energy use.
4. Develop life cycle cost effective residential retrofit packages that will reduce heating and cooling energy use by 50 percent or more in experimental homes in the Central Valley climate zones.

Benefits:

Existing buildings represent 90 percent of the residential building stock and most were built prior to building energy efficiency standards. This project identified cost-effective retrofit measures of various vintages of homes located in the Central Valley and showed savings between 50 and 70% in heating and cooling energy use from measured baseline energy use. The project also identified that improvements are needed on the HERS rating system to result in more accuracy for estimating retrofit measure energy savings or whole house energy savings.

Title:	Integrated Solar PV, Advanced Compressed Air Energy Storage, and Microgrid Demonstration Project				
Agreement Number:	PIR-12-004	**Project Number:**	1	**Research Stage:**	Applied Research
Electricity Funding:	$1,749,000	**Match Funding:**	$1,243,570	**Natural Gas Funding:**	$0
Start Date:	6/19/2013	**End Date:**	3/31/2015	**Technology Topic:**	Solar PV
Award Recipient:	Foresight Renewable Solutions			**End-Market:**	Ratepayers

Description:

This project will demonstrate the cost-efficient integration of high penetrations of renewable energy within a given community using locally-available renewable energy resources while increasing the energy security of the community. The community for this project, the Mobile Utilities Support and Equipment (MUSE) Facility located at Naval Base Ventura County (NBVC), will deploy 150 kW of solar photovoltaic (PV) into a community-based microgrid that will include extant diesel back-up generation, energy storage, and mission-critical and routine operational loads. The storage options deployed will include a 100 kW/1000 kW-hr vanadium redox flow battery funded by the Energy Commission in addition to traditional lead-acid deep cycle batteries provided by the Navy.

Objectives:

Design, develop, and deploy an innovative hybrid project that integrates 150 kilowatts (kW) of solar PV and a modular 100 kW/1000 kW-hr flow battery energy storage system with a microgrid serving the community at NBVC.

1. Measure, analyze, and document the capital and operating costs of the hybrid project.
2. Verify round‐trip efficiency of the vanadium‐redox flow battery system of 75 percent or more while supporting the microgrid in both grid‐connected and islanded modes.
3. Quantify various operational parameters in terms of power quality (voltage support, and frequency regulation), response time, and operational availability and runtime achievable in island mode.
4. Demonstrate and quantify cost savings to the MUSE facility and NBVC through displacement of utility electrical supply via renewable energy deployment, Battery Energy Storage System‐enabled load shifting,

Benefits:

One of the primary drawbacks of solar PV is that it is an intermittent resource that does not follow load during daylight hours when it is generating, and does not generate at all after dark. Successfully integrating PV into a microgrid that includes energy storage will enable a community to better match its generation to load by managing loads and by using storage to add or remove electricity to the microgrid to balance load as needed. This includes the ability to store excess electricity generation by day and shift to nighttime hours. Similarly, the ability of flow batteries to store electric power indefinitely affords the community the option of using solar energy as emergency back-up generation, offsetting the use of fossil fuels for that purpose. Energy costs are reduced via reduced consumption of grid electricity, especially during periods of high electricity prices, and via reduced demand charges achieved through peak shaving. Power quality will be improved by the rapid response of the microgrid to changing generation and loads to maintain voltage, frequency, waveform and other quality parameters. Increased reliance on solar will reduce the consumption of fossil fuels and the emission of priority pollutants and greenhouse gases produced thereto.

Title:	Zero Net Energy (ZNE) Demonstration- Integration of Dynamic Daylighting and Passive Cooling/ Heating for High Return on Investment				
Agreement Number:	PIR-12-024	**Project Number:**	1	**Research Stage:**	Applied Research
Electricity Funding:	$1,042,233	**Match Funding:**	$1,553,326	**Natural Gas Funding:**	$500,000
Start Date:	6/28/2013	**End Date:**	12/31/2016	**Technology Topic:**	Whole Building
Award Recipient:	View, Inc.			**End-Market:**	Ratepayers

Description:

This project resulted in the design, construction, and demonstration of an affordable and broadly replicable approach for renovating commercial buildings using an integrated technology package that includes a combination of eight emerging and mature technologies. The strategy includes installation of LED lighting and plug-load management, dynamic windows, sky lights, extreme insulation, nigh flushing, building controls and down-sizing the HVAC system and the PV array due to reduced energy loads. Ongoing monitoring and verification of building performance and energy and cost savings will occur in 2016.

Objectives:

1. Reduce cooling energy by 3 times at a heating, ventilation and air conditioning (HVAC) capital cost that is 5 times lower than required by Title 24 regulations.
2. Reduce lighting energy by 3 times, at a lighting installed cost that is 1.5 times lower than required by Title 24.
3. Reduce heating energy by 7 times, at an HVAC capital cost that is 5 times lower than required by Title 24.
4. Generate sufficient incremental net-operating income to provide a positive cash flow after servicing debt equal to the total incremental renovation costs over Title 24.
5. Has an incremental ROI greater than the market rate on comparable non‐sustainable construction (7.5%).

Benefits:

This project demonstration will document the designs, practices, savings and efficiencies of implementing a whole building retrofit strategy for commercial buildings and publicize the results to the construction, banking, and public policy communities and drive awareness, catalyze replication and accelerate benefits to California ratepayers.

This project will alter the landscape of future sustainable construction by making ZNE construction a compelling investment opportunity, and eliminates barriers to adoption. This project approach will accelerate adoption across the state, enabling California to not only meet policy goals for ZNE buildings, but to meet them on an accelerated and unsubsidized basis.

Title:	Demonstrating Scalable Very Energy Efficient Retrofits for Low Income, Multifamily Housing				
Agreement Number:	PIR-12-025	**Project Number:**	1	**Research Stage:**	Applied Research
Electricity Funding:	$851,283	**Match Funding:**	$1,112,800	**Natural Gas Funding:**	$500,000
Start Date:	6/30/2013	**End Date:**	3/31/2017	**Technology Topic:**	Whole Building
Award Recipient:	Electric Power Research Institute			**End-Market:**	Ratepayers

Description:

This project will develop cost-effective, replicable packages of energy-efficiency measures (EEMs) that can be used for deep energy efficiency retrofits of low-income multifamily properties. These packages will be installed and demonstrated in 30 apartment units at the Beachwood multifamily complex in Lancaster, California owned by project partner LINC.

Objectives:

1. Develop practical, replicable very efficient retrofit (VER) packages for low income multifamily housing.
2. Research measures, technologies, and building practices to make the VER retrofit packages as close as possible to ZNE capable and still practical, cost‐effective and replicable.
3. Demonstrate, measure, and evaluate the retrofit packages in the targeted community and define the financing requirements of and barriers in low‐income multifamily housing industry. This information will provide insightful recommendations to the financing industry for specific financing needed for widespread replication.

Benefits:

This project will develop retrofit packages with different magnitudes of energy savings from about 47 percent improvement from baseline conditions to at least meet 2008 Title 24 energy efficiency standards, to nearly 70 percent for zero net energy capable. Assuming the lowest estimated savings of about 47 percent, this project would reduce electricity use by over 150,000 kWh and natural gas use by over 9,000 therms (thus reducing greenhouse gas emissions by over 240,000 pounds). These numbers translate to reducing energy costs by over $32,000 annually for California ratepayers. The benefits of this project could also be extended to creating additional jobs. Retrofits of low income housing projects require on-site labor, estimated to be one full-time, permanent job for every $100,000 invested in a retrofit, and a corresponding 1.5 jobs off-site. Using these estimates, the LINC housing retrofits alone would produce an estimated 13 new jobs. Additional jobs could be created if LINC housing replicates these retrofits at their 65 other properties located throughout California.

Title:	Innovative Low-Energy Occupant-Responsive Controls for Heating, Ventilation and Air Conditioning Systems				
Agreement Number:	PIR-12-026	**Project Number:**	1	**Research Stage:**	Applied Research
Electricity Funding:	$629,399	**Match Funding:**	$192,500	**Natural Gas Funding:**	$1,000,000
Start Date:	6/30/2013	**End Date:**	3/31/2017	**Technology Topic:**	Whole Building
Award Recipient:	Regents of the University of California/ California Institute for Energy and			**End-Market:**	Ratepayers

Description:

This project has the goal of optimizing control of heating, ventilating, and air conditioning (HVAC) systems for energy efficiency in conjunction with the use of occupant–based personal comfort technology innovations. This project will build on efforts to demonstrate occupant comfort, control, and information systems. This project will create and demonstrate new personal comfort products and HVAC control & operation practices, and will work toward having them adopted in standards, codes, and common practice.

Objectives:

1. Demonstrate and bring to market new low‐energy, localized personal comfort systems (PCS).
2. Develop methods of test for certifying the efficiency of PCS.
3. Develop and demonstrate innovative improvements to Variable Air Volume control systems.
4. Use open‐source information technology software for implementing actuation control logic across a full range of DDC systems.
5. Implement the results and inform Standards and Codes (e.g., Title 24, Title 20, ASHRAE 90.1, ASHRAE 55, etc.).
6. Perform technology transfer activities to encourage standards' provisions to be adopted in common practice
7. Demonstrate and bring to the market new low‐energy, localized PCSs, and develop methods for certifying their efficiency.

Benefits:

This project will lead to the development of a new control paradigm based on enlarging the roles of occupants, operators, and automation in control of buildings. This paradigm applies equally to existing buildings as well as new designs, and includes innovative personal comfort technologies, control improvements, and web-based information technology. These new integrated control strategies have the potential to dramatically improve traditional levels of energy efficiency, increase occupant satisfaction and thermal comfort, and increase the flexibility and useful life of the conditioning systems.

Title:	Codes and Standards Quality Demonstration Program				
Agreement Number:	PIR-12-027	**Project Number:**	1	**Research Stage:**	Applied Research
Electricity Funding:	$642,103	**Match Funding:**	$121,600	**Natural Gas Funding:**	$525,000
Start Date:	7/12/2013	**End Date:**	3/31/2017	**Technology Topic:**	Benchmarking
Award Recipient:	The Regents of the University of California			**End-Market:**	Policymakers/ Regulators

Description:

The project will develop a detailed demonstration and assessment program for Energy Commission sponsored and other related building efficiency technologies. The Codes and Standards Enhancement Quality Demonstration project (CASE-QDP) will deliver a complete, robust data set on key energy-efficient technologies and inform and affect future California codes and standards (C&S) activities. Completed activities include compilation of HVAC fault detection diagnostic and gas engine heat pump data, evaluation of commercial clothes washers using polymer bead technology, residential luminaire lamp replacement, and occupancy sensors for outdoor applications.

Objectives:

1. Develop a CASE ‐ QDP Program Manual in collaboration with partners and PAC
2. Demonstrate the validity and success of the program framework through multiple technology demonstrations
3. Conduct pre- and post-retrofit assessments of each demonstrated technology according to the Program Manual framework.
4. Deliver energy, market, and economic analyses to CEC and other stakeholders for use in C&S activities.
5. Refine the Program manual based on demonstrations and lessons learned.

Benefits:

It is anticipated that the research will contribute to both the buildings (Title 24, part 6) and appliance (Title 20) energy efficiency standards associated with lighting, building envelope, HVAC, hot water heating and plug loads. Future codes and standards will reduce energy costs and greenhouse gas emissions for Californians.

Title:	Advanced Envelope Systems for Factory Built Homes				
Agreement Number:	PIR-12-028	**Project Number:**	1	**Research Stage:**	Applied Research
Electricity Funding:	$129,307	**Match Funding:**	$299,781	**Natural Gas Funding:**	$1,304,261
Start Date:	6/30/2013	**End Date:**	9/30/2016	**Technology Topic:**	Whole Building
Award Recipient:	The Levy Partnership, Inc.			**End-Market:**	Residential

Description:

This research project will focus on increasing the energy performance of factory built homes by developing and commercializing the next generation of cost-effective wall and roof envelope designs that, from an energy perspective, are high performance, cost effective and add minimally to first costs. This project will apply a combination of innovative design, concurrent engineering in the design-development process and leverage the advantages afforded by factory production and rapid commercialization. The Levy Partnership has completed testing the wall assembly and is currently testing four different roof assemblies in Jamestown, California. Two enhanced features, use of cool roofs and radiant barriers, are also being tested in Riverside, California.

Objectives:

1. Develop roof and wall panel.
2. Have an annualized energy cost markedly lower than the current construction methods.

Benefits:

Potential benefits include an estimated 1500 kWh per year savings for cooling and fan use and 140 therms per year for heating. These savings are a statewide average for manufactured housing over six climate zones. Significantly lower energy use and cost compared to current construction. Savings should be on the order of 15 percent electric and 22 percent natural gas over total energy of baseline homes. Base house is 1,680 square feet. Five California builders for manufactured homes are involved with the new energy efficient features.

Title:	Small and Medium Building Efficiency Toolkit and Community Demonstration Program				
Agreement Number:	PIR-12-031	**Project Number:**	1	**Research Stage:**	Technology Development
Electricity Funding:	$670,601	**Match Funding:**	$254,790	**Natural Gas Funding:**	$1,329,399
Start Date:	6/30/2013	**End Date:**	3/31/2017	**Technology Topic:**	Whole Building
Award Recipient:	Lawrence Berkeley National Laboratory			**End-Market:**	Ratepayers

Description:

This research will develop a retrofit energy toolkit for small and medium buildings (SMB) and demonstrate the Toolkit's capabilities on three to four building test sites. The project will also obtain input from stakeholders on retrofit packages, compile utility smart-meter data to develop the load shape analysis module, determine the indoor environmental quality effects on retrofitted small office and retail buildings, and develop a comprehensive web-based retrofit tool for business owners and energy professionals.

The Commercial Building Energy Saver (CBES), a web-based software tool for use by small business owners and operators has been developed. CBES identifies operational improvements and retrofits to improve efficiency and consider historical data and equipment. CBES includes guidance so that users can maintain indoor environmental quality as they retrofit. It has been demonstrated with California cities and energy service providers. The team is currently finalizing a scope of work and contract in place for Pacific Gas & Electric to share the small commercial building data. This data will allow the team to organize the electric load shape benchmarking work to enhance this feature of the tool.

Objectives:

1. Develop streamlined data collection and performance measurement systems that maximize existing data and approaches used in this sector.
2. Partner with California businesses, local governments, and Independently Owned Utilities to develop, test, and demonstrate the SMB Toolkit to validate a robust, practical and effective SMB retrofit assessment method.
3. Develop an Indoor Environmental Quality information and ventilation measurement system for rooftop HVAC, to ensure that ventilation rates are adequate but not excessive.
4. Develop a rapid web-based retrofit assessment tool based on load shapes, benchmarking, and a pre-simulated database of retrofit measure energy savings results for small and medium office and retail buildings.
5. Define the functional requirements for conducting SMB retrofit assessments.
6. Develop the SMB Toolkit web services APIs, based on the identified functional requirements, that can deliver SMB retrofit energy savings calculations for a wide range of web-based applications.
7. Prototype a freely available web-based retrofit analysis tool using the developed APIs to evaluate both individual and package of retrofit measures.

Benefits:

- The implementation and use of the SMB Toolkit to determine cost effective retrofits for small and medium office and retail buildings and for spaces is expected to increase the percent of energy retrofits implemented in these target sectors. The tool will be used by engineers, energy consultants, facility, property managers and building and business owners to systematically determine and rank energy retrofit opportunities.
- Providing the financial and energy savings data to the key decision makers will more than likely increase the likelihood that the building owners/operators make retrofit energy upgrades.
- This retrofit software will make it easier for building owners and operators to make energy efficiency upgrade decisions, which can lead to more energy efficiency retrofit upgrades.

Title:	Tools and Materials for Zero Net Energy California Buildings				
Agreement Number:	PIR-12-032	**Project Number:**	1	**Research Stage:**	Applied Research
Electricity Funding:	$635,074	**Match Funding:**	$0	**Natural Gas Funding:**	$700,000
Start Date:	6/30/2013	**End Date:**	3/31/2017	**Technology Topic:**	Modeling
Award Recipient:	The Regents of the University of California-University of California, Los Angeles			**End-Market:**	Ratepayers

Description:

This project will research new phase change materials to store thermal energy for wall assemblies, and develop associated software tools. Heat is absorbed or released when the materials change from solid to liquid or vice versa. Phase change materials absorb thermal energy. They can remove, or at least reduce, the need for heating and cooling in some buildings. Their impact is similar to that of adding thermal mass to the building. Unlike air conditioning systems, they require no maintenance. The use of phase change materials and associated software tools can contribute to zero net energy (ZNE) commercial buildings or to reduce the energy needs of buildings through passive designs that require low or no energy to operate.

Currently, the research has resulted in the development of a new control scheme for walls containing phase change materials for temperature control of a single room with a concrete wall. Preliminary simulations have shown that this control method consumes around 10% less energy than a traditional on/off control methods. Studies of the durability of PCM-mortar composites under simulated environmental conditions are ongoing. A final public release of Home Energy Efficient Design (HEED) Upgrade to meet 2013 Title 24 has been completed.

Objectives:

1. Develop a new kind of phase change material for envelopes for ZNE buildings.
2. Develop software tools for designing ZNE Buildings.
3. Analyze data and estimate associated energy savings.
4. Conduct technology transfer activities.

Benefits:

- Reduce cooling and heating energy and costs. For spring temperature conditions, a PCM-composite wall resulted in a cooling energy reduction of up to 80% and heating energy reduction of up to 25%.
- PCM materials can shift heating and cooling demand.
- Free climate consultant tools and tutorials developed to help building owners, builders, architects and students to create ZNE buildings. The tutorials are also posted on YouTube showing how to use HEED to create residential design alternatives that meet the 2013 California Energy Code and how to use Climate Consultant.

Title:	Arc Fault Circuit Interrupter Development for Residential DC Electricity				
Agreement Number:	500-01-043	**Project Number:**	16	**Research Stage:**	Applied Research
Electricity Funding:	$149,808	**Match Funding:**	$0	**Natural Gas Funding:**	$0
Start Date:	10/1/2013	**End Date:**	3/30/2015	**Technology Topic:**	ZNE
Award Recipient:	The Regents of the University of California on behalf of the California Institute for Energy and Environment			**End-Market:**	Ratepayers

Description:

This research developed an Arc Fault Circuit Interrupter (AFCI) for a DC-powered house. This project focused on increasing California's electric power supply efficiency with safety as the primary objective. Arcing events in which there is an electrical breakdown in the circuits are a significant fire risk, and AFCIs can significantly reduce this risk. AFCIs are currently in development for 80V or higher photovoltaic circuits, but this research developed a prototype AFCI for DC household plug circuits operating at 24-48V and integrated this technology into a Smart DC Wall Plug.

The AFCIs required in residential AC wiring cannot detect arcing downstream of any AC-DC converters. The project developed a system which is able to detect arcing downstream of a DC-DC converter to provided added safety over what is currently required by most electrical codes in the U.S.

Objectives:

1. Expand on existing literature search, to gather all available information on the topic
2. Design and build experimental set-up to simulate series, parallel, and ground arcs
3. Characterize spectral response of arcing behavior in current from DC power supply
4. Design, simulate and test arc detector to identify series, parallel, and ground arcs on both sides of the Smart DC Wall Plug
5. Consult with industry collaborators on design and practical considerations to ensure adoptability of the AFCI
6. Design and incorporate interrupter with arc detector to appropriately respond to arcing conditions
7. Test AFCI design to ensure it works under a wide-range of voltages, currents, load-types, and various conditions. Iterate on AFCI design based on prior testing

Benefits:

This project improved the reliability/quality of California's electricity by reducing service interruptions through expanded service options and new system-wide capabilities while also improving the energy cost/value of California's electricity by providing real-time information and a means to automatically respond to supply-side problems. This project also maximized market connection by reducing the installed cost of energy-related information, communication, and control technologies.

Title:	Porous Silicon-based Lithium Ion Anodes for Secondary Batteries				
Agreement Number:	500-01-043	**Project Number:**	18	**Research Stage:**	Applied Research
Electricity Funding:	$150,000	**Match Funding:**	$0	**Natural Gas Funding:**	$0
Start Date:	10/1/2013	**End Date:**	3/30/2015	**Technology Topic:**	Battery
Award Recipient:	The Regents of the University of California on behalf of the California Institute for Energy and Environment			**End-Market:**	Ratepayers

Description:

The research optimized the silicon (Si) etching process for lithium ion battery anodes, connections through which electric current flows in or out of a rechargeable battery, to increase the battery cycle life and capacity. The research team tailored the porous silicon etch process to enable the structure to withstand the repeated volume changes and stresses associated with charging and discharging the battery. The research team also developed a new method to chemically tailor a carbon-based coating on the porous silicon anode for optimal electrical conductivity and enhanced structural stability. The team then constructed and tested the performance of the anode materials and evaluated their behavior.

Objectives:

1. Optimize silicon etching conditions to optimize pore size (approximately 40nanometers [nm) and thickness (approximately 10 nm) of silicon pore walls, by etching single-crystal silicon wafers using electrochemical anodization in ethanolic hydrofluoric acid solutions
2. Develop new chemistry to tailor the carbon coating on porous silicon for optimal electrical conductivity and enhanced structural stability
3. Construct and test electrochemical properties of the anode materials in standard lithium ion half-cells
4. Use Analytical Transmission Electron Microscopy to study the electrode materials to fully characterize the surfaces and interfaces of the porous Si material in both powder and thin film forms
5. Test the performance of the anode materials in standard lithium ion half-cells using Electrochemical Impedance Spectroscopy
6. Evaluate behavior of anode materials in standard lithium ion half-cells in solid and polymer electrolyte junctions

Benefits:

This project improved the reliability/quality of California's electricity by reducing service interruptions through expanded service options and new system-wide capabilities while also improving the energy cost/value of California's electricity by providing real-time information and a means to automatically respond to supply-side problems. This project also maximized market connection by reducing the installed cost of energy-related information, communication, and control technologies.

Title:	Smart Power for the Smart House: Inverter Connections, Power Factor Corrections, and Peak Reductions				
Agreement Number:	500-01-043	**Project Number:**	19	**Research Stage:**	Applied Research
Electricity Funding:	$397,288	**Match Funding:**	$0	**Natural Gas Funding:**	$0
Start Date:	3/3/2014	**End Date:**	3/30/2015	**Technology Topic:**	Controllable/ Regulating Inverter
Award Recipient:	The Regents of the University of California on behalf of the California Institute for Energy and Environment			**End-Market:**	Ratepayers

Description:

This research developed an Active Power Factor Correction (APFC) Inverter to control the power factor in real time to reduce residential peak load, improving power factors, and advancing load monitoring technology in zero net energy (ZNE) homes. The APFC was tested along with wireless load monitoring hardware in a smart ZNE home in Davis, California. The compiled and analyzed smart home data was used to create a ZNE home baseline model for input into a feeder-level electrical grid model to simulate peak load reduction.

Objectives:

1. Develop and bench test APFC Inverter
2. Field evaluate APFC Inverter and Load Monitoring Tool in ZNE Residence
3. Perform load signature analysis for wireless monitoring and control
4. Perform parametric assessment of the grid benefits of APFC in combination with integrated mechanical design and control for peak shifting

Benefits:

This project improved the reliability/quality of California's electricity by reducing service interruptions through expanded service options and new system-wide capabilities while also improving the energy cost/value of California's electricity by providing real-time information and a means to automatically respond to supply-side problems. This project also maximized market connection by reducing the installed cost of energy-related information, communication, and control technologies.

Title:	Control of Networked Electric Vehicles to Enable a Smart Grid with Renewable Resources				
Agreement Number:	500-01-043	**Project Number:**	20	**Research Stage:**	Applied Research
Electricity Funding:	$400,000	**Match Funding:**	$0	**Natural Gas Funding:**	$0
Start Date:	3/3/2014	**End Date:**	3/30/2015	**Technology Topic:**	Distribution Management
Award Recipient:	The Regents of the University of California on behalf of the California Institute for Energy and Environment			**End-Market:**	Ratepayers

Description:

This research developed control technologies to leverage the aggregated energy storage capabilities of electric vehicles that are networked together to improve renewable generation reliability, support distributed system operation, and supply peak load demand and ancillary support to the grid. These objectives were achieved by using communication, computing, and control technologies for renewable resources, energy storage units, and networked electric vehicles (NEVs) management to enable a smart grid with renewable resources. NEVs are electric vehicles aggregated on a distribution grid to provide coordinated peak power support to increase power quality, greater grid stability, and reliability.

Objectives:

1. Develop a vehicle-to-grid system using CHAdeMO protocol.
2. Create a DER object to represent NEV within ISO/IEC 15118 and IEC 61850 protocols (with IEEE 1547 compliance).
3. Develop a charge and discharge device called the Grid and User-Friendly NEV Controller which is based on the existing WINSmartEV™ charging system.
4. Install a test PV solar unit and establish communication and control with the new DER object module and integrate it with the NEV controller.
5. Design a scalable open-architecture mesh network of NEVs based on WINSmartGrid™.
6. Design smart algorithms for charging and discharging of NEVs for peak shaving.
7. Develop optimal power flow (OPF) algorithms for volt-amperes reactive (VAR) control.
8. Develop distributed control based on OPF NEVs in the distribution system.

Benefits:

This project improved the reliability/quality of California's electricity by reducing service interruptions through expanded service options and new system-wide capabilities while also improving the energy cost/value of California's electricity by providing real-time information and a means to automatically respond to supply-side problems. This project maximized market connection by reducing the installed cost of energy-related information, communication, and control technologies.

Title:	Enabling Real-Time Residential Pricing with Closed Loop Customer Feedback				
Agreement Number:	500-01-043	**Project Number:**	21	**Research Stage:**	Applied Research
Electricity Funding:	$199,932	**Match Funding:**	$0	**Natural Gas Funding:**	$0
Start Date:	3/3/2014	**End Date:**	3/30/2015	**Technology Topic:**	Market (Rates)
Award Recipient:	The Regents of the University of California on behalf of the California Institute for Energy and Environment			**End-Market:**	Ratepayers

Description:

The proposed research developed a closed-looped customer feedback and cloud-based price control method to allow utilities to more accurately forecast future energy demands to better regulate customer pricing. This control method automatically provided real-time balancing of energy demand and generation. This objective was achieved by reconciling forecasted data with real power consumption and send real-time pricing information to the customer through mobile messaging (smartphone application). This solution was deployed with energy management and dynamic pricing solutions in cooperation with San Diego Gas & Electric (SDG&E).

Objectives:

1. Expand on existing literature search to gather all available information on the topic
2. Identify test sites and recruit consumers to take part in the research
3. Develop in-home display and energy management application
4. 4.Develop Cloud-to-Mobile Messaging application. Develop the cloud application for real time price computations based on demand elasticity
5. Integrate smart meter data into cloud application to close the loop in behavior monitoring and real time pricing. Deploy Application at selected consumer premises.
6. Analyze historical power consumption data provided by SDG&E California Green Button Data; this data is available with permission of the consumer in hourly intervals.
7. Test closed-loop, real-time pricing application at consumer premises in cooperation with SDG&E.

Benefits:

This project improved the reliability/quality of California's electricity by reducing service interruptions through expanded service options and new system-wide capabilities while also improving the energy cost/value of California's electricity by providing real-time information and a means to automatically respond to supply-side problems. This project maximized market connection by reducing the installed cost of energy-related information, communication, and control technologies.

Title:	Customer Premise Network Design, Cybersecurity Issue Identification and Simulations of DG Impacts on the Distribution System for the Benefit of California Investor Owned Utility Ratepayers				
Agreement Number:	500-09-039	**Project Number:**	1	**Research Stage:**	Technology Development
Electricity Funding:	$3,400,000	**Match Funding:**	$0	**Natural Gas Funding:**	$0
Start Date:	6/1/2010	**End Date:**	3/31/2015	**Technology Topic:**	Monitoring and
Award Recipient:	University Enterprises, Inc. (Auxiliary Organization to California State University, Sacramento)			**End-Market:**	Ratepayers

Description:

This project involved coordinating and performing research to enable a smart grid for statewide reliability and efficiency improvements through the following activities:

- Develop and establish mitigation algorithms to prevent significant events in the power grid and increase power flows.
- Develop and demonstrate smart grid technologies to increase communication and control in the power grid.
- Implement cybersecurity enhancements into smart grid equipment.
- Develop methods, standards and demonstrations to increase interoperability of smart grid technologies.

Objectives:

1. Create the California Smart Grid Center and identify the applied RD&D needs to solve practical and technical issues.
2. Engage in applied research, testing, demonstrations, and technology transfer of Smart Grid component technologies.
3. Facilitate practical solution development for the integration of smart grid infrastructure.
4. Conduct outreach efforts for a wide range of California stakeholders.
5. Provide, evaluate, quantify, and document the tangible benefits of Smart Grid Center activities to California ratepayers.

Benefits:

Key benefits of this research to California utilities included power protection schemes to allow the distribution system to effectively use localized renewable generation.

Title:	Renewable Resource Management at UCSD				
Agreement Number:	500-10-043	**Project Number:**	1	**Research Stage:**	Applied Research
Electricity Funding:	$2,994,298	**Match Funding:**	$1,964,644	**Natural Gas Funding:**	$0
Start Date:	6/20/2011	**End Date:**	3/31/2015	**Technology Topic:**	Forecasting
Award Recipient:	The Regents of the University of California, San Diego			**End-Market:**	Ratepayers

Description:

This project involved research in solar forecasting, distributed energy storage, microgrid observability by the California Independent System Operator (California ISO), and renewable energy for charging of electric vehicles. The forecasting research developed a better intra-hour forecast for solar photovoltaics. This was accomplished through devices that monitored cloud movement near large PV installations. The distributed energy storage research demonstrated an integrated solution that combined PV and battery energy storage to mitigate the intermittency of renewable generation. The microgrid observability research provided the California ISO with monitoring capability for University of California, San Diego's (UCSD) microgrid. A communication link was established between the California ISO and UCSD that provides full observability of the operation of the microgrid. The renewable charging of electric vehicle research demonstrated a direct current-linked charge port to maximize the use of renewable energy resources and reduce inverter losses.

Objectives:

1. Provide accurate intra-hour forecasting for solar generation.
2. Analyze the impact of photovoltaic (PV) and electric vehicles (EV) on microgrid voltages.
3. Demonstrate the ability of integrated PV and energy storage to smooth solar variability, reduce demand charge, and capture regulation value streams.
4. Facilitate deep situational awareness of the microgrid by the California ISO.
5. Show the feasibility of a DC linked renewable energy EV charge port with energy storage.

Benefits:

Benefits to ratepayers include greater reliability of solar renewable energy through improved solar forecasting as well as electric energy storage systems combined with solar PV technology, improved integration of renewable energy into the electrical grid, and reduced greenhouse gas emissions by using renewable energy resources for electric vehicle charging.

Title:	WindSENSE-Determining the Most Effective Equipment for the California ISO to Gather Wind Data for Forecasting				
Agreement Number:	500-11-010	**Project Number:**	1	**Research Stage:**	Technology Development
Electricity Funding:	$646,661	**Match Funding:**	$76,986	**Natural Gas Funding:**	$0
Start Date:	2/1/2012	**End Date:**	3/31/2015	**Technology Topic:**	Wind
Award Recipient:	The Regents of the University of California, Davis			**End-Market:**	Energy Suppliers

Description:

This project deployed atmospheric remote sensing systems at selected locations to assess the impact on the accuracy of short-term forecasts in the Tehachapi Wind Resource Area. The goal of this research was to help mitigate the problems and reduce the costs of integrating large amounts of wind-based electric power into the grid.

Objectives:

1. Determine whether atmospheric sensing equipment are a cost-effective way to gather data to improve short-term power prediction.
2. Determine the relative impact of the individual sensing equipment and the combined equipment on wind power forecast performance. (i.e., is most of the value in one sensor or the other or is there substantially more value in operating the combined equipment?)
3. Measure how much improvement in forecast performance can be achieved by the use of data from these sensors.
4. Determine what types of forecasts achieve the most and least impact from the measurement systems.
5. Determine whether the results (i.e., the identified best locations) of the DOE-sponsored observation targeting study provide effective guidance for the optimal deployment of sensors.
6. Identify the physical processes that cause wind ramp events in the Tehachapi Wind Resource Area.
7. Determine the physical processes that cause wind ramp events in the Tehachapi Wind Resource Area.

Benefits:

This project benefited California by addressing the California ISO's need for an effective way to collect data to create short-term wind forecasts. Creating accurate short-term wind forecasts help mitigate the problems and reduce the costs of integrating large amounts of wind-based electric power into the grid. Benefits included reduced dependency on fossil fuel imports, reduced greenhouse gas emissions, increased grid reliability and stability, and increased sources of renewable energy to help meet California's Renewable Portfolio Standard, which requires renewable energy resources to be 33% of total procurement by 2020.

Title:	Implementation of Demand Response in a University Campus				
Agreement Number:	500-11-013	**Project Number:**	1	**Research Stage:**	Applied Research
Electricity Funding:	$499,999	**Match Funding:**	$0	**Natural Gas Funding:**	$0
Start Date:	4/2/2012	**End Date:**	3/31/2015	**Technology Topic:**	Whole Building
Award Recipient:	The Regents of the University of California on behalf of the California Institute for Energy and Environment			**End-Market:**	Ratepayers

Description:

This project performed research on a new architecture design for AutoDR by interfacing UCLA's WINSmartGrid communications platform with OpenADR, creating a new AutoDR model based on this architecture, performing simulations on the AutoDR model, and conducted a field test in a University of California, Los Angeles residential campus dwelling.

Objectives:

1. Investigate, demonstrate, and quantify the potential for peak load reduction via an AutoDR research demonstration project in UCLA.
1. Research, create, and demonstrate AutoDR within the UCLA campus residential dwelling load.
2. Research, test, and evaluate the information and network interface between OpenADR platform from Lawrence Berkeley National Laboratory and WINSmartGrid platform from UCLA for demonstrating AutoDR.
3. Research and test the ability of the campus residential infrastructure using WINSmartGrid to support and carry AutoDR signals generated using OpenADR and the ability and effectiveness of these signals to reach the target loads and provide the desired peak load reduction via AutoDR.
4. Investigate and research scale-up of the campus demonstration DR architecture into that of the local utility (Los Angeles Department of Water and Power) infrastructure model.
5. Research and evaluate customer response and behavior to AutoDR programs.
6. Implement the Technology Transfer Plan.
7. Propose hypotheses for the success of AutoDR in campus residential dwelling loads and prove, disprove, or partially prove these hypotheses.

Benefits:

DR benefits include better grid balance, reduction in lost energy, and increase in grid efficiency. During peak demand on a hot summer's afternoon, a demand response signal is used to reduce the energy demand for short time periods so that the grid operator does not need to obtain electricity from economically and environmentally inefficient peaker plants. Offering DR capability to residential customers could result in substantial benefits to the grid operator, the consumer, society, and the environment.

Title:	Advanced Control Technologies for Distribution Grid Voltage and Stability with Electric Vehicles and Distributed Renewable Generation				
Agreement Number:	500-11-018	**Project Number:**	1	**Research Stage:**	Applied Research
Electricity Funding:	$1,535,725	**Match Funding:**	$0	**Natural Gas Funding:**	$0
Start Date:	6/30/2012	**End Date:**	3/30/2015	**Technology Topic:**	Smart Grid
Award Recipient:	Pacific Gas and Electric Company			**End-Market:**	Ratepayers

Description:

This project conducted computer simulations using CYME and GridLAB-D software to identify potential voltage issues on twelve PG&E distribution circuits as increasing amounts of distributed solar generation are added at different locations on each circuit. Potential solutions such as enabling smart inverters and voltage regulators to adjust the system voltage were also simulated to determine their effectiveness in resolving voltage violations.

Objectives:

1. Investigate system voltage and end-of-line issues and determine if they can be managed through centralized control distribution line equipment.
2. Identify significant issues directly related to high penetration levels of electric vehicles (EVs), solar photovoltaics (PVs), or distributed generation (DG).
3. Identify intermittency and variability and issues with EVs, PVs, and other DG.
4. Identify high/low voltage effects on utility customers caused by EVs and DG at higher penetration levels.
5. Identify mitigation measures that may be necessary to ensure that utility systems will operate safely and reliably.

Benefits:

Improved future distribution planning and operations. Research results included open source models that are available to the public through GridLAB-D's website. Developed techniques for analyzing the time-variant nature of solar PV and its interaction with system loads.

Title:	Distribution System Field Study with California Utilities to Assess Capacity for Renewables and Electric Vehicles				
Agreement Number:	500-11-019	**Project Number:**	1	**Research Stage:**	Applied Research
Electricity Funding:	$1,167,380	**Match Funding:**	$0	**Natural Gas Funding:**	$0
Start Date:	6/30/2012	**End Date:**	3/31/2015	**Technology Topic:**	Distribution Management
Award Recipient:	The Regents of the University of California on behalf of the California Institute for Energy and Environment			**End-Market:**	Ratepayers

Description:

Gathered existing distribution monitoring data from the three IOUs and SMUD, and used this information to develop accurate models and simulate increasing penetrations of distributed, renewable generation and electric vehicles on those circuits.

Objectives:

1. Coordinate the collection of empirical data by several California utilities on a representative sample of distribution circuits.
2. Analyze the data for critical information about the performance of different distribution circuits at different penetration levels of distributed generation and electric vehicles.
3. Extract and combine information from prior distribution circuit studies to build on existing knowledge and avoid duplication of effort.
4. Test, validate, and develop models of distribution circuits with high penetrations of distributed resources that capture interactive effects at high resolution.
5. Share results and conclusion with California utilities and the CAISO.

Benefits:

The project provided recommended practices for improving existing distribution monitoring systems so that higher penetrations of distributed resources can be accommodated on the distribution grid.

Title:	Underground Electric Cable Diagnostics: Miniaturize, Field Test, and Commercialize State of the Art Sensors				
Agreement Number:	500-11-021	**Project Number:**	1	**Research Stage:**	Technology Development
Electricity Funding:	$1,200,000	**Match Funding:**	$0	**Natural Gas Funding:**	$0
Start Date:	6/29/2012	**End Date:**	3/16/2015	**Technology Topic:**	Other
Award Recipient:	The Regents of the University of California on behalf of the California Institute for Energy and Environment			**End-Market:**	Energy Suppliers

Description:

The purpose of this project was to complete and commercialize diagnostic tools to determine the condition of underground electric cables. The project developed a patented “grabber” device that can identify failed or broken wires in underground cables, and a patented method to identify the presence of cable insulation break-down within underground cables.

Objectives:

1. Install previously developed sensor prototypes in the field and in the lab.
2. Run extended long-term testing for six or more months.
3. Collect long-term data from the sensors.
4. Develop techniques to assess cable integrity and devise means to improve the reliability of the sensors.
5. Research ways to miniaturize diagnostic sensors using micro- and nano-fabrication techniques.
6. Develop energy harvesting technologies for the purpose of self-powering the sensors.
7. Perform life-cycle analysis of the new sensors with the goal of achieving a 20-year life of the sensors.
8. Fabricate the new sensors in the Contract's state-of-the-art micro-/nano-fabrication facilities. Testing of the sensors will be in both laboratory and field environments.
9. Work with stakeholders such as the California IOUs, packaging/MEMS companies, and Agilent Technologies, to foster discussion of commercializing the sensors. Conduct design-for-manufacturing analysis to engineer and harden the sensors for widespread use.
10. Work with the stakeholders to develop a commercialization plan.

Benefits:

The project provided methods to improve safety and reliability and reduce unplanned outages by providing advance warning of possible underground electric cable failure.

Title:	Wind Firming EnergyFarm				
Agreement Number:	PIR-10-029	**Project Number:**	1	**Research Stage:**	Technology Demonstration
Electricity Funding:	$1,000,000	**Match Funding:**	$45,700,000	**Natural Gas Funding:**	$0
Start Date:	7/1/2011	**End Date:**	3/31/2015	**Technology Topic:**	Battery
Award Recipient:	Primus Power Corporation			**End-Market:**	Energy Suppliers

Description:

Primus Power Power's 25 MW/75 MWh energy storage system replaced a planned 25 MW fossil fuel plant required to compensate for the variable nature of wind energy and to provide load shifting capabilities. The primary application for the EnergyFarm™ was energy balancing. Secondary applications included targeted renewable firming and strategic local peak shaving, automated load shifting, ancillary services, reactive power compensation, and emissions reduction.

Objectives:

1. Trigger rapid adoption of grid storage systems in the U.S. by demonstrating a low-cost, robust and flexible EnergyFarm™
2. Accelerate adoption of renewable energy and enhance grid stability by firming the output of wind and solar farms
3. Demonstrate improved grid asset utilization by storing energy during off-peak periods for dispatch during local load peaks
4. Establish an advanced battery manufacturing industry in the U.S.
5. Reduce emissions and water usage by utilities

Benefits:

Benefits of the project included the creation of jobs and deployment of new storage technologies which will help customers more efficiently and effectively address renewables integration, transmission congestion, ancillary services, and transmission and distribution capital requirements. The project also facilitated the integration of intermittent renewable resources in a way that will help improve grid reliability and stability.

Title:	SMUD SCADA Retrofit				
Agreement Number:	PIR-10-034	**Project Number:**	1	**Research Stage:**	Technology Demonstration
Electricity Funding:	$1,000,000	**Match Funding:**	$307,591,845	**Natural Gas Funding:**	$0
Start Date:	6/1/2011	**End Date:**	3/31/2015	**Technology Topic:**	AMI/Smart Meters
Award Recipient:	Sacramento Municipal Utility District			**End-Market:**	Energy Suppliers

Description:

This project deployed a comprehensive regional smart grid solution built upon the installation and operation of an end-to-end smart grid that extends from the transmission system to the smart meters of all 600,000 SMUD customers. SMUD partnered with the State of California Department of General Services, California State University Sacramento, and the Los Rios Community College District.

Objectives:

1. Deploy Advanced Metering Infrastructure.
2. Assist in the recovery of vital data.
3. Create a fully automated distribution system for SMUD.

Benefits:

The project linked smart meters and home area networks with upstream, automated distribution operations; optimized distribution system operations to improve system reliability and efficiency; and, fully enabled customers to participate in the electricity marketplace by accelerating the introduction of dynamic pricing and demand response programs. The project accelerated and expanded the deployment of advanced smart grid technologies throughout the Sacramento region, created new jobs, preserved existing jobs, reduced customer energy costs, and reduced greenhouse gas emissions.

Title:	Flow Battery Solution to Smart Grid Renewable Energy Applications				
Agreement Number:	PIR-10-066	**Project Number:**	1	**Research Stage:**	Applied Research
Electricity Funding:	$476,428	**Match Funding:**	$9,052,139	**Natural Gas Funding:**	$0
Start Date:	9/1/2011	**End Date:**	12/31/2015	**Technology Topic:**	Battery
Award Recipient:	EnerVault Corporation			**End-Market:**	Ratepayers

Description:

This project demonstrated an iron-chromium redox flow battery system in combination with an intermittent, renewable energy source. The project used EnerVault's long duration system to reduce demand charges and enhance the performance of a 150kW peak, AC dual-axis tracking photovoltaic system to power a large 260 kW irrigation pump. The demonstration established the suitability of megawatt-hour scale, long duration energy storage systems to meet the safety, reliability, and cost requirements of distributed energy storage.

Objectives:

1. Demonstrate the commercial viability of EnerVault's novel redox flow battery energy storage system
2. Integrate 250kW / 1MW-hr system with a 150 kW AC dual axis photovoltaic system

Benefits:

Established a safe, reliable cost effective energy storage solution for enabling high penetrations of intermittent renewable energy on the utility grid.

Title:	Glendale Water & Power - Marketing. Public Benefits				
Agreement Number:	PIR-10-069	**Project Number:**	1	**Research Stage:**	Technology Demonstration
Electricity Funding:	$1,000,000	**Match Funding:**	$50,302,105	**Natural Gas Funding:**	$0
Start Date:	6/1/2011	**End Date:**	3/31/2015	**Technology Topic:**	AMI/Smart Meters
Award Recipient:	City of Glendale			**End-Market:**	Energy Suppliers

Description:

Glendale Water & Power installed 83,000 smart meters with large data storage capabilities and two-way communications hardware and software. The smart meters were connected through a wide area network to allow two-way communications between the utility and each meter. Additionally, the smart meters possess the capability to communicate with a home area network (HAN) to promote demand response, energy and water conservation, and dynamic pricing options.

Objectives:

1. Deploy smart meters.
2. Create customer interfaces for HANs.
3. Implement dynamic pricing.
4. Enable demand response program participation.
5. Provide information to help customers conserve energy and water.

Benefits:

The benefits include reduced peak demand, increased energy efficiency, improved grid reliability, and economized use of existing transmissions assets.

Title:	Smart Grid Demonstration Project				
Agreement Number:	PIR-11-009	**Project Number:**	1	**Research Stage:**	Technology Demonstration
Electricity Funding:	$1,000,000	**Match Funding:**	$119,560,000	**Natural Gas Funding:**	$0
Start Date:	6/25/2012	**End Date:**	5/31/2015	**Technology Topic:**	Total Energy
Award Recipient:	Los Angeles Department of Water & Power			**End-Market:**	Ratepayers

Description:

This project supported LADWP's Smart Grid Demonstration Program by developing the Chatsworth test bed, which was used in demonstrating demand response, electric vehicles, distribution automation, cybersecurity, and customer behavior studies.

Objectives:

1. Develop the Chatsworth test bed.
2. Demonstrate demand response.
3. Demonstrate adoption of electric vehicles and their impact.
4. Demonstrate distribution automation.
5. Demonstrate next-generation cybersecurity for the Advanced Metering Infrastructure.
6. Demonstrate customer behavior towards smart grid.

Benefits:

The project helped to improve LADWP's grid reliability and supported higher penetration of distributed generation resources and electric vehicles.

Title:	SGIG Distribution Infrastructure Substation Upgrades				
Agreement Number:	PIR-11-015	**Project Number:**	1	**Research Stage:**	Technology Demonstration
Electricity Funding:	$149,315	**Match Funding:**	$2,837,025	**Natural Gas Funding:**	$0
Start Date:	6/25/2012	**End Date:**	3/31/2015	**Technology Topic:**	Distribution
Award Recipient:	Modesto Irrigation District			**End-Market:**	Energy Suppliers

Description:

Modesto Irrigation District implemented a multi-stage smart grid deployment and installation project. The project included three phases.

- Meter purchase and installation in the Mountain House Development completed a full rollout of smart meters that began in 2009 for which the utility has already invested $20 million.
- Distribution grid upgrades to improve communication and better control over various aspects of the distribution level grid.
- Customer program development, including customer interface, cost of service and pricing studies, and customer outreach and education.

Objectives:

1. Smart meter purchase and installation, completing a full roll out of smart meters.
2. Distribution smart grid upgrades to improve communication and control.
3. Customer program development, including customer interface, cost of service and pricing studies, and customer outreach and education.

Benefits:

Benefits include optimized feeder voltage to minimum allowable levels for end-of-line customers, reduced feeder losses; deferred feeder upgrades due to overloads; economized use of capacitors; improved grid reliability; integrated renewable resources; and improved use of existing transmissions assets.

Title:	Smart Grid High Concentration Solar Photovoltaic Integration				
Agreement Number:	PIR-11-017	**Project Number:**	1	**Research Stage:**	Technology Demonstration
Electricity Funding:	$1,000,000	**Match Funding:**	$39,735,991	**Natural Gas Funding:**	$0
Start Date:	6/25/2012	**End Date:**	3/31/2015	**Technology Topic:**	AMI/Smart Meters
Award Recipient:	Burbank Water and Power			**End-Market:**	Energy Suppliers

Description:

The project demonstrated new smart grid technologies, including Insulated Gate Bipolar Transistor-based inverters. This project promoted the integration of distributed renewable energy resources into the electric grid, leading to improved reliability and stability, a more diverse generation portfolio, and greenhouse gas emission reductions. The system was installed in the City of Burbank.

Objectives:

1. Implement a full-scale smart grid.
2. Conserve water and electricity.
3. Implement distribution automation.
4. Deploy customer network interfaces.
5. Deploy electricity storage.
6. Promote integration of renewable resources.

Benefits:

The project demonstrated smart grid integration of new technologies that maximize the advancements made in concentrated photovoltaic cells, optics, and tracking systems; and inverters. Additionally, this project improved grid reliability, facilitated integration of renewable resources, and improved the use of existing transmission assets.

Title:	Advanced Underground CAES Demonstration Project Using a Saline Porous Rock Formation as the Storage Reservoir				
Agreement Number:	PIR-12-001	**Project Number:**	1	**Research Stage:**	Technology Demonstration
Electricity Funding:	$1,000,000	**Match Funding:**	$49,000,000	**Natural Gas Funding:**	$0
Start Date:	11/26/2012	**End Date:**	3/15/2015	**Technology Topic:**	Compressed Air
Award Recipient:	Pacific Gas and Electric Company			**End-Market:**	Energy Suppliers

Description:

The goal of this project was to demonstrate the viability of advanced, compressed air energy storage (CAES) technology utilizing a porous rock formation. This project established the costs and benefits of CAES, verified its technical performance, and validated system reliability and durability at a scale that can be readily adapted and replicated around the country.

Objectives:

1. Verify the technical performance of advanced CAES technology using a porous rock formation as the underground storage reservoir
2. Integrate intermittent renewable resources by using the CAES plant to provide ramping/regulation to steady the power fluctuations from load and intermittent renewable generation
3. Use the CAES plant to provide emergency spinning/non-spinning reserve (synchronous and non-synchronous)
4. Perform Volt-Amperes Reactive (VAR)/voltage support

Benefits:

The project study identified locations in California that may be suitable for a new CAES plant. This information was used in later phases of PG&E's DOE ARRA-funded project to select a potential demonstration site.

Title:	Peak Shaving with Flywheel Energy Storage Device				
Agreement Number:	PIR-11-010	**Project Number:**	1	**Research Stage:**	Applied Research
Electricity Funding:	$1,800,000	**Match Funding:**	$800,000	**Natural Gas Funding:**	$0
Start Date:	6/29/2012	**End Date:**	6/30/2015	**Technology Topic:**	Storage
Award Recipient:	Berkeley Energy Sciences Corporation			**End-Market:**	Industrial

Description:

This project demonstrated and verified the performance of Berkeley Energy Science Corporation's (BESC) novel flywheel energy storage technology. The system was used as a means of reducing demand and usage charges and doubled as an uninterruptable power supply.

Objectives:

1. Develop a multi-hour flywheel energy storage system with high round-trip efficiency and low coasting losses.
2. Test and demonstrate the performance of the multi-hour flywheel system.
3. Develop a manufacturing plan to achieve commercial cost targets.

Benefits:

This demonstration of two 40-kWh flywheel energy storage devices created an extensive data set to enable accurate characterization of system efficiency, power, kWh load shift capability, and total cost savings.

Title	Characterization of Wilmington Graben for Large Scale CO_2 Geologic Storage				
Agreement Number:	PIR-10-062	**Project Number:**	1	**Research Stage:**	Technology Development
Electricity Funding:	$500,000	**Match Funding:**	$9,100,604	**Natural Gas Funding:**	$0
Start Date:	5/14/2011	**End Date:**	3/31/2015	**Technology Topic:**	GHG Sequestration
Award Recipient:	Terralog Technologies			**End-Market:**	Energy Suppliers

Description:

The Pliocene and Miocene Formations in the Wilmington Graben were characterized and documented through a comprehensive research effort that included:

- Evaluation of existing two-dimensional and three-dimensional seismic data for the region, with some additional new data acquisition.
- Detailed evaluation of well logs from historical exploration wells in the area, compared with and tied to more extensive onshore well data.
- Drilling, coring, and testing new stratigraphic wells in the graben.
- Development of three- dimensional geologic models, geomechanical models, and CO_2 injection models.
- Comprehensive evaluation of storage capacity, seals, and risk assessment.
- Project documentation and interaction with DOE.

The Energy Commission funded the data evaluation, risk assessment, model development, project documentation, and technology transfer.

Objectives:

1. Provided improved evaluations and interpretations of existing and newly acquired seismic data within the Wilmington Graben.
2. Provided detailed log evaluations of previously drilled exploration wells in the area and tied existing seismic data to them for a better understanding of the geology throughout the graben.
3. Drilled and core two new evaluation wells, and deepen an existing well in the Wilmington Graben to test for Miocene sand continuity.
4. Developed 3D geologic models, geomechanical models, and CO2 injection and migration models for the region.
5. Provided risk assessment and characterization of the Wilmington Graben for large-scale CO2 storage.
6. Detailed review, quantification and documentation of the top 20 industrial sources of CO2 emission in the area.
7. Detailed engineering review and analysis of existing and new, potential pipeline and gas storage systems in the LA Basin.
8. Contribute data to both California-specific and national CO_2 sequestration investigations and greenhouse gas emission reduction efforts.

Benefits:

The project provided more data and understanding on the potential for CO_2 geologic storage in the Wilmington Graben to help reduce the area's CO_2 emissions by establishing and documenting the potential for more than 50 million tons of CO_2 storage in a high-need area.

Title:	Determining Best Location for Energy Storage to Maximize Effectiveness with Residential Renewable Generator Clusters				
Agreement Number:	500-11-006	**Project Number:**	1	**Research Stage:**	Technology Development
Electricity Funding:	$539,350	**Match Funding:**	$0	**Natural Gas Funding:**	$0
Start Date:	11/7/2011	**End Date:**	3/31/2015	**Technology Topic:**	Battery
Award Recipient:	San Diego Gas & Electric Company			**End-Market:**	Energy Suppliers

Description:

This project aimed to address operating challenges of renewable generation by installing and appropriately dispatching distributed energy storage systems to smooth variability in load and generation. Customer-owned solar photovoltaic (PV) systems were a focus of the project because their generation is variable and intermittent, and these systems are appearing on utility grids in increasing numbers. This project installed three controllable energy storage systems to explore strategies to improve distribution grid operations.

Objectives:

1. Develop criteria for the installation of distributed energy storage devices.
2. Install the energy storage devices on distribution feeders.
3. Develop techniques for managing and dispatching the devices.
4. Test the effectiveness of the devices in mitigating renewable generation intermittency.
5. Quantify additional benefits of the energy storage systems, such as peak shaving and reactive power support.

Benefits:

The project demonstrated that controllable energy storage devices installed on utility distribution systems can operate to enhance system stability and support renewable generation. The devices, which were installed at a utility test center, at a group of small commercial customers (a strip mall), and at a residence with a large solar photovoltaic system, successfully performed peak shaving, electricity arbitrage, 4-quadrant operation, PV smoothing, and other functions. The project also provided practical lessons to utility engineers on the feasibility of finding sites for this type of equipment. Once reliable remote operation of the devices had been achieved, the devices were successful at mitigating intermittent generation in numerous operational modes.

Title:	Electric Vehicle Charging Simulator for Distribution Grid Feeder Modeling				
Agreement Number:	500-11-007	**Project Number:**	1	**Research Stage:**	Applied Research
Electricity Funding:	$680,000	**Match Funding:**	$592,000	**Natural Gas Funding:**	$0
Start Date:	11/7/2011	**End Date:**	3/31/2015	**Technology Topic:**	Loading Monitor
Award Recipient:	San Diego Gas & Electric Company			**End-Market:**	Ratepayers

Description:

The goal of this project was to simulate the load and power quality effects of multiple electric vehicles charging on a distribution circuit. These hardware-based simulation activities help determine the impact of electric vehicles on grid performance and operation. The project also demonstrated an integrated approach to electric vehicle charging that incorporates renewable generation, battery energy storage, and controllable charging. This project consisted of two main activities: 1) the design and assembly of a state-of-the-art PEV charging simulator to model the impacts of electric vehicle charging on SDG&E's distribution grid in unprecedented detail, and 2) a small real-world demonstration site that includes PEV charging, stationary battery energy storage, and solar PV generation integrated with optimization controls.

Objectives:

1. Design a plug-in electric vehicle (PEV) charging simulator to be used for testing distribution grid arrangements.
2. Build a model of a typical electrical circuit with high PEV penetration.
3. Integrate the PEV simulator with the circuit model and conduct a series of tests to evaluate the impact of PEVs on a distribution circuit.
4. Conduct a real-world demonstration of the integration of PEVs with energy storage and renewable generation to evaluate the ability to offset charging load through optimized control.

Benefits:

The project developed a PEV charging simulator, a hardware-based real-time digital simulator (RTDS) that is at the cutting edge of power grid research, which produced valuable PEV grid impact data. The simulator's use of state-of-the-art transformer less inverters allows it to be used for modeling smart inverter impacts on the distribution grid; in this way, it exceeded original project expectations. The demonstration site provided valuable data on the various capabilities and efficacy of currently-available methods of mitigating the impacts of PEV charging.

Title:	Pacific Gas & Electric Energy Storage Demonstration				
Agreement Number:	500-09-027	**Project Number:**	1	**Research Stage:**	Technology Demonstration
Electricity Funding:	$3,300,000	**Match Funding:**	$8,000,000	**Natural Gas Funding:**	$0
Start Date:	6/15/2010	**End Date:**	3/31/2015	**Technology Topic:**	Battery
Award Recipient:	Pacific Gas and Electric Company			**End-Market:**	Ratepayers

Description:

PG&E demonstrated two sodium-sulfur battery energy storage systems: a two megawatt system at PG&E's Vaca-Dixon Substation and a four megawatt system at Hitachi Global Storage Technologies in San Jose. Both systems have more than six hours of energy storage capacity. The battery system in San Jose is currently the largest grid-connected battery in California and helped reduce the number of outages for the Hitachi facility. The battery system at the Vaca-Dixon substation helps smooth out the variability of the power generated by the nearby Vaca-Dixon solar photovoltaic (PV) plant, which produces up to two megawatts.

Objectives:

1. Install and monitor two large-scale, sodium-sulfur battery energy storage systems and document the experience, costs, schedule, performance, and lessons learned.
2. Demonstrate the use of the storage systems to enhance service reliability and power quality on the PG&E transmission and distribution system.
3. Demonstrate the use of the storage systems to enhance the value of wind and/or solar generation on the PG&E transmission and distribution system.
4. Compare the Vaca-Dixon and Hitachi storage systems to other sodium-sulfur battery energy storage system projects.
5. Transfer results and lessons learned via a workshop to California utilities to enable energy storage deployments in California.

Benefits:

The project helped mitigate the variability of a large PV system on a distribution circuit and improved the electric service to a large industrial customer at the end of a long distribution circuit. The project results also provided more real-world information about the performance of a large-scale, sodium-sulfur battery energy storage system at both a distribution substation and an industrial customer's facility that is valuable for other energy storage project developers.

Title:	Integrated Solar PV, Advanced Compressed Air Energy Storage, and Microgrid Demonstration Project				
Agreement Number:	PIR-12-004	**Project Number:**	1	**Research Stage:**	Applied Research
Electricity Funding:	$1,749,000	**Match Funding:**	$1,243,570	**Natural Gas Funding:**	$0
Start Date:	6/19/2013	**End Date:**	3/31/2015	**Technology Topic:**	Solar PV
Award Recipient:	Foresight Renewable Solutions			**End-Market:**	Ratepayers

Description:

This project demonstrated the cost-efficient integration of high penetrations of renewable energy within a given community using locally-available renewable energy resources while increasing the energy security of the community. The community for this project, the Mobile Utilities Support and Equipment Facility located at Naval Base Ventura County, deployed a 150 kW of solar photovoltaic into a community-based microgrid that included extant diesel back-up generation, energy storage, and mission-critical and routine operational loads. The storage options deployed included a 100 kW/1000 kW-hr vanadium redox flow battery funded by Energy Commission in addition to traditional lead-acid deep cycle batteries provided by the Navy. The VR and solar components were installed at the naval facilities in fall 2015. System shakedown and testing began in late November 2015. Foresight was not able to fully test the system during the project term but continued testing using its own funding through February 2015.

Objectives:

1. Design, develop, and deploy an innovative hybrid project that integrates 150 kilowatts (kW) of solar PV and a modular 100 kW/1000 kW-hr flow battery energy storage system with a microgrid serving the a community at Naval Base Ventura County.
2. Measure, analyze, and document the capital and operating costs of the hybrid project.
3. Verify round-trip efficiency of the vanadium-redox flow battery system of 75 percent or more while supporting the microgrid in both grid-connected and islanded modes.
4. Quantify various operational parameters in terms of power quality (voltage support, and frequency regulation), response time, and operational availability and runtime achievable in island mode.
5. Demonstrate and quantify cost savings to the MUSE facility and NBVC through displacement of utility electrical supply via renewable energy deployment, BESS-enabled load shifting, and peak shaving.

Benefits

One of the primary drawbacks of solar PV is that it is an intermittent resource that does not follow load during daylight hours when it is generating, and does not generate at all after dark. Successfully integrating PV into a microgrid that includes energy storage will enable a community to better match its generation to load by managing loads and by using storage to add or remove electricity to the microgrid to balance load as needed. This includes the ability to store excess electricity generation by day and shift to nighttime hours. Similarly, the ability of flow batteries to store electric power indefinitely affords the community the option of using solar energy as emergency back-up generation, offsetting the use of fossil fuels for that purpose. Energy costs are reduced via reduced consumption of grid electricity, especially during periods of high electricity prices, and via reduced demand charges achieved through peak shaving. Power quality will be improved by the rapid response of the microgrid to changing generation and loads to maintain voltage, frequency, waveform and other quality parameters. Increased reliance on solar will reduce the consumption of fossil fuels and the emission of priority pollutants and greenhouse gases produced thereto. Integrating energy storage in a microgrid that includes intermittent solar electric generation will mitigate the effects of intermittency and unpredictable ramping behavior of solar electric generation on the microgrid. Solar electric generation will partially replace generation currently supplied by a diesel generator. Energy storage will enable Navy Engineering and expeditionary Warfare Center to continue to operate during periods when commercial power becomes unavailable, including outages that may occur due to acts of war.

Title:	Analysis of Forest Biomass Removal on Biodiversity				
Agreement Number:	500-09-031	**Project Number:**	1	**Research Stage:**	Applied Research
Electricity Funding:	$1,149,361	**Match Funding:**	$0	**Natural Gas Funding:**	$0
Start Date:	6/1/2010	**End Date:**	3/31/2015	**Technology Topic:**	Forestry
Award Recipient:	USDA Forest Service, Sierra Nevada Research Center, Pacific Southwest			**End-Market:**	Energy Suppliers

Description:

Bioenergy systems in forested areas rely on biomass residue harvested from the ground. This study examined the effects of different types and impacts of biomass harvest, also known as fuel reduction treatment, in conifer forests on the vertebrate biological diversity. In addition, this research examined impacts of fuels treatments, as currently applied within the Sierra Nevada, on bird and small mammal communities.

Objectives:

1. Determine stand-scale responses of songbirds and small mammals to different intensities of fuels reduction treatments.
2. Compare responses of songbirds and small mammals to other forest management objectives, such as reducing surface and ladder fuels and the risk of crown fire.
3. Determine how different landscape management scenarios would affect the proportion of the landscape that provides suitable habitat for various species of songbirds and small mammals that represent different life history characteristics and habitat needs.

Benefits:

Wildlife response to fuels treatments was studied at two locations that spanned a diversity of forest types and featured fuels treatments of markedly different intensities. The research shows that both bird and small mammal communities are likely to benefit modestly from more widespread fuel treatments. Ratepayer benefits from this study are that forest fuel thinning and harvesting can be conducted without adversely affecting the diversity or abundance of these wildlife communities.

Title:	Air Quality Implications of Electrification and Renewable Energy Options				
Agreement Number:	500-09-040	**Project Number:**	1	**Research Stage:**	Policy/Regulation Support
Electricity Funding:	$835,711	**Match Funding:**	$0	**Natural Gas Funding:**	$0
Start Date:	6/7/2010	**End Date:**	3/31/2015	**Technology Topic:**	Criteria Pollution Emissions
Award Recipient:	Advanced Power and Energy Program - University of California, Irvine			**End-Market:**	Policymakers/ Regulators

Description:

The goal of this project was to:

- Identify and analyze renewable power implementation scenarios with enabling technologies and demand response strategies that can maintain system reliability and substantially improve air quality and reduce greenhouse gas emissions in California; and,
- Explore reducing emissions of criteria pollutants and greenhouse gases (GHG) to meet future health- based federal air quality standards and GHG targets in California through increased electrification.

This project identified and analyzed renewable power implementation scenarios with enabling technologies and demand response strategies that can maintain system reliability and optimize the impact on air quality and greenhouse gas emissions in California. The project also identified and analyzed electrification scenarios that:

- Reduce emissions of GHGs to meet California targets.
- Pollutant levels in the SCAQMD and SJVAPCD that meet the federal Clean Air Act standards by 2023 and 2032

Objectives:

1. Review existing relevant literature and previous studies.
2. Organize and conduct stakeholder interviews and a workshop focused on coordination with current and previous efforts including at the California Energy Commission (Energy Commission) and National Renewable Energy Laboratory (NREL).
3. Develop future more renewable grid implementation scenarios (detailed electric sector modeling)
4. Develop electrification scenarios.
5. Spatially and temporally allocate emissions from each scenario.
6. Simulate air quality impacts of each scenario with a detailed atmospheric chemistry and transport model Develop life cycle GHG emissions inventories for each scenario

Benefits:

Project results provided decision makers and regulations with rigorous and scientifically sound determination of the air quality impacts of installing and operating renewable power and the required complementary resources to meet California RPS goals; and implementation of electrification.

Electrification is seen as one of the key components to both improving air quality in the South Coast and San Joaquin Valley Air Management Districts and meeting state GHG reduction goals. The South Coast has made it a priority to promote electrification in both stationary and mobile applications.

Several scenarios for high renewable use and end-use electrification were developed for the years 2020, 2030, and 2050. Results show that decarbonizing the power sector without electrifying end-use sectors reduces greenhouse gas emissions only by up to 6 percent, while electrification of end-use sectors alongside with decarbonizing electricity generation yields up to 33 percent greenhouse gas emissions reductions compared to 1990 levels. Air quality impacts are mixed. In some scenarios, when both the electric power generation and electrified end-uses are highly dynamic, the criteria pollutant emissions dynamics lead to worse air quality, while in other cases (e.g., when smart grid and smart EV charging are widely used) air quality improvements are concomitant with greenhouse gas emissions reductions.

Title:	Use of Habitat Suitability Models and Head-Start Techniques to Minimize Conflicts Between Desert Tortoises and Energy Development Projects in the Mojave Desert				
Agreement Number:	500-10-020	**Project Number:**	1	**Research Stage:**	Applied Research
Electricity Funding:	$238,310	**Match Funding:**	$46,000	**Natural Gas Funding:**	$0
Start Date:	11/1/2010	**End Date:**	3/31/2015	**Technology Topic:**	Fauna
Award Recipient:	The Regents of the University of California, Davis			**End-Market:**	Policymakers/ Regulators

Description:

This research produced a habitat suitability model for desert tortoises in the Mojave Desert region of California that included new data on the habitat use of juvenile desert tortoises studied and to determine the effectiveness of head-starting as an augmentation tool for reversing declines of the desert tortoise, caused in part by the expansion of renewable energy development within their geographic range.

Objectives:

1. Produce a habitat suitability model for desert tortoises in the Mojave Desert region of California that includes new data on the habitat use of juvenile desert tortoises studied under the terms of this agreement.
2. Determine the effectiveness of head-starting as an augmentation tool for reversing declines of the desert tortoise, including quantifying the increase in growth or survival that arises from captive head-starting as compared to natural growth and survival of direct released animals at hatching.

Benefits:

This research will help meet the goals of maximizing sustainability while minimizing environmental costs. First, the development or enhancement of habitat suitability models that delineate the distribution and habitat use of special-status species can inform sustainable site selection of planned facilities to minimize their impacts on these species or populations. Second, the establishment or refinement of mitigation strategies and protocols can help ensure persistence of special-status species in suitable areas in a manner that may offset negative impacts to local populations due to energy site installations.

Title:	The Projected Effects of Climate Change Induced Changes in Vegetation on Future Hydrologic Energy Generation in California				
Agreement Number:	500-10-045	**Project Number:**	1	**Research Stage:**	Applied Research
Electricity Funding:	$600,000	**Match Funding:**	$0	**Natural Gas Funding:**	$0
Start Date:	6/30/2011	**End Date:**	3/31/2015	**Technology Topic:**	Climate Change Adaptation
Award Recipient:	University of California, Santa Barbara			**End-Market:**	Policymakers/ Regulators

Description:

Relatively little is known about the extent to which feedbacks between fire and invasive species may alter natural fire regimes and long term trends in vegetative cover and hydrologic cycling in California due to climate change. This project made improvements to watershed-scale models for managers of hydroelectric facilities.

Objectives:

1. Characterize representative watersheds in the Sierra Nevada Mountains and coastal southern California for vegetation analysis and application of eco-hydrology models.
2. Quantify the degree to which fire, invasive species and climate change play a role in vegetation type conversion in these environments.
3. Examine sensitivity of stream flows, nutrient dynamics and hydropower generation to vegetation characteristics and climate variability.

Benefits:

The complex feedbacks between fire and invasive species may alter natural fire regimes and long term trends in vegetative cover and hydrologic cycling in California due to climate change. A greater understanding of these issues will improve the ability of water managers to predict the effects of land cover and climate change on the availability of water for hydropower operations. These issues will become more critical as climate change affects both water supplies and occurrence of wildfire.

Title:	Hyperlight™ Low-Cost Solar Thermal Technology				
Agreement Number:	500-10-063	**Project Number:**	1	**Research Stage:**	Technology Demonstration
Electricity Funding:	$1,000,000	**Match Funding:**	$447,175	**Natural Gas Funding:**	$0
Start Date:	6/30/2011	**End Date:**	3/30/2015	**Technology Topic:**	Solar Thermal
Award Recipient:	Combined Power Cooperative (formerly Advanced Lab Group Cooperative)			**End-Market:**	Energy Suppliers

Description:

This project developed an innovative utility-scale solar energy technology that resulted in significantly lowered facility footprint, land impact, and freshwater consumption. The system was installed at the Center for Energy Sustainability at San Diego State University in Brawley, California. Eight full-scale Hyperlight™ modules were tested and electricity was generated by the system.

Objectives:

1. Increase the size of the Hyperlight™ demonstration units
2. Improve system thermal efficiency from 17% to 30%
3. Reduce evaporative water loss to less than 10%
4. Validate predictive cooling model

Benefits:

Results indicate better than 30% solar to thermal energy efficiency in conversion of input light to usable heat for the system, exceeding project targets. A predictive cooling model was generated and validated. The results of this project suggest that Hyperlight™ has potential to reduce the solar field costs, and therefore reduce land impacts of CSP, but that innovative use of the system's water support structure is not likely to reduce water usage of CSP. Hyperlight™ technology has even lower land requirements than conventional linear Fresnel technology because it can space the mirrors closer together and is lower cost due to lower cost materials. This allows greater usage of disturbed and developed lands to expand site selection options. Because of the lower cost, smaller projects can be built on small parcels of land. This will increase opportunities to avoid undisturbed habitats and large areas of remote and environmentally sensitive desert lands, as are currently needed for large-scale solar developments.

Title:	Economically and Environmentally Viable Strategies for Conversion of Bio-resources to Power				
Agreement Number:	500-11-028	**Project Number:**	1	**Research Stage:**	Policy/Regulation Support
Electricity Funding:	$397,236	**Match Funding:**	$0	**Natural Gas Funding:**	$0
Start Date:	6/29/2012	**End Date:**	3/31/2015	**Technology Topic:**	Biomass
Award Recipient:	Advanced Power and Energy Program - University of California, Irvine			**End-Market:**	Policymakers/ Regulators

Description:

The goal of this project was to quantify the energy and environmental impacts of increased biomass electricity generation, and the generation and utilization of transportation fuels derived from biogas in California with an emphasis on air quality improvement and economic viability. The project characterized air quality, greenhouse gas, fossil fuel consumption and economic implications of increased biomass and biogas usage for several electricity generation, heat, and transportation fuel strategies. It also assessed the potential implementation of new bioenergy infrastructure to inform preferred uses and strategies for a set of California renewable resources. The analysis quantified the emissions of criteria pollutants for several biomass and biogas technology supply chain and utilization scenarios. The resulting emissions were spatially and temporally resolved and used in air quality modeling to account for atmospheric chemistry and transport to determine the overall air quality impacts of the new biopower infrastructure.

Objectives:

1. Characterize system implications of increased biomass and biogas usage for several electricity generation, heat generation, and transportation fuel strategies.
2. Evaluate air quality, greenhouse gas, fossil fuel consumption and economic implications.

Benefits:

The study evaluated the potential to convert biomass and biogas resources into electric power and transportation fuels in California as well as the air quality impacts. The project provided insight into the best feasible technology for biomass and biogas use, to facilitate developing California’s future biopower infrastructure.

Title:	Air Quality Issues Related to Using Biogas from Anaerobic Digestion of Food Waste				
Agreement Number:	500-11-030	**Project Number:**	1	**Research Stage:**	Applied Research
Electricity Funding:	$164,201	**Match Funding:**	$0	**Natural Gas Funding:**	$0
Start Date:	6/29/2012	**End Date:**	3/30/2015	**Technology Topic:**	Biogas
Award Recipient:	California State University, Fullerton			**End-Market:**	Policymakers/ Regulators

Description:

Biogas is the main desirable product from anaerobic digestion of food waste. The quality and quantity of biogas will be affected by many parameters including pH, temperature, food composition, loading rate, mixing condition, reactor design, and retention time. This project collected biogas data to generate scientific information needed to more accurately estimate emissions from anaerobic digesters. A literature review on anaerobic digestion of food waste, biogas generation, and beneficial uses of biogas was conducted. Field data were collected from a wastewater treatment plant that employs anaerobic digestion of fats, oils, and grease, food waste, and wastewater sludge and uses an internal combustion engine to generate biopower using the biogas.

Objectives:

1. Develop the scientific information needed to more accurately estimate emissions from anaerobic digesters that use food waste.
2. Develop scientific information needed for conditioning/pretreatment of raw biogas.
3. Develop the scientific information needed to support the air quality permitting process for this type of anaerobic digester in the future

Benefits:

Meeting air emission requirements is paramount to the successful implementation of any biopower project in California. Scientific information on air quality of biogas from anaerobic digesters treating food waste and the emissions from beneficial uses of this type of biogas is very scarce.

The findings from this study shows:

- Additional volatile solids in fats, oils, and grease (FOG) and food waste increases the biogas production.
- Hydrogen sulfide was the dominant reduced sulfur compound in the raw biogas.
- The combustion engine emission data showed that NOx concentrations (at 15 percent oxygen) in the exhausts using natural gas and biogas were essentially the same. The average carbon dioxide, carbon monoxide and sulfur dioxide emission from using biogas is higher.

Title:	Measure of Carbon Balance in California Deserts: Impacts of Widespread Solar Power Generation				
Agreement Number:	500-11-033	**Project Number:**	2	**Research Stage:**	Applied Research
Electricity Funding:	$164,879	**Match Funding:**	$0	**Natural Gas Funding:**	$0
Start Date:	6/29/2012	**End Date:**	3/31/2015	**Technology Topic:**	Land Use
Award Recipient:	The Regents of the University of California on behalf of the California Institute for Energy and Environment			**End-Market:**	Policymakers/ Regulators

Description:

Large-scale solar development in the desert is a significant source of renewable energy with no or little carbon emissions. Large stores of carbon however, are buried in desert soils that can be exposed and released into the atmosphere when disturbed for utility scale solar energy development; partially offsetting the carbon reduction benefits of this renewable energy technology. This UC Riverside project assessed the capability of California desert soils to release large amounts of stored inorganic carbon into the atmosphere

Objectives:

The objectives of this research were to provide a comparative measure of the natural dynamics and storage of organic and inorganic carbon in desert soils and how these factors were affected by such conditions as vegetation removal and varying levels of soil moisture, soil temperature and atmospheric carbon.

Benefits:

The research shows that avoiding sensitive soil and vegetation areas when siting large scale solar energy facilities in the California desert can avoid releasing large amounts of carbon into the atmosphere, otherwise potentially offsetting some of the benefits of this technology.

Title:	Assessment of Offshore Wind Development Impacts on Marine Ecosystems				
Agreement Number:	500-11-033	**Project Number:**	4	**Research Stage:**	Applied Research
Electricity Funding:	$153,017	**Match Funding:**	$0	**Natural Gas Funding:**	$0
Start Date:	6/29/2012	**End Date:**	3/31/2015	**Technology Topic:**	Wind (offshore)
Award Recipient:	The Regents of the University of California on behalf of the California Institute for Energy and Environment			**End-Market:**	Energy Suppliers, Policymakers/ Regulators

Description:

California possesses significant off-shore wind resources; the environmental effects of developing this resource however, are poorly understood. The purpose of this UC Los Angeles project was to use a high-resolution regional climate model to investigate the atmospheric effects on marine weather and climate of an offshore wind farm near the San Francisco Bay area.

Objectives:

The researchers developed an advanced wind farm simulation model that describes the flow distortion from wind farm operation and is operated within a regional atmospheric model. This model was compared with regional coastal climate information, such as wind speed, air temperature and turbulence from existing weather data sources to ensure realistic, high-resolution simulations of the wind farm effects on the atmosphere.

Benefits:

This research benefits California ratepayers by showing that large scale wind energy development off the state's coastline may increase moisture, cloudiness and precipitation, improving our understanding of atmospheric effects of developing this resources.

Title:	Evaluation of a Passive Acoustic Monitoring Network for Harbor Porpoises in California				
Agreement Number:	500-11-033	**Project Number:**	5	**Research Stage:**	Applied Research
Electricity Funding:	$149,815	**Match Funding:**	$0	**Natural Gas Funding:**	$0
Start Date:	6/29/2012	**End Date:**	3/31/2015	**Technology Topic:**	Wind (offshore)
Award Recipient:	The Regents of the University of California on behalf of the California Institute for Energy and Environment			**End-Market:**	Energy Suppliers

Description:

California has significant wave energy resources along the California coast. Harbor porpoises, a protected species, occupies near shore areas along the California cost and may be adversely affected by wave energy development. Monitoring of this species is necessary prior to such development to assess effects and to select sites where effects to this marine mammal are minimal. This San Jose State University project established and evaluated a passive acoustic monitoring network for harbor porpoise in California.

Objectives:

To assess such a monitoring network, the researchers deployed acoustic monitoring devices in the Northern Monterey Bay and compared the two years of collected detection data with information collected from aerial surveys of the area. The researchers found that a passive acoustic monitoring network is an improvement over the traditional visual surveys due to increased temporal sampling. They also developed guidelines for development of the optimal spatial and temporal sampling scales for an effective acoustic monitoring network.

Benefits:

Ratepayer benefits from this project include development of effective monitoring methodology that will be directly applicable to monitoring, assessment, and mitigation for future wave energy development mooring designs, documenting the temporal and spatial variability in harbor porpoise distributions, and provided guidelines for future passive acoustic monitoring network development. Approaches will be directly applicable to monitoring, assessment, and mitigation during future MRE development confirming the feasibility of passive acoustic monitoring over traditional aerial surveys and evaluated the optimal spatial and temporal sampling scales for an effective monitoring network

Title:	Development of an Environmental Impact Assessment Tool for Wave Energy				
Agreement Number:	500-11-033	**Project Number:**	6	**Research Stage:**	Applied Research
Electricity Funding:	$165,000	**Match Funding:**	$0	**Natural Gas Funding:**	$0
Start Date:	6/29/2012	**End Date:**	3/31/2015	**Technology Topic:**	Wave Power
Award Recipient:	The Regents of the University of California on behalf of the California Institute for Energy and Environment			**End-Market:**	Energy Suppliers

Description:

California has significant wave energy resources along the California coast. Development of this resource, however may adversely affect near shore environments. This San Diego State University project developed an assessment tool to evaluate the effects of altering near shore wave-driven processes due to wave energy development along the California coast.

Objectives:

The researchers assessed a variety of existing computational models, each having a particular physical basis, such as wave models to describe wave creation and propagation and sediment models to show sediment movement and deposition. These and other models were coupled within the Wave Energy Environmental Assessment Tool, which was then applied to a case study off the coast of San Diego. This case study showed that the effect of a wave farm on suspended sediment movement is very small.

Benefits:

Benefits from the development of this wave energy assessment tools is that it can provide a consistent approach to determine the environmental effects of this technology across different wave energy conversion technologies, siting and ocean conditions.

Title:	Development of a Modeling Tool to Assess and Mitigate the Effects of Small Hydropower on Stream Fishes in a Changing California Climate				
Agreement Number:	500-11-033	**Project Number:**	7	**Research Stage:**	Applied Research
Electricity Funding:	$0	**Match Funding:**	$0	**Natural Gas Funding:**	$0
Start Date:	6/29/2012	**End Date:**	3/31/2015	**Technology Topic:**	Fish Passage
Award Recipient:	The Regents of the University of California on behalf of the California Institute for Energy and Environment			**End-Market:**	Policymakers/ Regulators

Description:

While California has significant resources remaining suitable for small hydropower development, the environmental effects of this may constrain future development. This UC Davis project developed an integrated modeling framework consisting of a watershed hydrology model and a fish habitat model to assess the impacts of small hydropower plants on freshwater fish in California.

Objectives:

The researchers developed and tested a model designed to function seamlessly within an integrated modeling framework that includes both a watershed hydrology and water management model, and a fish habitat suitability model. The integrated model was designed to be easily modified for different watersheds and fish populations, and can be used to assess environmental effects of numerous small hydropower projects in more than one watershed simultaneously.

Benefits:

The anticipated future impact of this project will be that small hydropower producers will be able to more efficiently mitigate effects on California stream fishes, thereby also minimizing unnecessary curtailment of hydropower production. This project will lay the groundwork for future efforts to assess trade-offs between water use providing freshwater habitat for native fish populations, and the cost-efficient provision of water to small hydropower installations.

Title:	Assessment of the Potential Environmental Impacts of Alternative Energy Scenarios for California				
Agreement Number:	500-11-033	**Project Number:**	8	**Research Stage:**	Applied Research
Electricity Funding:	$0	**Match Funding:**	$0	**Natural Gas Funding:**	$0
Start Date:	6/29/2012	**End Date:**	3/31/2015	**Technology Topic:**	Other
Award Recipient:	The Regents of the University of California on behalf of the California Institute for Energy and Environment			**End-Market:**	Policymakers/ Regulators

Description:

As California strives to meet its greenhouse gas emission and renewable energy goals, it is important to understand the environmental consequences of different pathways to reaching these goals. This UC Berkeley project developed a tool to identify potential environmental issues associated with different energy development scenarios, including land-use and air-quality impacts.

Objectives:

This project estimated different potential environmental implications based upon energy scenarios developed using the Solar, Wind, Hydro, and Conventional Generation and Transmission Investment (SWITCH) model to estimate, at the highest possible level of geographic resolution. Environmental effects addressed included land use, air quality water demand as well examining potential biomass locations.

Benefits:

Ratepayer benefits from this study include identifying the need to clearly delineate the environmental costs and benefits associated with different approaches to California meeting its greenhouse gas emission and renewable energy goals.

Title:	Investigation of Discrepancies in Regional Climate Projections for California				
Agreement Number:	500-12-001	**Project Number:**	1	**Research Stage:**	Applied Research
Electricity Funding:	$300,000	**Match Funding:**	$0	**Natural Gas Funding:**	$0
Start Date:	2/1/2013	**End Date:**	2/1/2015	**Technology Topic:**	Climate Change
Award Recipient:	The Regents of the University of California, San Diego			**End-Market:**	Policymakers/ Regulators

Description:

This project investigated the causes of discrepancies in regional climate projections for California. This work assisted with energy forecasting and planning.

Objectives:

1. Compare outputs from statistical and dynamic regional climate models.
2. Investigate large-scale control of future precipitation over California.
3. Explore the simulation of aerosols in regional climate models.

Benefits:

The research team developed the first version of a new downscaling technique known as LOCA under this Agreement. In addition, they analyzed the field data collected for CALWATER and showed that including an improved representation of the interactions of aerosols and clouds could substantially improve regional climate models, but more work is needed.

Title:	Aerial Line Transect Surveys for Golden Eagles within the Desert Renewable Energy Conservation Plan Area				
Agreement Number:	500-12-005	**Project Number:**	1	**Research Stage:**	Applied Research
Electricity Funding:	$200,000	**Match Funding:**	$0	**Natural Gas Funding:**	$0
Start Date:	6/14/2013	**End Date:**	3/31/2015	**Technology Topic:**	Avian Impacts
Award Recipient:	Humboldt State University Sponsored Programs Foundation			End-Market:	Policymakers/ Regulators

Description:

This project estimated the abundance and age structure of golden eagles within the Desert Renewable Energy Conservation Plan area and southwestern Imperial County during the early breeding season and during the post-fledging period. The surveys provided unbiased estimates of the size of the golden eagles population within the study area and provide a baseline for detecting trends in the population over time.

Objectives:

1. Establish unbiased aerial line-transect surveys across a study area of sufficient length to obtain accurate estimates of the golden eagle population.
2. Estimate the survey effort needed to obtain accurate estimates of the golden eagle population in the study area on future surveys.
3. Estimate the proportion of golden eagles detected within the two kilometer-wide line transects during the early breeding and post- fledging surveys.
4. Compare the accuracy of estimates using the previously established protocol for golden eagle aerial surveys and a Bayesian approach that uses information from previous surveys and from those conducted in the DRECP area.

Benefits:

The researchers flew aerial surveys in 2013 over the Desert Renewable Energy Conservation Plan area and tested an accepted survey methodology. The research team found that additional efforts or a different survey design is needed to obtain the needed level of precision. This project will provide a greater understanding of golden eagle populations within the Desert Renewable Energy Conservation Plan (DRECP) area, facilitating effective balance of eagle conservation and renewable energy development within the DRECP.

Title:	Research to Improve Golden Eagle Management in the Desert Renewable Energy Conservation Planning Area				
Agreement Number:	500-12-007	**Project Number:**	1	**Research Stage:**	Applied Research
Electricity Funding:	$314,000	**Match Funding:**	$14,700	**Natural Gas Funding:**	$0
Start Date:	6/21/2013	**End Date:**	3/31/2015	**Technology Topic:**	Avian Impacts
Award Recipient:	US Geological Survey			**End-Market:**	Policymakers/ Regulators

Description:

This project researched Golden Eagle population dynamics in the desert and the potential impacts of wind and other energy development on that population in order to help achieve Desert Renewable Energy Conservation Plan goals.

Objectives:

1. Develop monitoring guidelines to ensure future surveys and monitoring efforts provide a statistically robust methodology to assess Golden Eagle population dynamics.
2. Conduct surveys to identify Golden Eagle nesting sites and to assess prey availability and the habitat necessary for the prey to determine effects of renewable energy development on the Golden Eagle.

Benefits:

The researchers developed monitoring guidelines for surveys and conducted survey to identify Golden Eagle nesting sites which will inform future renewable energy projects. This project will provide a greater understanding of golden eagle populations within the Desert Renewable Energy Conservation Plan, facilitating effective balance of eagle conservation and renewable energy development within the DRECP.

Title:	Population Viability and Restoration Potential for Rare Plants Near Solar Installations				
Agreement Number:	PIR-10-047	**Project Number:**	1	**Research Stage:**	Applied Research
Electricity Funding:	$753,100	**Match Funding:**	$149,885	**Natural Gas Funding:**	$0
Start Date:	11/22/2010	**End Date:**	3/23/2015	**Technology Topic:**	Flora
Award Recipient:	BMP Ecosciences			**End-Market:**	Energy Suppliers

Description:

The overarching goal of this project was to provide Energy Commission and other agency staff, renewable energy developers and other stakeholders information on the population viability of a number of special status plant species likely to be impacted by utility scale solar energy development in the Mojave and Colorado Deserts. This project was a significant first step to improving the understanding of rare desert plants and reducing the impacts of future energy development on these important public resources in the Mojave and Sonoran Deserts of California. Field, laboratory, and modeling methods were applied to fill important information gaps in the ecology and conservation of rare plants. These gaps are major impediments to deploying large-scale renewable energy developments.

Objectives:

1. Identify a representative suite of six to eight target plant taxa of special status or conservation concern (including listed taxa if possible)
2. Identify and characterize two to three occupied natural study populations of each target taxon
3. Collect four years of field demographic data to parameterize population viability models for each target taxon. Complete demographic data collection will include experiments to determine rates of seed dormancy, a seldom-studied yet essential model component
4. Develop and interpret PVA models for each of the target taxa, including estimation of extinction threshold subpopulation size and its associated expressions as generated by a sensitivity analysis that links population viability to levels of project impact

Benefits:

Project results will provide information on population viability for rare plant taxa that may be impacted by utility scale solar energy development in the Mojave and Sonoran Deserts of California. Models used the information collected by these studies to predict the likelihood of local extinction or persistence, reveal sensitivities to environmental change, and understand the factors that affect population trends. From these efforts, 19 recommendations were offered to improve conservation and mitigation actions for rare plants in relation to utility-scale solar energy development in the California deserts.

Title:	Effect of Utility-Scale Solar Development and Operation on Desert Kit Foxes				
Agreement Number:	PIR-11-012	**Project Number:**	1	**Research Stage:**	Applied Research
Electricity Funding:	$606,257	**Match Funding:**	$29,710	**Natural Gas Funding:**	$0
Start Date:	6/29/2012	**End Date:**	3/1/2015	**Technology Topic:**	Fauna
Award Recipient:	Randel Wildlife Consulting, Inc.			**End-Market:**	Energy Suppliers

Description:

This research quantified the effects utility-scale solar facility construction and operations have on the home ranges and movements of desert kit foxes and provide a scientific baseline for guidance in assessing, mitigating, and evaluating utility-scale solar development impacts on the desert kit fox.

Objectives:

1. Quantify the effects of utility-scale solar facility construction and operations have on the home range and movements of desert kit foxes.
2. Provide a scientific baseline for developing guidelines to evaluate utility-scale solar development impacts on the desert kit fox

Benefits:

Researchers fitted 56 desert kit foxes with mortality-sensitive radio collars in the Upper Chuckwalla Valley of California. Results provide baseline life history data for future energy development. This research will help lessen barriers and delays in the renewable energy facility siting and permitting process.

Title:	Improving Environmental Decision Support for Proposed Solar Energy Projects Relative to Mojave Desert Tortoise				
Agreement Number:	PIR-11-013	**Project Number:**	1	**Research Stage:**	Applied Research
Electricity Funding:	$563,776	**Match Funding:**	$62,970	**Natural Gas Funding:**	$0
Start Date:	6/26/2012	**End Date:**	3/30/2015	**Technology Topic:**	Fauna
Award Recipient:	Redlands Institute, University of Redlands			**End-Market:**	Energy Suppliers

Description:

This research helped to reduce environmental conflict over solar energy development projects by providing scientific information and decision support technology to better assess the potential threats, impacts, and recovery actions affecting the desert tortoise in California.

Objectives:

1. Improve system models to evaluate the direct and indirect effects of solar energy development projects on the Mojave desert tortoise
2. Better assess the relative value of recovery actions for mitigation
3. Provide scientifically-robust results with appropriate measures of uncertainty to help inform decision-making both at the project and landscape scale
4. Develop tools to support efficient evaluation of proposed projects and recovery action portfolios

Benefits:

The project provided planners and regulators with scientific information and online analytical tools for predicting the impacts of proposed solar energy projects on the Mojave desert tortoise and the benefits of alternative mitigation strategies. The Desert Tortoise Spatial Decision Support System is helping the State of California to achieve its Renewables Portfolio Standard goals by providing science-based information related to the probable effects, both positive and adverse, of proposed solar energy development projects on this key protected species. Timely access to this information in the environmental review process helps to reduce conflict and avoid impacts that are costly to mitigate, thus keeping energy costs lower for the California ratepayer.

Title:	Test of Avian Collision Risk of a Closed Bladed Wind Turbine				
Agreement Number:	PIR-11-022	**Project Number:**	1	**Research Stage:**	Applied Research
Electricity Funding:	$716,596	**Match Funding:**	$174,498	**Natural Gas Funding:**	$0
Start Date:	6/25/2012	**End Date:**	3/31/2015	**Technology Topic:**	Avian Impacts
Award Recipient:	Shawn Smallwood, Sole Proprietor			**End-Market:**	Energy Suppliers, Policymakers/ Regulators

Description:

A major environmental concern with wind energy, a clean, renewable energy resource is the bird and bat mortalities caused by collisions with wind turbines. The two most promising approaches to reduce these collisions are to carefully site new wind turbines to avoid the locations where birds and bats are the most vulnerable, and to test whether new wind turbine designs will reduce collision risk. The original goal of this study was to test whether a new shrouded wind turbine design would reduce collisions; unfortunately, after significant amount of information was collected before the installation of the new wind turbines, the project was cancelled. The researchers then analyzed the collected data to explore whether variation in fatality rates can be explained by bird and bat flight patterns and avoidance behaviors.

Objectives:

1. Compare avian interactions with wind turbines between mixer-ejector wind turbines and conventional turbines at known high- fatality sites during the day, night, and various wind and terrain conditions using a short search interval and a before-after, control- impact experimental design.
2. Explain variation in fatality rates by turbine design, flight patterns, and avian interactions with wind turbines (i.e. avoidance behaviors) and provide field-tested behavior survey methods and data that inform avoidance rates in collision risk models and map- based collision hazard models to guide wind turbine siting.

Benefits:

The information gathered from this study was used to map collision hazards to inform the siting of new and repowered wind turbines and to improve how collision risks are estimated. Ratepayer benefits from this research come from reducing bat and avian collision risk that delays wind energy permitting and increases operating costs.

Title:	CO_2 to Oil Production Using Kiverdi's Novel Microbial System				
Agreement Number:	PIR-11-025	**Project Number:**	1	**Research Stage:**	Applied Research
Electricity Funding:	$747,126	**Match Funding:**	$587,027	**Natural Gas Funding:**	$0
Start Date:	6/20/2012	**End Date:**	3/31/2015	**Technology Topic:**	GHG Sequestration
Award Recipient:	Kiverdi, Inc.			**End-Market:**	Ratepayers

Description:

This project used a newly developed chemoautotrophic technology that uses microbes to convert CO_2 from flue gas sources to produce high-value oils and palm oil-equivalents.

Objectives:

1. Optimize current lab-scale production of palm oil-equivalent using CO_2 and hydrogen (H2
2. Develop a pilot-scale reactor for the microbes, based on lab-scale reactors
3. Create technology to use flue gas feedstock to produce a palm oil-equivalent, and determine the safety profile for the product
4. Determine and achieve a conversion efficiency for CO_2 to palm oil

Benefits:

By developing a new method for capturing carbon from flue gases, this project will help California meet its greenhouse gas emission reduction goals. Additionally, the creation of a revenue source by converting CO_2 to valuable products will reduce overall costs of compliance with the Global Warming Solutions Act of 2006 (AB 32) and Executive Order S-3-05. Kiverdi improved a technique to use microorganisms to convert carbon dioxide in flue gases from power plants to useful chemicals. This was the first step in a long process towards commercialization.

Title:	Novel Controls for Time-Dependent Economic Dispatch of Combined Cooling, Heating, and Power in Light Industrial, Commercial, and Institutional Markets with High Temperature Fuel Cells and Gas Turbines

Agreement Number:	500-10-010	**Project Number:**	1	**Research Stage:**	Applied Research
Electricity Funding:	$300,000	**Match Funding:**	$0	**Natural Gas Funding:**	$0
Start Date:	8/30/2010	**End Date:**	4/30/2015	**Technology Topic:**	Modeling
Award Recipient:	University of California, Irvine			**End-Market:**	Ratepayers

Description:

The goal of this project was to develop physics-based models supporting development of novel controls for combined cooling, heating and power systems. The models were built in the MATLAB- Simulink® framework using a methodology developed by the University of California Irvine. Additionally, the project team developed economic and environmental analysis strategies for these models. The following models were developed and verified by this project: Photovoltaic Model, Lead-acid Battery Model, Lithium-ion Battery Model, Ultra-capacitor Model, Heat Recovery Steam Generator Model, and the Steam Turbine Model. The novel control algorithms and architectures developed were implemented in the combined heat and power facilities of the university's Engineering Laboratory and Central Plant to demonstrate controlled dispatch capability.

Objectives:

1. Develop first principles dynamic physical models of emerging CCHP technologies.
2. Support installation of equipment to measure dynamic building loads and the dynamic performance characteristics of emerging CCHP technologies.
3. Support field installation and performance verification of the novel controls in a CCHP system.
4. Support extension of the control strategies to emerging CCHP systems technology

Benefits:

The novel controls developed through this project represent a step forward to helping CHP/CCHP systems become more capable of meeting demands for a larger cross-section of the potential market and will accelerate market adoption of CHP/CCHP technology. Increasing the market potential and market adoption of CHP/CCHP technology will provide California ratepayers with the following benefits:

- Lower energy use (improved fuel use efficiency).
- Reduced criteria pollutants that can lead to improved air quality.
- Reduced greenhouse gas emissions, which contributes to meeting state goals for GHG reduction and lessens impacts on the global climate.
- Lower ultimate cost of electricity and heat.

Title:	Development and Demonstration of a Novel High-Temperature Fuel Cell Absorption Chiller CCHP System				
Agreement Number:	PIR-09-018	**Project Number:**	1	**Research Stage:**	Technology Demonstration
Electricity Funding:	$1,480,000	**Match Funding:**	$2,140,000	**Natural Gas Funding:**	$0
Start Date:	10/25/2010	**End Date:**	3/31/2015	**Technology Topic:**	Hybrid Plants
Award Recipient:	National Fuel Cell Research Center - University of California, Irvine			**End-Market:**	Ratepayers

Description:

The intent of the project was to develop and demonstrate an integrated high-temperature fuel cell absorption chiller (HTFC/AC) combined cooling, heating and power system at a building facility in the UC Irvine campus. The project characterized the economics associated with the HTFC/AC technology in an arid climate such as southern California using select scenarios. However, the intended installation and demonstration of an HTFC/AC was not completed within the term of the project due to a number of issues including the third party financing. Construction of a demonstration unit at the UC Irvine Medical Center, located outside the main campus, was underway by the end of the agreement term in March 31, 2015. The system was subsequently completed about a year after the agreement ended.

Objectives:

1. Optimize Design.
2. Establish Power Purchase Agreement (PPA) and Complete Engineering Drawings.
3. Manufacture, Install, and Commission the System.
4. Evaluate System Performance.
5. Evaluate System Economics and Market Competitiveness.
6. Transfer Technology and Advance Market Engagement.
7. Evaluate System Economics and Market Competitiveness.
8. Transfer Technology and Advance Market Engagement.

Benefits:

While the intended project was expected to help develop and bring to market advanced electricity generation technologies that exceed applicable standards to reduce greenhouse gas emissions from electricity generation, no data from an actual operating system was collected and reported to support the hypothesized benefits.

Title:	University of California, Davis West Village Energy Initiative: ARRA Cost Share Funding				
Agreement Number:	PIR-10-061	**Project Number:**	1	**Research Stage:**	Technology Demonstration
Electricity Funding:	$500,000	**Match Funding:**	$0	**Natural Gas Funding:**	$0
Start Date:	6/30/2011	**End Date:**	6/30/2014	**Technology Topic:**	Zero Net Energy Building Design
Award Recipient:	The Regents of the University of California, Davis			**End-Market:**	Ratepayers

Description:

The Energy Commission provided cost share funding for a USDOE ARRA grant to design, develop and construct an advanced on-site waste to renewable energy (WTRE) facility as a critical part of University of California Davis's (UC Davis) West Village Energy Initiative (WVEI). The WVEI created a new, mixed-use community in Davis, with the goal of achieving Zero Net Energy (ZNE). UC Davis completed the installation, testing and demonstration of an innovative 50 tons per day anaerobic digester under a cost-share funded agreement with the DOE's ARRA of 2009 program, Energy Commission, UC Davis and CleanWorld.

Objectives:

1. Remove barriers that prevent the commercial deployment of biogas generation in California and beyond.
2. Assist in making UC Davis West Village a ZNE community.

Benefits:

Called Renewable Energy Anaerobic Digester or READ, the system was installed in a closed landfill in the UC Davis campus and has an electrical generation capacity of 690 kW biogas with an additional capacity of 235 kW provided from the landfill gas. The average biogas production was about 222,802 standard cubic feet per day (scf/d) with 60% methane. During the January and February 2015 operations, and prior to agreement term end date of March 31, 2015, the system generated a total of 137,912 kWh, contributing a net electricity to the grid of 43,115 kWh. Overall, the digester performed well as expected from the designs. Renewable energy produced from the WTRE will enable a secure community electricity grid with increased power reliability and quality, competitive management & operations and electricity costs, and drastically reduced peak energy demand, transmission and distribution losses and greenhouse gas emissions. West Village (WV) will serve as a model approach for the implementation of community scale renewable energy deployment.

Title:	Bay Area Biosolids to Energy				
Agreement Number:	500-10-034	**Project Number:**	1	**Research Stage:**	Applied Research
Electricity Funding:	$999,924	**Match Funding:**	$3,739,000	**Natural Gas Funding:**	$0
Start Date:	5/9/2011	**End Date:**	3/31/2015	**Technology Topic:**	Biomass
Award Recipient:	Delta Diablo Sanitation District			**End-Market:**	Ratepayers

Description:

Under an amended agreement, Delta Diablo Sanitation District (DDSD) partnered with the technology provider Chemergy, along with the LBNL to demonstrate a thermo-electro-chemical conversion technology based on a two stage bromination and electrolysis processes to produce hydrogen out of biosolids and then its subsequent use in a fuel cell to generate electricity.

Objectives:

1. Design and procure components for an electrochemical conversion plant to process biosolids.
2. Demonstrate reliable conversion of biosolids to hydrogen gas for electrical power production or fuel alternate.
3. Demonstrate electrical power generation using fuel generated by conversion of biosolids.
4. Test and evaluate the conversion system.
5. Verify the conversion efficiency of biosolids to hydrogen.
6. Establish the treatment procedures and confirm bromine recovery.
7. Confirm preliminary cost for hydrogen production via this process.
8. Prepare an economic analysis of the system.
9. Complete a preliminary permitting assessment for regulatory and safety issues.
10. Make available technical data for use by agencies interested in developing a biosolids to energy program.

Benefits:

Chemergy determined the viability of the process in laboratory experimentation while LBNL conducted system analysis and safety assessment. However, Chemergy was unable to fulfill its commitment to install, test and demonstrate the system at the DDSD facility before the end of the project.

Title:	Utility Scale Solar Forecasting, Analysis and Modeling				
Agreement Number:	500-10-060	**Project Number:**	1	**Research Stage:**	Road Mapping
Electricity Funding:	$450,000	**Match Funding:**	$140,217	**Natural Gas Funding:**	$0
Start Date:	6/30/2011	**End Date:**	3/30/2015	**Technology Topic:**	Solar PV
Award Recipient:	EnerNex, LLC			**End-Market:**	Energy Suppliers

Description:

This project addressed both short-term and long-term forecasting needs. Short-term forecasts combined satellite and ground-based sky imagery to track cloud formations and used shading models to forecast of solar plant output seconds, minutes and hours ahead. Forecast performance was validated against output from existing rooftop solar facilities in Fontana, California, and improvements to forecasting capabilities compared to cloudless- sky and cloud-persistence models was verified. Long-term forecasting focused on the effects of increasing penetration of PV to as much as 45 percent of the market in the Inland Empire area of Riverside and San Bernardino counties in California.

Objectives:

1. Develop a short-term forecasting tool for predicting solar plant output in the seconds to hours-ahead timeframe.
2. Demonstrate and validate the solar forecasting tool at several locations in Southern California.
3. Develop long term system forecasting models to predict the system effects of high solar penetration.

Benefits:

This research developed a short term forecasting tool for predicting solar plant output in the seconds-ahead to hours-ahead timeframe which was demonstrated and validated at several locations in Southern California's Inland Empire. The project also developed long term system forecasting models for predicting the effects of large amounts of variable solar generation resources. The outcomes of the project will facilitate the increased use of renewable energy resources, and improve integration and distribution of electricity generated from renewable energy resources. Utilities using electricity generated from PV will benefit from using the forecasting capabilities to improve the efficiency and reduce the costs of integrating rapidly changing amounts of renewable energy into their system operations.

Title:	Renewable Energy Resource, Technology and Economic Assessments				
Agreement Number:	500-11-020	**Project Number:**	1	**Research Stage:**	Applied Research
Electricity Funding:	$2,000,000	**Match Funding:**	$0	**Natural Gas Funding:**	$0
Start Date:	6/15/2012	**End Date:**	3/31/2015	**Technology Topic:**	Renewables
Award Recipient:	The Regents of the University of California, Davis			**End-Market:**	Ratepayers

Description:

This project updated and refined existing renewable energy resource and technology assessments and databases needed by stakeholders; provided for regional renewable energy assessments that are integrated, comparative and multi-dimensional; and addressed the complex issues and renewable energy development and integration data needs arising from efforts to increase California's use of its extensive renewable energy resources.

Objectives:

1. Update and refine existing renewable energy resource and technology assessments and databases needed by stakeholders.
2. Provide for renewable energy assessments that are integrated, comparative, and multi-dimensional.
3. Address the complex issues and renewable energy development and integration data needs arising from efforts to greatly increase California's use of its extensive renewable energy resources.

Benefits:

The results of this research provide California policymakers, utilities, industries, state and local agencies, and project developers with current information on the major renewable energy resources, including biomass, geothermal, solar, wind, and small hydropower. The technical and economic analysis of the related conversion technologies will help the state reach established renewable energy goals, take advantage of renewable energy deployment opportunities, and address potential development challenges that may arise.

Title:	High Solar PV Penetration Modeling				
Agreement Number:	PIR-10-003	**Project Number:**	1	**Research Stage:**	Technology Development
Electricity Funding:	$500,000	**Match Funding:**	$1,932,579	**Natural Gas Funding:**	$0
Start Date:	12/6/2010	**End Date:**	2/6/2015	**Technology Topic:**	Generation Forecasting
Award Recipient:	University of California, San Diego			**End-Market:**	Energy Suppliers

Description:

The project developed advanced modeling tools and electric power control strategies to optimize electric power value and reduce the impact of PV-sourced electricity on existing microgrids and the smart grid. The project monitored micro-climate effects and sky imaging systems to enable 1-hour-ahead PV-sourced electric power output forecasting in conjunction with a utility's dynamic price signals.

Objectives:

1. Achieve greater than twenty percent reduction in feeder peak load.
2. Demonstrating the capability of Volt-Amps-Reactive (VAr) electric power management.
3. Develop and demonstrate a strategy for information integration focused on security and system architecture.
4. Demonstrate the capability to use automated distribution control to island in response to system problems.
5. Developing information/tools addressing the impact of multiple DER technologies.

Benefits:

The project developed modeling tools for high penetration scenarios of photovoltaics (PV) on a distribution feeder system for the power system planning process and operations in order to sustain or accelerate high penetrations of PV for grid-tied solar energy systems. This package provides any user the ability to assess maximum loading of solar PV on a distribution feeder (10% to 50% of the feeder's peak load demand) based upon power flow, short circuit and transient stability analyses and adherence to power system reliability indices. These tools are open source and available for utilities and planners at the DOE High Solar Penetration Portal. The project's findings showed that the application of solar forecasting results in significant financial savings and are realized from a combination of several different factors impacted by more efficient solar forecasts and result in greater savings for California residents, in particular by reducing the demand charges which are a major component of the utility bill for commercial and industrial customers of the investor owned utilities.

Title:	SMUD's Smart Grid Pilot at Anatolia				
Agreement Number:	PIR-10-004	**Project Number:**	1	**Research Stage:**	Technology Demonstration
Electricity Funding:	$500,000	**Match Funding:**	$6,016,174	**Natural Gas Funding:**	$0
Start Date:	6/30/2011	**End Date:**	3/31/2015	**Technology Topic:**	Storage
Award Recipient:	Sacramento Municipal Utility District			**End-Market:**	Energy Suppliers

Description:

This project evaluated the value of advanced metering infrastructure, PV, and storage for homes with advanced metering infrastructure and PV in combination with three storage scenarios: 1) no storage, 2) home-based storage, 3) community-based storage. The data collected by SMUD was analyzed and made available in the final project report for assessing the performance and market impacts of these options. The project included an assessment of hardware performance, a benefits framework for rooftop PV with distributed storage, and evaluation of different operating scenarios, and the impacts of different technology configurations and pricing mechanisms on customer behavior.

Objectives:

1. Deploy distributed energy storage.
2. Install communications so that the energy storage can be monitored and controlled.
3. Install a Utility portal that will allow the recipient to monitor PV output, energy storage, and customer loads, as well as coordinate the resources at a system aggregate level, or more granularly at the substation, feeder, or individual residence level.
4. Deploy a Customer portal that will allow consumers to monitor their energy usage, PV output, and energy storage in real-time. In addition, consumers will receive energy conservation tips and other educational tools to help them change their energy use patterns.
5. Determine pricing signals (sent via the Customer portal) that will change the energy usage behaviors of customers.
6. Determine if customers who have PV and energy storage manage their energy usage differently when compared to those that do not.
7. Control a PV/energy storage inverter with a smart meter from the recipient's Automated Meter Infrastructure (AMI) deployment.
8. Develop a functional specification for a smart meter/inverter interface that would enable management of

Benefits:

The project yielded some valuable results and conclusions that can benefit similar projects in the future. Key takeways from this study include:

- Distributed energy storage can help manage high penetrations of PV by controlling voltage, managing reverse power flow (reducing ramping), and shifting load.
- Distributed energy storage can add value for SMUD and its customers with benefits of $88/kW to $215/kW for customer-sited and $67/kW to $176/kW for transformer-sited distributed energy storage.
- The impact of PV on the distribution feeder was low. Even though almost all of the 300 homes in the neighborhood had solar PV, SMUD did not find issues at the substation or feeder level.
- A smart meter can be used to control a PV inverter, and most of the necessary protocols are already in place to facilitate this.
- Business models for using distributed PV and energy storage are still in the early phases.

Title:	Plumas Energy Efficiency and Renewable Management Action Plan (PEER MAP)				
Agreement Number:	PIR-12-003	**Project Number:**	1	**Research Stage:**	Applied Research
Electricity Funding:	$300,000	**Match Funding:**	$75,000	**Natural Gas Funding:**	$0
Start Date:	6/19/2013	**End Date:**	3/31/2015	**Technology Topic:**	Planning
Award Recipient:	Sierra Institute for Community and Environment			**End-Market:**	Ratepayers

Description:

The project developed an integrated renewable energy network in Plumas County through development of the Plumas Energy Efficiency and Renewables Management Action Plan (PEER MAP). Through a bottom-up process, which included multiple interviews and in-person meetings with a variety of local stakeholders, county officials, and others working to advance biomass utilization in the region, Sierra Institute developed an understanding of the economic, environmental, and community benefits that could be realized by implementing PEER MAP.

Objectives:

1. Establish PEER MAP advisory body,
2. Identify and produce feasibility reports for critical facilities in Plumas County,
3. Develop financial proformas for facilities,
4. Develop PEER MAP Energy Vision,
5. Produce various policy and barrier issues reports,
6. Explore solar PV feasibility,
7. Obtain partner commitments,
8. Develop network of biomass boilers,

Benefits:

Plumas Energy Efficiency and Renewables Management Action Plan addresses the economic, environmental, and social challenges facing not only Plumas County, but many other rural forested communities in Northern California. When Fully implemented PEER MAP can save Plumas County tax payers more than $200,000 in heating costs and reduce fossil fuel consumption by more than 175,000 gallons per year. Replacing aging heating oil boilers with state of the art biomass boilers and providing an alternative to open pile burning will improve air quality across the county. Installation of solar PV panels at Feather River College, in conjunction with their current geothermal systems and proposed biomass boiler, will make FRC a model for how multiple forms of renewable energy can be integrated into college and university campuses. Greater demand for forest biomass will increase forest managers' ability to implement silvicultural prescriptions that promote forest health and resilience in the face of climate change and higher fire risk. Finally, a stronger forest products sector and new employment opportunities will have significant positive impacts on the local economy.

Title:	Energizing Our Future: Community Integrated Renewable Energy (CIRE) Assessment				
Agreement Number:	PIR-12-010	**Project Number:**	1	**Research Stage:**	Applied Research
Electricity Funding:	$300,000	**Match Funding:**	$300,000	**Natural Gas Funding:**	$0
Start Date:	6/24/2013	**End Date:**	3/31/2015	**Technology Topic:**	Other
Award Recipient:	Department of the Environment- City and County of San Francisco			**End-Market:**	Ratepayers

Description:

This project assessed the feasibility of a community energy center, integrating district heating and cooling, renewable electricity, waste-derived biogas, geothermal heat pumps, regenerative breaking energy from public transportation, demand response, and smart distribution technology to serve multiple community members. The final report recommended specific near-term technical actions to help achieve the State's long-term vision and analyze the local and statewide economic and environmental benefits.

Objectives:

1. Investigate and identify barriers and economics of community DG on the secondary network.
2. Study enabling technologies to link community DG.
3. Study energy storage and generation for community DG.
4. Study district thermal energy for the central corridor in San Francisco.
5. Data collection and analysis of potential economic and energy benefits.

Benefits:

The project studies the benefits of carefully planned, community-scale, renewable energy systems to property developers, property owners, tenants and for the City of San Francisco. Its investigation of the feasibility of various community-scale renewable energy systems can be applied to cities throughout the state of California. The benefits of these systems include lower development costs, reduced capital and operating costs, higher property values, reduced living expenses and sustainability.

Title:	Davis Future Renewable Energy and Efficiency ("Davis FREE")				
Agreement Number:	PIR-12-011	**Project Number:**	1	**Research Stage:**	Applied Research
Electricity Funding:	$300,000	**Match Funding:**	$75,000	**Natural Gas Funding:**	$0
Start Date:	6/1/2013	**End Date:**	3/31/2015	**Technology Topic:**	Solar PV
Award Recipient:	City of Davis			**End-Market:**	Ratepayers

Description:

The project developed highly detailed and comprehensive integrated renewable energy and enhanced energy efficiency deployment plans that will be linked to goals and milestones in the CAAP. The project (1) expanded the City's existing GIS spatial analysis system to allow parcel-specific data development on the potential for renewable energy and enhanced efficiency measures; (2) developed analytical and modeling tools to support building owner and ratepayer decision making on energy and efficiency investments; (3) developed Zero Net Energy Retrofit Guidelines for existing residences, and a rapid deployment for solar water heating.

Objectives:

1. To develop databases, supply curves, and net zero building guidelines to determine which initiatives recommended in previous analyses should receive priority in the next phase of the Recipient's Climate Action and Adaptation Plan (CAAP) implementation.
2. To develop methodologies and community energy flow models that will be used to plan subsequent community renewables deployment phases.

Benefits:

The Davis FREE program developed information and deployment plans that encouraged and enabled Davis residents and businesses to invest in renewable energy and enhanced efficiency. The results contribute to the carbon reduction goals of AB 32, the California RPS, the Renewable Electricity Standard (RES), the Million Solar Roofs photovoltaic initiative, and Executive Order S-06-06 addressing biomass to electricity goals.

Title:	MaxSun - A Novel Community-Ccale Renewable Solar Power System for California				
Agreement Number:	PIR-12-012	**Project Number:**	1	**Research Stage:**	Technology Development
Electricity Funding:	$525,000	**Match Funding:**	$155,659	**Natural Gas Funding:**	$0
Start Date:	6/14/2013	**End Date:**	3/31/2015	**Technology Topic:**	Solar PV
Award Recipient:	Cogenra Solar, Inc.			**End-Market:**	Ratepayers

Description:

This project developed a novel solar power co-generation system (MaxSun) that generates electricity from concentrated photovoltaic solar cells (CPV) in addition to capturing and delivering the generated heat in the form of hot water to thermal loads in a combined heat and power configuration.

Objectives:

1. Develop and design a high-temperature hybrid photovoltaic/thermal solar power generation system.
2. Optimize the performance of the system to operate efficiently under intended operating conditions.
3. Develop software to control the system and to dynamically optimize the value of the delivered energy.
4. Building, test, operate, analyze and validate a pilot-scale system that implements the novel approach.

Benefits:

The system developed under this project integrates CPV and solar thermal technologies in a hybrid system CHP configuration with demand response and thermal storage to generate as much electricity directly from sunlight as is practical through CPV, capture the remaining solar energy as heat, store the heat as hot water, and convert it on demand into electricity. Harnessing this heat mitigates the intermittency and low-efficiency of PV, dramatically reducing the cost to customers. The research team successfully developed new manufacturing techniques, designed, tested, and completed two major industry certifications of a solar module capable of operating at temperatures up to 110°C. As proposed, two full-size modules were built and tested in the laboratory and outdoors on a pilot system. Once the pilot modules had been proven internally, Cogenra completed and built an additional six full size modules and initiated the process for independent IEC certification. On average, the modules resulted in 20 percent more energy output compared to standard modules.

Title:	Predictable Solar Power and Smart Building Management for California Communities				
Agreement Number:	PIR-12-016	**Project Number:**	1	**Research Stage:**	Technology Demonstration
Electricity Funding:	$1,726,438	**Match Funding:**	$1,025,822	**Natural Gas Funding:**	$0
Start Date:	6/19/2013	**End Date:**	3/31/2015	**Technology Topic:**	Solar PV
Award Recipient:	Cool Earth Solar, Inc.			**End-Market:**	Ratepayers

Description:

The project demonstrated and evaluated a community-scale energy model that incorporates a full value chain of generating solar energy, forecasting the availability of that solar generation, and developing proactive building energy management tools to adapt to the solar forecasts.

Objectives:

1. Install 100kW of CPV, achieving a 75%+ performance ration and 90%+ availability factor.
2. Install 12 solar met stations. Met stations will accurately read Direct Normal Irradiance (DNI) measurements to within 4% Root- Mean-Square (RMSE), and be capable of transmitting data and cloud image files to Lawrence Livermore National Laboratory (LLNL) every minute.
3. Develop, demonstrate, and verify a solar power forecast method for up to an hour ahead that relies on an inexpensive networked array of instruments and public satellite imagery. Increase the temporal and spatial resolution of cloud and aerosol tracking from 1 kilometer (current state of the art) to 1 meter (sky imagers).
4. Develop, demonstrate, and verify improvements in building energy power use and demand reduction by implementing an energy use forecast from environmental factors (solar + weather). By predicting future energy needs and solar generation, it is expected to reduce heating, ventilation, and air-conditioning (HVAC) power demands by up to 10%.
5. Document and communicate the lessons and successes form this model to relevant stakeholders including other California communities, regional governments, municipal utilities, research institutions, and business groups.

Benefits:

The benefits of this project are primarily related to cost reductions for concentrating photovoltaic (CPV) technologies. The CPV system demonstrated in this project uses a low-cost inflatable plastic tube liner fresnel optic to dramatically reduce concentrator and racking costs, as well as an innovative, minimally-invasive radial tracker to streamline deployment for a range of potential commercial, industrial, and institutional settings. The project successfully deployed over 20 kilowatts of Cool Earth Solar's unique inflatable concentrating solar photovoltaics and tracker system design at the Livermore Valley Open Campus community site. This demonstration directly led to system design improvements and increased customer confidence in the Cool Earth Solar brand. Follow-on purchase orders include a single purchase for up to 100 megawatts of Cool Earth installed flat-plate PV, with a small portion dedicated to the concentrating PV technology. This capacity increase has allowed Cool Earth Solar to stay on track toward their stated goal of achieving costs at or below $1/watt by the year 2020. The project team also verified a proof of concept for a low-cost method for forecasting solar production that may lead to additional research breakthroughs in the future.

Title:	Renewable Energy Regional Exploration Project				
Agreement Number:	PIR-12-018	**Project Number:**	1	**Research Stage:**	Road Mapping
Electricity Funding:	$139,830	**Match Funding:**	$72,352	**Natural Gas Funding:**	$0
Start Date:	6/8/2013	**End Date:**	3/31/2015	**Technology Topic:**	Renewables
Award Recipient:	South Tahoe Public Utility District			**End-Market:**	Policymakers/ Regulators

Description:

The purpose of the project was to develop a model partnership agreement, standardized technology evaluation criteria, and processes that can be tested and used in a multi-jurisdictional setting for creating a plan to guide expansion and integration of local renewable energy technologies and resources in environmentally sensitive communities. It also explored the possibility of coordinating energy loads and resources of water and other infrastructure systems with electric utility distribution grid operations, and developed a strategic, integrated renewable energy plan for the South Tahoe Public Utility District region.

Objectives:

1. Develop a model, evaluation criteria, and processes for a community plan to integrate renewable energy.
2. Coordinate with regional electric utility distribution grid operations among other independent stakeholders.
3. Develop a strategic renewable energy plan for the STPUD/Liberty Utilities region.

Benefits:

Benefits from this project include cost reduction and reduced environmental impacts to electricity ratepayers, reliability improvement to the Liberty Utilities grid, establishment of renewable energy policies associated with the regional schools, and identification and future development of unique water system/electrical grid integrating concepts that support the Tahoe Regional Planning Agency's "environmental redevelopment" focus. The results will directly contribute to the carbon reduction goals of AB 32, the California RPS, the Renewable Electricity Standard (RES), and Executive Order S-06-06 addressing biomass to electricity goals. Information developed in this project will be transferable to other mountain and rural communities in California.

Title:	Breakthrough Power Density for Rooftop PV Applications				
Agreement Number:	PIR-12-019	**Project Number:**	1	**Research Stage:**	Technology Development
Electricity Funding:	$475,095	**Match Funding:**	$325,692	**Natural Gas Funding:**	$0
Start Date:	6/7/2013	**End Date:**	3/31/2015	**Technology Topic:**	Solar PV
Award Recipient:	Sun Synchrony			**End-Market:**	Ratepayers

Description:

The purpose the project was to develop a new generation of the rooftop-deployable concentrating photovoltaic (CPV) technology and to combine it with a novel tilt up tracking technology and power conversion electronics to support the advent of CPV on rooftops through the regions of California with the appropriate solar resource for the product. The project will advance the state of the art in rooftop concentrating photovoltaics (CPV) thereby supporting enhanced penetration of the technology to buildings and institutions within the state.

Objectives:

1. Lower installed cost of rooftop CPV.
2. Increase energy production with novel tilt-up tracker.
3. Hit module power density by area and weight targets.
4. Self-stow to flush in-base flat position triggered by high winds or drive failure.
5. Scalable plan for maintaining site performance and testing.

Benefits:

Sun Synchrony collected data from test-bed demonstrations and modeling efforts but the results of analysis has not been reported. The company reported several technical issues such as problems with solar cell receiver assemblies and design of reflectors. The company has not provided the final report, so the actual benefits of this project are unknown. The project ended in December 2015.

Title:	Repowering Humboldt with Community Scale Renewable Energy				
Agreement Number:	PIR-12-022	**Project Number:**	1	**Research Stage:**	Technology Demonstration
Electricity Funding:	$1,750,000	**Match Funding:**	$1,793,762	**Natural Gas Funding:**	$0
Start Date:	6/19/2013	**End Date:**	3/31/2015	**Technology Topic:**	Renewables
Award Recipient:	Redwood Coast Energy Authority			**End-Market:**	Ratepayers

Description:

The project demonstrated, deployed, and integrated promising renewable energy technologies within Humboldt County, California. The technologies deployed include an innovative biomass gasification and fuel cell system which provides combined heat and power for a local facility, as well as an evaluation for optimized deployment of other distributed energy resources within the region. The lessons learned from this project benefit a variety of other communities across California seeking to develop localized renewable energy resources.

Objectives:

1. Demonstrate a cutting edge distributed biomass gasification system that produces syngas with at least a 60% hydrogen content.
2. Integrate the biomass gasifier with a pressure swing absorption cleanup system and a proton exchange membrane fuel cell, and demonstrate successful operation of the first-of-its-kind integrated system. Successful operation will be a measured as a peak electrical output of >175 kW, a capacity factor of >75%, a biomass-to-electricity efficiency of >25%, and an overall system energy efficiency (including waste heat recovery) of >50%.
3. Publish at least two journal articles, present at one conference, and post information on at least three energy organization websites to publicize biomass project results.
4. Implement an innovative, community-based energy upgrade model that is shown to be economically self-sustaining and secures a robust participation of at least 20-60 site assessments and 10-20 energy upgrade projects.
5. Secure the participation of one or more local lenders in a local energy upgrade financing program and provide loans to 5-10 participants.
6. Install air source heat pumps in two facilities and monitor performance in terms of energy, cost, and greenhouse gas emission savings.
7. Install and monitor two electric vehicle charging stations and record >100 charging events.

Benefits:

This project offers many potential benefits to California's electricity ratepayers. First, by demonstrating a distributed biomass energy system that can be scaled-up and replicated to provide 1,400 MW of renewable DG capacity in the state, especially in rural counties with substantial timber and agricultural biomass residues. This includes the typical benefits attributed to DG systems: power provided on location, higher overall efficiency, lower transmission and distribution system costs, reduced energy losses in the T&D system, and lower environmental impacts when compared to central-station generation. The biomass energy system utilizes a local renewable energy resource to provide steady, reliable baseload power. If the system uses forest residue for energy production, it can also reduce fire hazards, improve forest ecosystem health, and increase timber production. Economically speaking, biomass energy is estimated to create more local jobs than other renewable energy resources.

The energy upgrade program offers additional ratepayer benefits. These include cost savings through increased energy efficiency to homes and businesses and a decrease in energy consumption and carbon emissions. The program demonstrates a streamlined customer/contractor model that offers lower costs and increased security to both parties. The program is expected to be easily replicable throughout the state.

Title:	Camp Pendleton Area 52 FractalGrid Demonstration Project				
Agreement Number:	PIR-12-033	**Project Number:**	1	**Research Stage:**	Technology Demonstration
Electricity Funding:	$1,722,890	**Match Funding:**	$1,172,428	**Natural Gas Funding:**	$0
Start Date:	6/30/2013	**End Date:**	3/31/2015	**Technology Topic:**	Microgrids
Award Recipient:	Harper Construction Company, Inc.			**End-Market:**	Energy Suppliers

Description:

This project demonstrated a set of intelligent microgrids that use community-scale renewable energy resources and energy storage within an existing utility grid at Camp Pendleton, which is a large marine base with dispersed loads and generation. The energy generation and demand was optimized by installation of the power controllers, distribution and isolation switches and local energy storage, and analysis of critical mission priorities. This project identified constraints and priorities to reduce energy and peak demand by 10% while meeting base priorities.

Objectives:

1. Reduce kilowatt hours per day by 10% during the demonstration period by optimizing generation and load resources.
2. Reduce Peak Demand kilowatts by 10% during the demonstration period by using energy storage to optimize generation and load resources.
3. Reduce the carbon footprint by at least 5% against the baseline by using solar forecasting.
4. Demonstrate the grid-independent ability of multiple distributed microgrids (from the local utility grid as well as from other microgrids) with FractalGrid architecture.

Benefits:

The project developed an enhanced, renewable microgrid that meets the demands of community energy security as well as high-risk clients such as large industrial institutions and army bases. The system combines renewable energy resources with traditional generation assets and energy storage to shed loads based on criticality to support community functions and provide long-term energy security. Among the successfully demonstrated goals of the FractalGrid architectural approach was to reduce energy and power consumption by replacing grid-produced energy with locally generated renewables. Total energy production on the Camp Pendleton site in 2014 was 738.14 MWh, corresponding to 97,385 kgCO2 emission reduction from the local utility company. These were accomplished through a combination of various techniques such as load-shifting, peak-shaving, load-leveling, and islanding. The implementation also provided additional energy surety and security through federated microgrids, substantially increasing uptime during planned and unplanned grid outages, while intelligent reporting and alarming systems captured system behavior and anomalies for operations and maintenance.

Title:	California Center for Sustainable Communities at UCLA				
Agreement Number:	500-11-012	**Project Number:**	1	**Research Stage:**	Policy/Regulation Support
Electricity Funding:	$1,900,000	**Match Funding:**	$0	**Natural Gas Funding:**	$0
Start Date:	4/4/2012	**End Date:**	6/30/2015	**Technology Topic:**	EV Charging Stations
Award Recipient:	The Regents of the University of California on behalf of the			**End-Market:**	Ratepayers

Description:

This project developed a California Center for Sustainable Communities (CCSC) that synthesized, coordinated, and communicated sustainable energy systems research and development to 1) reduce energy use through improved community design and integrated land use and transportation practices; and 2) increase faster adoption of lower emission electric vehicles by providing tools that will help municipalities provide public infrastructure to benefit electricity ratepayers.

Objectives:

1. Reduced energy use through improved community design and integrated land use and transportation practices.
2. Reduced vehicle miles traveled and GHG emissions through more sustainable land use and transportation planning.
3. Reduced legal and policy barriers to resource-efficient communities and streets.
4. Increased prevalence of pedestrian friendly street environments through use of rating system for pedestrian environments and thermal comfort modeling.
5. Faster adoption of lower emission electric vehicles by providing tools that will help municipalities provide public infrastructure.

Benefits:

Electricity ratepayers benefit from reduced GHG emissions and increased energy savings through the support of local governments and regional MPOs that create resource efficient communities by that encourage alternative forms of transportation, reduce the use of automobiles and trucks, and increase the overall energy sustainability of cities by better land use planning and system design.

Examples of support for local government include providing timely, valuable and unbiased information via the CCSC website on impacts of land use on California's energy challenge and creating a tool that makes research accessible across three related areas: (1) the demand for EV; (2) the usage patterns of EV; and (3) the charging infrastructure necessary to serve EV. The website and tools are open access so ratepayers (consumers) benefit from the available knowledge.

Title:	The Market Impact of Standardized Design in PEV Battery Pack Purchase and Disposal				
Agreement Number:	PIR-12-005	**Project Number:**	1	**Research Stage:**	Applied Research
Electricity Funding:	$750,000	**Match Funding:**	$150,000	**Natural Gas Funding:**	$0
Start Date:	6/19/2013	**End Date:**	3/31/2015	**Technology Topic:**	Battery
Award Recipient:	Electricore, Inc.			**End-Market:**	Ratepayers

Description:

Electricore, in collaboration with the California Center for Sustainable Energy (CCSE), SDG&E, and Ricardo, completed an in-depth study on how standard system designs for plug-in electric vehicle battery packs can potentially meet requirements for original equipment manufacturers, vehicle customers, remanufacturers, and second use applications as well as quantified the economic impact of such standardization. They developed potential design options for the standardization of battery modules for vehicle and second use applications and have identified barriers as well as provided recommendations for implementing standardized battery system design.

Objectives:

1. Evaluate how standard system designs compare to the current non-standard systems in their ability to meet original equipment manufacturer, vehicle customer, remanufacturer, and second use system requirements; including performance, form factor, manufacturability, cost, and longevity.
2. Quantify the impact on battery system costs of standardization for each stakeholder in the battery pack value chain.
3. Identify the barriers to a standard battery system design.
4. Quantify the added value for a standard system compared to a non-standard system when sold to secondary application markets.
5. Identify and evaluate potential pathways for implementation of PEV battery pack standards.

Benefits:

Electricore surveyed stakeholders in the battery pack value chain (original equipment manufacturers, vehicle customers, remanufacturers, customers for second use applications) to determine the necessary requirements and needs, and used the results to develop two standard battery pack designs for commercial vehicles. A cost-benefit analysis was completed based on a value chain assessment of the battery system life cycle, and determined that standardization has the potential to reduce the delivered battery price to vehicle manufacturers by 3 to 15 percent. Additionally they provided recommendations for potential pathways to battery pack standardization.

Title:	Strategies for Sustainable and Cost-Effective Scale-up of Second-Life, Recycling, and Disposal Pathways for PEV Battery Packs				
Agreement Number:	PIR-12-015	**Project Number:**	1	**Research Stage:**	Applied Research
Electricity Funding:	$250,290	**Match Funding:**	$51,000	**Natural Gas Funding:**	$0
Start Date:	6/19/2013	**End Date:**	3/31/2015	**Technology Topic:**	Electric Vehicles
Award Recipient:	Lawrence Berkeley National Laboratory			**End-Market:**	Ratepayers

Description:

Under this agreement, Lawrence Berkeley National Lab developed strategies for the scale-up of plug-in electric vehicle battery recycling infrastructure in California. Based on the recycling scenarios, the team also created and applied a cost and environmental impact model that calculates transportation distances and determines optimal battery collection and recycling facility locations.

Objectives:

1. Develop scenarios to estimate potential consumer adoption of PEVs in California and the resulting battery disposal rates.
2. Establish a set of cost and environmental metrics by which to compare battery recycling and reuse strategies.
3. Create optimal large-scale recycling infrastructure and logistics scenarios and estimate the environmental implications for each.
4. Make results from the environmental assessment and infrastructure scenarios available to guide future recycling process development in prioritizing particular materials, or taking steps to reduce transportation and capital costs, such as the ability to recycle multiple battery types in a single facility.

Benefits:

The project determined that California is likely to reach a sufficient plug-in electric vehicle battery pack disposal rate to justify an instate pilot-scale recycle facility running at full capacity by approximately 2030, but may not be able to justify a commercial-scale facility until after 2050. An assessment of plug-in electric vehicle battery second-life energy storage was conducted and determined that this scenario could play a modest role in achieving the state's stationary energy goals and, if paired with renewables, would reduce greenhouse gas emissions significantly by 2050. The analysis produced for this project will help decision-makers weigh the potential economic, energy, climate, and human health costs and benefits of managing used plug-in electric vehicle batteries. The scenarios created under this agreement will inform industry on the rate in which plug-in electric vehicle battery recycling infrastructure must be scaled up in California as well as the identification of optimal facility functions, locations, and transportation logistics. This strategic development will minimize capital costs, transportation distances, and environmental impacts associated with plug-in electric vehicle battery recycling.