COMMISSION REPORT

PUBLIC INTEREST ENERGY RESEARCH 2010 ANNUAL REPORT

CALIFORNIA
ENERGY COMMISSION

Edmund G. Brown Jr., Governor

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Dear Legislators:

I am pleased to present this annual report to you. This report presents a review of the Energy Commission's Public Interest Energy Research (PIER) program and its public role, followed by a discussion of the benefits that have accrued to California ratepayers as a result of the Energy Commission's stewardship of the PIER funding. The Energy Commission ensures that energy RD&D under the PIER program is conducted in harmony with both California statute and the state's public interest energygoals, including energy efficiency, alternative energy and related infrastructure development, and environmental stewardship.

We are embarking on a strategic planning process to update the PIER Program for the next decade. Active stakeholder and scientific community engagement will guide this process. This extensive review and overhaul of the PIER Program will be initiated in spring 2011 and will examine the role of the American Recovery and Reinvestment Act funding, advances in science and technology, the changing regulatory and competitive marketplace, and new legislation that passed since our last review in 2006. We expect the strategic vision from this process to be completed in early 2012.

Energy research, like all RD&D, is inherently risky with no guaranteed outcomes. This program fills a critical role by conducting public benefit research having high- risk thresholds to help fill research gaps that are not being met in either the competitive or regulated marketplaces. Public RD&D remains the catalyst for future market investments for the public good. The Energy Commission's PIER program has developed over time using two inter-related structural elements that help define its value to the public— impartial evaluation and strategic partnerships.

First, the Energy Commission fills the role of an impartial evaluator for PIER RD&D funding among a variety of California stakeholders. These stakeholders range from small businesses to universities to California-based national laboratories to utilities and energy companies and public interest and advocacy groups. The ability to select and coordinate research across these organizations sets PIER apart from other research programs, certainly within California. The Energy Commission, which does not make PIER awards to itself or serve one organization or group, advocates for the people of California, according to its statutory foundation.

Second, the Energy Commission's PIER program has successfully built a national reputation for partnerships in California-based energy RD&D. PIER creates and sustains these partnerships on both the state and national level. The combination of the Energy Commission's neutral coordination and strategic partnerships helps PIER avoid research duplication, builds on previous successful work, generates new ideas, leverages investments, and ensures that PIER RD&D provides benefits to the state's energy ratepayers.

The Energy Commission's reputation and network of strategic partners enable it to attract and leverage millions of dollars in matching funds from private and public sources. Over the 12-year history of the program these leveraging efforts have resulted in $1.7 million in total

research for every $1 million of PIER funds encumbered. Recently, PIER has been successful in dramatically leveraging federal funds with state dollars. PIER is investing $20 million to leverage over $500 million of U.S. DOE American Recovery and Reinvestment Act of 2009 (ARRA) funds and $900 million private investment funds.

Several PIER projects, many of which are highlighted in this report, will provide lasting benefits to the California economy. For example:

- The results of PIER projects incorporated to date into California Title 20 Appliance Efficiency Standards and Title 24 Building Standards will result in annual cost savings of nearly $1 billion for California electric and natural gas ratepayers. Savings will continue to increase as future PIER-funded work is incorporated into the standards.
- Advanced power grid monitoring software has increased system reliability and prevented cascading blackouts. The software's estimated benefits from reduced outages over a 10-year period range from tens of millions to over $300 million for California and up to nearly $1 billion for the entire Western Coordinating Council region (including California).

The Energy Commission is committed to responsible stewardship of the PIER Program on behalf of Californians. This stewardship is illustrated both by the Energy Commission's strict adherence to statutory direction and by administrative adjustments made in response to feedback from the Legislature and an Energy Commission requested audit conducted by the Department of Finance. Adjustments to the PIER program in recent years include an increased use of competitive solicitations with a preference given to California based contractors, a reduction in the use of sole source contracts, and increased transparency of the program's policies and procedures.

This report captures the spirit and intent of the Energy Commission's PIER RD&D activities that continue to provide benefits to California ratepayers. I hope you will find this research as vital to California as I do.

Sincerely,

MELISSA JONES
Executive Director

ABSTRACT

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

In SB 1250 (Perata, Chapter 512, Statutes of 2006), the Legislature declared 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 make research investments in the following four categories:

- Advanced transportation technologies that reduce air pollution and greenhouse gas emissions beyond applicable standards
- Increased energy efficiency in buildings, appliances, lighting, and other applications beyond applicable standards
- Advanced electricity generation technologies that exceed applicable standards to increase reductions in greenhouse gas emissions from electricity generation
- Advanced electricity technologies that reduce or eliminate consumption of water or other finite resources, increase use of renewable energy resources, or improve transmission or distribution of electricity generated from renewable energy resources

The Energy Commission's Public Interest Energy Research 2010 Annual Report is prepared under Public Resources Code Section 25620.8. This report describes what PIER accomplished in 2010, new work initiated, and steps taken to prepare California to meet the research needs of tomorrow. This report covers PIER RD&D projects funded from January 1, 2010, through December 31, 2010. In 2010, the Energy Commission administered a total of $86.5 million for public interest electricity and natural gas research—$62.5 million for electricity RD&D projects and $24 million for natural gas RD&D projects.

Keywords: California Energy Commission, PIER, annual report, energy research, RD&D, energy efficiency, climate change, advanced generation, renewable energy, demand response, energy storage, transmission, distribution, infrastructure, buildings, distributed generation, Smart Grid, carbon sequestration, carbon capture, transportation

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EXECUTIVE SUMMARY

The Public Interest Energy Research (PIER) Program was created in 1996 when the California Legislature enacted Assembly Bill 1890 (Brulte, Chapter 854, Statues of 1996). This law shifted the administration of public interest energy research, development and demonstration (RD&D) from California's investor-owned utilities to state government—a major change intended to ensure the continuation of public interest RD&D. This legislation directed the California Energy Commission to "develop, and help bring to market, energy technologies that provide increased environmental benefits, greater system reliability, and lower system costs."[1]

Similar legislation was enacted in 2000 with Assembly Bill 1002 (Wright, Chapter 952, Statutes of 2000), which required the California Public Utilities Commission (CPUC) to impose a surcharge on all natural gas consumed in California to fund public interest research and development activities specific to natural gas. In 2004, the CPUC designated the Energy Commission as the administrator for its natural gas research program. The California Energy Commission manages the electricity and natural gas research programs through its Energy Research and Development Division.

PIER conducts research, development and demonstrations consistent with state law, various Governors' Executive Orders, the Energy Commission's *Integrated Energy Policy Report*, and the *Energy Action Plan*. In response to legislative direction, the PIER Program funds research in energy efficiency and demand response, renewable energy resources, advanced electricity generation, transmission and distribution, energy-related transportation, and energy-related environmental research. This public interest energy research helps achieve state energy policy goals by conducting research that is not adequately provided by competitive and regulated markets.

The Energy Commission's *Public Interest Energy Research 2010 Annual Report* is prepared under Public Resources Code Section 25620.8. This report covers PIER RD&D projects funded from January 1, 2010, through December 31, 2010. This report also highlights recently funded electricity research, notable results from ongoing and completed projects, and research initiatives. The report also includes projects in the Energy Commission's natural gas RD&D program. In 2010, the Energy Commission administered a total of $86.5 million for public interest electricity and natural gas research—$62.5 million for electricity RD&D projects and $24 million for natural gas RD&D projects.

In response to recommendations from the PIER Advisory Board, Legislative oversight, and input from key stakeholders, the Energy Commission is embarking on a number of Program improvements The Energy Commission is committed to:

[1] Public Resources Code section 25620.1

- Establish research priorities through a more transparent decision making process and with greater focus on the later stages of the research, development and demonstration continuum, without sacrificing critical research needs.
- Better integrate the PIER research agenda with other state agencies, especially the Air Resources Board and the California Public Utilities Commission.
- Involve California's utilities, California Independent System Operator, the scientific community, and the private sector in the process for formulating research initiatives.
- Streamline Program administration and measure the economic and jobs benefits of the Program overall and of specific research projects.
- Update the CEC's five-year Strategic Plan with clearly articulated goals and objectives and research priorities .

Highlights of 2010 PIER Funding

In 2010, the Energy Commission funded projects that brought potentially groundbreaking science and technologies to California in the following areas: Smart Grid, renewable resource integration, advanced transportation and fuel technologies, efficient industry and offices, zero net energy homes, climate change, and innovative energy small grants. PIER's research investments will help meet the state's greenhouse gas emission goals, continue improving the Smart Grid, demonstrate microgrids, achieve a higher penetration of renewable resources, move toward zero net energy-smart communities, and create lasting jobs and businesses in modern clean technology industries for a sustainable California economy.

The Energy Commission leverages the combined $86.5 million electricity and natural gas RD&D budgets to maximize benefits for California ratepayers. In 2010, the three major leveraging approaches included:

- leveraging cost shares from other research partners for investments in California technologies.
- leveraging funds across different PIER research areas.
- leveraging technical expertise from within the state from utilities, universities, energy industries, other state agencies and federal agencies to stimulate higher quality research.

Benefits of PIER Funding

Publicly-funded energy research presents diverse gains to society. The PIER Program provides economic, environmental and reliability benefits, and will help California meet its greenhouse gas and renewables targets. PIER research saves energy and money, promotes customer choice, and leads to job creation. Creating new jobs positively contributes to the overall economic climate of the state.

Since 1974, a core function of the Energy Commission has been to increase energy efficiency to provide savings to California ratepayers. Since 1998, PIER research has contributed to this goal.

As a result, California ratepayers will save nearly $1 billion annually from PIER-funded efficiency research incorporated into California Title 20 Appliance Efficiency Standards and Title 24 Building Standards.

PIER-funded research catalyzes new companies that attract investment capital and creates jobs. The PIER Small Grants research area has led to approximately $38 of private non-utility follow-on investment for every dollar of PIER funding. Additionally, PIER-funded research directly employs over 2,000 researchers, scientists, technicians and others. This research activity creates an additional 3,700 indirect and induced jobs.

PIER funding brings outside investment into California. In 2010, the Energy Commission's PIER program invested $13.2 million in 15 California-based American Recovery and Reinvestment Act (ARRA) Smart Grid field testing projects that brought into California over $426 million in federal ARRA funding from the U.S. Department of Energy and created over 23,000 jobs in California. These projects will assist California in meeting its energy policy goals to increase the use of renewable generation, reduce greenhouse gas emissions, and create a highly skilled clean technology workforce.

This outside investment also saves ratepayers money on their utility bills. If California utilities had capitalized these Smart Grid efforts into their rates at a capital cost of 8.75 percent[2], ratepayers would be paying an additional $46 million a year over the next 20 years.

Future Focus

For the foreseeable future, the PIER program will continue to follow the "loading order" to establish research priorities. The loading order identifies these priorities as first energy efficiency and demand response, followed by renewables, and distributed generation, and finally improvements to infrastructure. Additionally, the Energy Commission will seek input from the PIER Advisory Board to refine these research priorities. Emphasis will be placed on demonstration projects to develop the Smart Grid, microgrids, net zero homes and businesses, and renewable energy.

As always, the Energy Commissions RD&D Policy Committee will approve the final allocation of funding while specific projects will be approved at the public Energy Commission Business Meetings. RD&D funding is expected to attract increased match funding from project developers.

Some of the future research activities include the following:

- Continue developing and demonstrating energy efficiency technologies that can be implemented by ratepayers.
- Continue accelerating the deployment of multiple renewable energy technologies.
- Develop and demonstrate zero net energy buildings and energy-smart communities.

[2] Utility Weighted Average Cost of Capital, California Public Utilities Commission, Gas and Utility Cost Report, Public Utilities Code Section 747, Report to Governor and Legislature.

- Incorporate automated demand response technologies into California's statewide Smart Grid infrastructure.
- Develop tools and strategies to address intermittency of renewables including storage.
- Create a research roadmap for Smart Grid.
- Continue providing new technologies and documenting industry best practices to grow California's clean energy workforce.
- Use the Energy Innovations Small Grant program to fund new and creative ideas from innovative small businesses, non-profits, individuals, and academic institutions.
- Continue research and develop technologies, tools, and methods for implementing renewable "drop-in" transportation fuels and research new value propositions to lower electric vehicle battery cost.

The PIER Program will fund RD&D for additional challenges facing the state. Examples include the intermittency issues of renewable resource integration, resolving environmental impacts and permitting issues associated with new and existing forms of energy generation, and the interoperability of energy technologies to enable them to work together as a system. These challenges are opportunities for the PIER Program.

CHAPTER 1:
Shaping the Future

In Governor Brown's Clean Energy Jobs Plan, he outlined a goal of 20,000 new megawatts (MW) of renewable electricity by 2020 and bold steps to increase energy efficiency and net zero buildings. In the Governor's plan, Public Interest Energy Research is an important component of achieving California's unique and aggressive goals, and will pave the way to creating half a million new jobs in research, development, manufacturing, construction, installation, and maintenance over the next decade.

In a speech at the National Press Club in Washington, D.C., U.S. Energy Secretary Steven Chu said that the success of China and other countries in clean energy industries represents a new "Sputnik Moment" for the United States, and requires a mobilization of America's innovation machine so that we can compete in the global race for the clean energy jobs of the future. "When it comes to innovation, Americans don't take a back seat to anyone - and we certainly won't start now," said Secretary Chu. "From wind power to nuclear reactors to high speed rail, China and other countries are moving aggressively to capture the lead. Given that challenge, and given the enormous economic opportunities in clean energy, it's time for America to do what we do best: innovate."

California leads the nation in energy efficiency innovation, greenhouse gas reduction goals, and forward-thinking energy policies. California cannot afford to take its scientific leadership and innovation for granted. Secretary Chu stressed that our economic competitiveness depends on jump-starting the next round of American innovation in clean energy. Many of these clean energy technologies and policies were catalyzed by PIER.

Last year the *PIER 2009 Annual Report* explained how the Energy Commission used PIER funding to shape the future directions of California's electricity and natural gas systems and created a green technology foundation for a strong 21st century economy. This year's report highlights how the Energy Commission is using PIER funding for innovative research to meet today's energy research needs and to help California meet the challenges of a dynamic energy future.

Energy Commission Expertise

The Energy Commission was created by the Legislature in 1974 to serve the broad public interest, support the state's energy policies and address the needs of consumers. The Energy Commission operates its programs efficiently and leveraging efforts have resulted in $1.7 million in total research for every $1 million of PIER funds encumbered. The Energy Commission will continue to use PIER funding to meet California's aggressive energy policy goals for a clean, affordable, reliable, and efficient energy system.

Ensuring Tangible Public Benefits

By supporting RD&D work dedicated to benefit ratepayers and society at large, the Energy Commission is uniquely positioned to continue managing research that provides policy makers

information to pursue standards and goals that increase the quality of life of Californians. The Energy Commission conducts public interest energy research by considering the needs of the entire state and its energy policies, and establishes research goals for the greatest public benefit. California has used this research to develop some of the most aggressive statewide standards and goals for the adoption of renewables, energy efficiency, air and water quality, and green buildings.

Policy and Planning as the State's Primary Energy Policy Agency

The Energy Commission is the state's primary energy policy and planning agency. PIER staff works directly with other knowledgable staff within the Energy Commission to plan research that supplies the tools, methods and insights vital to informing policies, codes, standards and regulations. These other offices and divisions of the Energy Commission provide groundbreaking energy policies that benefit from across-the-board energy research. Public interest research yields public interest benefits in the form of better informed and more coordinated public policies.

As the primary energy policy agency, the Energy Commission is the author of the state's guiding energy policy document, the biennial *Integrated Energy Policy Report (IEPR)*, which evaluates overall supply and demand trends for electricity, natural gas, and transportation fuels in California, as well as issues associated with energy infrastructure, efficiency, reliability, and cost. The *2009 IEPR* describes the energy policies significantly affecting California.

Three of these policies – Assembly Bill 32 (Nuñez, Chapter 488, Statutes of 2006) and Executive Orders S-14-08 and S-21-09 – reaffirm the Energy Commission's research for "increased development of renewable electricity sources, energy efficiency and demand response … to meet the greenhouse gas reduction goal of 1990 levels by 2020 and 80 percent below 1990 emissions levels by 2050."[3] Executive Order S-21-09 accelerated the Renewable Portfolio Standard to 33 percent renewable energy generation by 2020. The PIER program staff is working with the Energy Commission's Facility Siting Division, Efficiency and Renewables Division and the Electricity Analysis Office to provide research results that will help the Energy Commission staff work in unison to meet the 33 percent renewable energy generation goal.

Energy Commission RD&D efforts identify new energy resources and provide new technologies, tools, standards, and protocols to help implement California's energy policies. The *2009 IEPR* articulates state energy policy and informs the Commission's PIER program portfolio. The PIER research portfolio includes projects that:

- Increase energy efficiency and demand response.
- Integrate renewable energy resources and distributed generation resources, including energy storage and Smart Grid.
- Advance clean generation technologies and improving the state's transmission infrastructure.

[3] Governor of the State of California, Executive Order S-21-09

- Reduce the environmental impacts from energy generation, transmission, distribution and end-use.
- Advance transportation technologies and alternative fuels to reduce air pollution and greenhouse gases emissions.

PIER Research Meets Policy Objectives

The PIER Research portfolio reflects the state's energy policies.

Energy efficiency and demand response research projects address the following state policies and goals— the CPUC Energy Efficiency Strategic Plan and *IEPR 2009* (sets zero net energy goals for residential buildings by 2020 and commercial buildings by 2030), Governor Brown's Clean Energy Job Plan and Executive Order S-20-04 (increase energy efficiency in existing buildings), and AB 32 (reduce green house gas production).

Renewable energy research is driven by a number of renewable energy generation and greenhouse gas reduction goals, including AB 32. Additionally, California's Renewable Portfolio Standard (as mandated by SB 1078 and SB 107) is one of the most aggressive in the United States. The goals of this standard were expanded by Executive Orders S-14-08 and S-21-09, which aim for 33 percent of generation to be provided by renewables by 2020. Executive Order S-06-06 set an additional target of 20 percent of the state's electricity to be generated from biopower by 2020. Renewable energy technologies will also be critical in meeting the goals of Executive Order S-03-05, which establishes a state goal to reduce greenhouse gas emissions by 2050 to 80 percent below 1990 levels. Governor Brown's progressive energy plan will advance the state's renewable energy goals even further by requiring 8,000 MW of energy to be generated from renewable resources, and 12,000 MW of energy to be generated by distributed generation.

Advanced generation, transmission, distribution, and smart grid research projects address the requirements of SB 1250 (enhance the capabilities of the transmission and distribution system), AB 32 (advanced generation to reduce greenhouse gas emissions), and SB 17 (smart grid planning and implementationEnergy-related environmental research falls into four main categories: Air Quality, Water Resources, Terrestrial Resources, and Climate Science. All research is tied to energy policies, such as SB 1078 (Renewable Portfolio Standard), SB 1250 (reduce or eliminate consumption of finite resources), AB 32 (greenhouse gas reduction), Executive Orders (increase biomass production in the state, conduct climate science and expedite renewable energy development) and numerous *Integrated Energy Policy Report* (IEPR) recommendations.

PIER energy-related transportation research addresses policy goals for deploying sustainable fuels and improving vehicle efficiency as stipulated in SB 1250, SB 76, and the State Alternative Fuels Plan. PIER energy-related transportation research also addresses statutory goals as stated in SB 375 for sustainable communities.

Building and Fostering Coordinated Efforts

The Energy Commission has built a national reputation as a model for partnerships in energy RD&D. The Energy Commission administers the PIER Program to coordinate and oversee funding with a variety of California stakeholders, including small businesses, universities, the California-based national laboratories, California investor owned utilities, energy technology companies, and various advocacy groups. The Energy Commission creates and sustains these partnerships, statewide and nationally, and coordinates between these various organizations.

National coordination and partnership efforts help avoid research duplication, build on successes, generate new ideas, leverage investments and attract new funding to ensure that PIER maximizes the tangible benefits to California's ratepayers. In these efforts, the Energy Commission coordinates nationally with the US Department of Energy (DOE), energy experts from a multitude of other states, Standards Development Organizations (SDOs), ratepayer and consumer advocacy groups, and other energy experts. These efforts allow California to be the national leader in the in the energy research and technology implementation sectors.

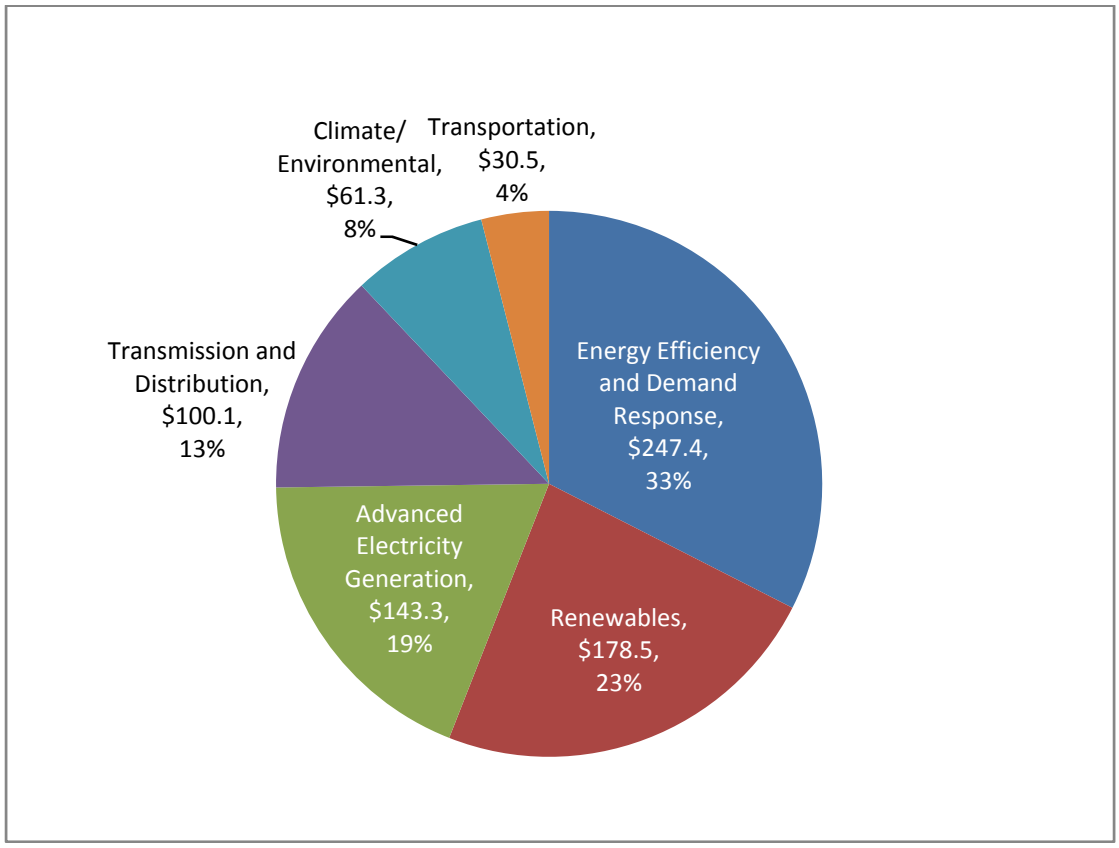
Natural Gas and Electricity Synergies in California

Recognizing the Energy Commission's leadership in energy research, the CPUC in 2004 designated the Energy Commission as the administrator of the CPUC-funded natural gas research program. In 2010, the Energy Commission administered a total of $86.5 million for research through the PIER program—$62.5 million for electricity RD&D projects and $24 million for natural gas RD&D. This allowed the Energy Commission to address all of the energy research needs of California through a program that shares and leverages RD&D knowledge. This coordinated approach allows the Energy Commission to provide increased benefits to California ratepayers and maximizes the effectiveness of research funds.

In California, almost half of all electricity generated is produced by natural gas. Applying its experience and expertise, the Energy Commission recognizes the links between natural gas and electricity RD&D, and leverages this symbiotic relationship. Consequently, any RD&D that yields electricity savings from reductions in electricity consumption, whether through energy efficient consumer products or new technologies, also results in substantial natural gas savings. This reduces the natural gas demand and reduces greenhouse gases.

By integrating natural gas and electricity RD&D efforts, the Energy Commission also leverages funding, expands partners, and shares knowledge to meet California's energy goals. For example, integrating direct natural gas applications with electricity energy efficiency improvements, results in a reduction of total energy consumed and saves ratepayers money on their total electricity and natural gas bills. Figure 1 illustrates the percentage of PIER electric and natural gas allocations by focus area.

Figure 1: PIER Electric and Natural Gas Research Budget Allocations, 1997 - 2010



Source: California Energy Commission

Expert Administration of PIER Portfolio

Public research programs should be administered by public agencies that are transparent, accountable to the public and follow legislative energy policies and directives. For the last decade, the Energy Commission successfully guided PIER projects and products, fostering energy technologies for the public benefit, and created partnerships with other governmental agencies. The Energy Commission leads these partnerships with other state institutions and directs research to achieve the greatest benefit for California ratepayers.

In administering PIER, the Energy Commission draws on its research and management expertise to ensure benefits to Californians by:

- Providing transparency and accountability for all funds and projects.
- Providing coordinated research to avoid duplication.
- Providing independent and impartial evaluations of proposals and projects.
- Supporting R&D work with a state-wide, policy-focused interest dedicated to benefitting ratepayers and society at large.
- Generating research opportunities for California-based companies that create jobs and stimulate the economy.

- Building long-standing relationships with California's diverse and substantial research capabilities at state universities, national laboratories, and high-tech companies.
- Leveraging funds with private sources and the federal government.
- Working with the Legislature to ensure the program is operating to fulfill statutory goals.

PIER Advisory Board

The Energy Commission regularly convenes a PIER Advisory Board to make recommendations and guide the Commission's selections of the programs and projects that are funded by the PIER program. The PIER Advisory Board has a diverse makeup consisting of 22 members. The members represent experts and stake holders with an interest in energy, including the California Legislature, California electric utilities, the California Independent System Operator, the California Air Resources Board (ARB), the venture capital community, California Public Utilities Commission (CPUC), members and organizations of the environmental community and others. The PIER Advisory Board provides advice to the Energy Commission on the funding direction of the program and recommends ways to improve the overall program. The PIER Advisory Board meets twice a year to review program performance and provide advice.

The last meeting of the Advisory Board was November 10, 2010. During the meeting, participants discussed the PIER project portfolio and provided insight as to how the energy business and sectors have changed since PIER began and the potential changes anticipated over the next decade. When the PIER program started in 1996, the industry focus was on lowering generation costs through competition. Today, industry focus has shifted to a hybrid model with aggressive energy and environmental goals. The emphasis on technology has also changed. Today's emphasis is on integration of technologies to achieve the state's aggressive energy goals, improve customer options and also grid interoperability. If the program is continued, next year's research will focus more on demonstration projects that will provide greater insight into the best strategies to meet policy goals, while maintaining reliability and controlling costs.

The Advisory Board recognized that innovation will increase manufacturing in the clean technology sector and will develop a new manufacturing base in California, leading to an energy efficient and clean generation industry. For the coming year, the PIER program RD&D will leverage California's existing communications and high powered computing industry to achieve even greater energy efficiency across the grid and expand the market for these technologies.

The Advisory Board found value in PIER's efforts in the commercialization of the energy technologies and the jobs and careers created from PIER RD&D. They recognized how PIER leverages private sector match funds and follow-on funding including that from the venture capital community and recognized the significant amount of funding PIER has brought to California increasing the potential for ratepayer benefits. The next Advisory Board meeting will be March 30, 2011.

Report Structure

This report describes the RD&D activities and accomplishments of the program. Chapter 1 explains how the Energy Commission's approaches public interest energy research. Chapter 2 highlights the tangible benefits including dollar savings, energy savings, greenhouse gas reductions, electric generation, criteria pollutants, and job/career creation as a result of the PIER program. Chapter 3 provides examples of major research initiatives that are on-going for the immediate future and identifies the initial research efforts toward meeting the state energy goals of 2020. The Appendix contains a summary list of the RD&D projects that were initated in 2010.

CHAPTER 2:
Benefits

Public Interest Energy Research Creates New Jobs

The California Energy Commission's Public Interest Energy Research (PIER) program creates jobs through four different channels. Creating new jobs positively contributes to the overall economic climate of the state.

First and foremost, PIER projects lead to the creation of new companies or new lines of business in existing companies. The private sector investment in these new activities greatly exceeds the initial PIER funding. For example, the PIER small gants program area, which regularly surveys award recipients for follow-on funding, has led to about $38 of private non-utility follow-on investment for every $1of PIER funding. These new companies or new lines of business create private sector jobs. For successful companies, the number of jobs increases over the years. As current PIER research is completed and attracts capital, more jobs will be created as these companies grow. For example, one PIER-funded developer of combined heat and power technologies for fuel cells and boiler burners projects 3,710 jobs over the next 10 years.

Second, PIER-funded research directly employs over 2,000 researchers, scientists, technicians and others. This research activity creates more than 3,700 indirect and induced jobs. Many of these jobs may continue beyond the initial PIER fund investment as research is picked up by the marketplace.

Third, PIER results in publicly available knowledge that fosters additional innovation by the private sector. This innovation frequently results in new products that create new jobs.

Fourth, PIER-supported products that create jobs in installation, product education and other areas. An advanced lighting manufacturer, who received American Recovery and Reinvestment Act (ARRA) funds, stated that 1,600 jobs would be developed as a result of improved technology co-funded by the PIER Program. A firm building and testing a 150-megawatt turbine using oxygen-combustion technology projected 150 direct jobs and thousands of indirect jobs over the next several years.

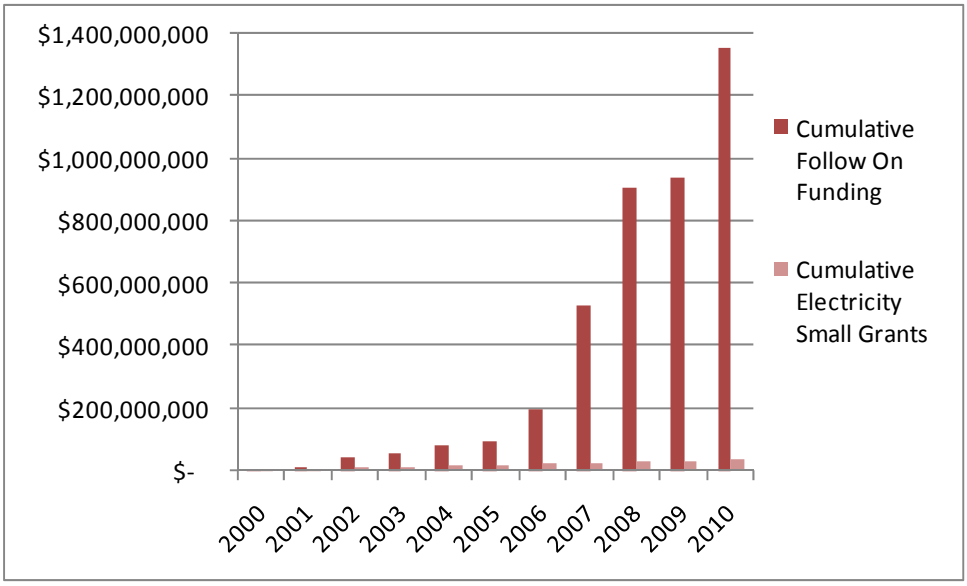
PIER Attracts Private Investment

The Energy Commission invests in RD&D to advance clean energy technology starting at the feasibility level, while venture capitalists do not usually fund technology until its feasibility is established and it is three or fewer years from the commercial market, maybe five years at most. On average social benefits of projects far outweigh costs, but because any individual project may have a high probability of failure and the benefits often carry over to many companies besides the one making the investment, private RD&D funds are difficult to obtain.

After PIER funds projects and demonstrates their viability, successful projects procure private funding and move on to produce and sell their products, earning further private investment. Figure 2 shows the rapid growth of cumulative small grant follow-on funding as mature projects attracted increasingly more funds. New and cumulative follow-on funding continues to

grow rapidly even though new funding for electricity small grants remains constant. This growth in cumulative follow-on funding will likely continue for many years as successful companies expand.[4] Since the small grants program began in 1999, awardees have garnered over $1.3 billion in follow-on investment, including $1.1 billion in private, non-utility investment.

Figure 2: PIER Small Grants Follow-on Funding



Source: California Energy Commission

Public Interest Energy Research Leverages Dollars and Creates Economic Partnerships

ARRA Smart Grid in California

The Energy Commission's PIER program invested $13.2 million in 15 California-based ARRA Smart Grid field testing projects that received over $426 million in ARRA funding from the DOE and created over 23,000 jobs in California. If California utilities had capitalized these Smart Grid efforts into their rates at a capital cost of 8.75 percent[5], ratepayers would be paying an additional $46 million a year over the next 20 years.

This endeavor is therefore saving ratepayers .016 cents per kWh in avoided utility capital costs. PIER staff helped applicants obtain their DOE grants by assisting with applications, writing letters of support to DOE, and by showing support with PIER investments up to $1 million per project. PIER staff leveraged additional ARRA funding for renewables, energy efficiency, advanced energy projects, carbon sequestration and training. Add these projects to the Smart

[4] The chart shows follow-on funding for recipients of small grants related to electricity supply or demand. The natural gas small grants program started in 2006 and its first awardees are just completing their work. The chart includes only that follow-on funding for which the year is known.

[5] Utility Weighted Average Cost of Capital, California Public Utilities Commission, Gas and Utility Cost Report, Public Utilities Code Section 747, Report to Governor and Legislature.

Grid work, and the Energy Commission's PIER program in total provided $21 million in funding and leveraged $1.4 billion of federal and private funding for 37 research projects.

Small Grants: Big Benefits

Small grants also yield large dividends. Since the PIER small grant program area's first competitive solicitation in 1999, over 300 grants were awarded for a total of over $29 million collectively. This funding fostered the growth of California companies and brought out-of-state companies to California. Starting with a $75,000 PIER grant:

- Nanosolar headquartered in San Jose, California proved the feasibility of a very thin film solar cell and received $400 million in follow-on funding from the private sector, and built production plants in San Jose, California and Germany.
- Dehlsen Associates, LLC (now ClipperWind), headquartered in Carpenteria, California proved the feasibility of a compact two-stage helical power train for wind turbines. In 2010, United Technology Corporation (UTC), one of the world's leading industrial technology companies, purchased the company for $318 million, infusing them with capital.
- Adura Technologies of San Francisco, California proved the feasibility of a wireless lighting control network that can control individual light fixtures in buildings, creating energy reductions of up to 70 percent. Adura received $20 million in follow-on funding from private venture capital firms to produce a commercially available product. Adura was recognized as one of CNBCs top 15 greentech startups and are on Greentech Medias top 50 list of companies poised for success in the emerging green technologies sector.
- CHA Corporation, at the time a Wyoming-based company, determined the feasibility of a carbon-based, microwave treatment system that removes hydrogen sulfide from dairy digester biogas and nitrogen oxide from engine exhaust to cost effectively meet 2007 ARB emission standards. CHA Corporation then engaged SMUD to fund a field demonstration in Elk Grove and is now working with ARB to develop permitting processes for the technology. CHA Corporation has now moved to Sacramento, bringing more clean technology expertise and job opportunities.

Research Highlights Environmental Issues and Avoids Billions in Property Damage

Environmental benefits accrue to the California ratepayer in two key ways. First, they reduce the emissions of criteria pollutants from energy-related activities in the state and, second, they reduce the impacts on California's ecosystem from all energy-related activities.

- Adaptation to Climate Change – $130 billion per year of property is at risk of coastal flooding because of climate change, and can be protected for $20 billion with seawalls, levees, and assorted maintenance suggested by PIER-funded studies. The California Coastal Commission continuously references PIER-funded and co-funded studies to make sure development projects will be prepared for flooding, erosion, storm events, and high waves due to climate change. The Bay Conservation Development

- Improved Water and Energy Management in California Reservoirs – PIER was an indispensible one-third partner in developing a modeling system to help operators optimize energy generation and water releases. The system is expected to save 700 GWh a year (enough energy to power 100,000 homes) and $46 million a year in the value of electricity saved and carry-over water storage.
- Reducing avian collision with wind turbines – PIER research strongly suggests that wind turbines on taller towers and careful placement within a given landscape can reduce bird collisions. This information is being used by several wind companies, including NextEra, to repower the Altamont Pass Wind Resource area with more efficient turbines which will lead to greater electricity generation per land area.
- Understanding air quality implications of using non-traditional fuels research program - the Energy Commission manages the natural gas research for the CPUC under the PIER Program. One project in this area is investigating the potential air emissions, safety and performance of using non-traditional natural gas (NG). This non-traditional NG has a higher Btu content and the potential to burn with a higher temperature, which creates more air pollution. This research has oversight and input from the South Coast Air Quality Management District (SCAQMD), the San Diego Air Pollution Control District (SDAPCD) and the California Air Resources Board (ARB). SCAQMD used results in the SCAQMD Final Staff Report for Proposed Rule 433 – Natural Gas Quality, May 2009. San Diego Air Pollution Control District (SDAPCD) is using the results to prepare for the importation of LNG into their District. Air Resources Board is using results from this program in revising their Compressed Natural Gas Fuel Specifications for Motor Vehicles.
- Evaluating the emission and performance impacts of NG vehicles from using high Btu natural gas – SCAQMD and ARB are co-funding a project that will evaluate the emissions and vehicle performance impacts using this non-traditional fuel.

Research Provides Grid System Reliability Benefits

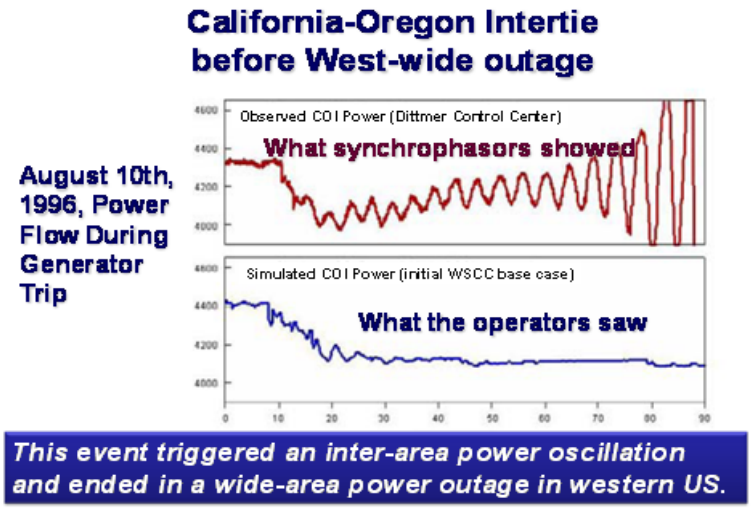
To increase reliability, the PIER program staff works to identify and develop technology and tools that reduce electricity disruptions. One example is PIER's support of synchrophasors-related research.

Synchrophasors

Transmission lines are currently vulnerable to large outages in part because their monitoring has become inadequate as the demands and stress placed on the grid have increased.

Trying to foresee and prevent outages using the current Supervisory Control and Data Acquisition (SCADA) grid measurement systems is like driving a car and only being able to open your eyes once every four seconds, since the SCADA system only reports status every four seconds. In contrast, "synchrophasors" measurement systems collect and report data 30 times a second. Synchrophasors provide much greater detail to assess the condition of the grid.

Figure 3 : Wide Area Power Outage



Source: California Energy Commission

The western United States power outage in August 1996—which cost California an estimated $2 billion—and the 2003 Eastern United States outage causing over $7 billion in damages might have been prevented by using synchrophasors to identify unstable power conditions leading up to the outage that current SCADA equipment misses.[6]

Synchrophasor research products, funded by the Energy Commission's PIER program, have reached a high level of development. One product, the Phasor-Real Time Dynamic Monitoring System (Phasor-RTDMS®) available from Electric Power Group LLC, is in version 7 release and is used by the CAISO and throughout North America. Other research products over the last 10 years include: development of an operator platform; applications for situational awareness, diagnostics, and control; and intelligent protection systems. These projects contribute to the development of state of the art synchrophasors and their applications.

In addition, the Energy Commission is partnering with the Western Electricity Coordinating Council (WECC) to create a Western Interconnection Synchrophasor Program (WISP) to deploy synchrophasors and associated Smart Grid functions on a large scale throughout WECC, based on PIER funded research, including oscillation detection and analysis and mode analysis for grid operation.[7] "There is a significant opportunity for improved Western Interconnection

[6] The $2 billion cost is cited by Vikram S. Budhraja. "California Electricity Crises" July 16, 2001 – Vancouver, Canada. Presented to. IEEE-PES Summer 2001. A $7 to $10 billion cost for the Northeast blackout was estimated by consulting firm ICF, in a report posted at http://www.solarstorms.org/ICFBlackout2003.pdf

[7] For example, at an "Oscillation Damping Meeting Update" at BPA in Portland, August 23-24, 2010, Vickie VanZandt said that WISP planned to incorporate the results of PIER projects 500-07-037 Task 3.2

reliability, the ultimate prevention of system-wide disturbances, and the integration and use of intermittent renewable resources through the use of Synchrophasor technology," WISP program manager and former senior vice president of Bonneville Power Administration (BPA) Vickie VanZandt notes. Regarding PIER's leadership role, VanZandt says, "We can stand on the shoulders of utility, government, and academic visionaries involved in the PIER program whose research and development will guide us in the implementation of a better, more flexible, and more resilient grid. The industry is benefitting today from the Energy Commission's imagination of a better future."[8]

Benefits of PIER Synchrophasor research include avoided costs of electric grid disturbances and outages to the California economy. Although PIER Synchrophasor research benefits extend far beyond California, the benefits quantified in this report pertain directly to California.

The Benefits of Outage Prevention

California faces approximately $8.1 billion a year in costs from electric grid reliability problems, while the U.S. as a whole faces approximately $79 billion according to Lawrence Berkeley National Laboratory researchers.[9] $49 billion worth of costs from reliability failures can be addressed if Americans would bring electric sector RD&D in line with that of other sectors, expand and strengthen transmission, create highly efficient microgrids with Combined Heat and Power generators (CHP) and storage, and build a self-healing Smart Grid, according to Smart Grid "father" Massoud Amin.[10] Amin was working from an Electric Power Research Institute study that estimated $119 to $168 billion in costs[11], so he is essentially arguing that 31 to 41percent of outages and disturbances could be avoided. For California, a 31 to 41percent reduction in the $8.1 billion unreliability costs per year would save $2.5 billion to $3.3 billion, an average $2.9 billion per year.

Ten percent of reliability problems occur in transmission and 90 percent in distribution,[12] so the expected cost of preventable transmission outages over a 10-year period range from tens of millions to over $300 million for California and up to nearly $1 billion for the entire Western Coordinating Council region (including California). A utility expert interviewed for a synchrophasor study estimated that half of transmission outages could be prevented with

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Oscillation Detection and Analysis (Completed 9/2010) and 500-07-037 Task 3.3 Application of Mode Analysis for Grid Operation (MANGO) on the Western Interconnection (Completed 12/2010).

[8] email message to PIER staff, quoted with permission of the author

[9] Hamachi-LaCommare, Kristina and Joe H. Eto, "*Understanding the Cost of Power Interruptions to U.S. Electricity Consumers."Lawrence Berkeley National Laboratory. September 2004.* http://certs.lbl.gov/CERTS_P_Reliability.html

[10] Amin, S. Massoud, "U.S. Electrical Grid Gets Less Reliable", Inside Technology: iEEE Spectrum." January 2011. http://spectrum.ieee.org/energy/policy/us-electrical-grid-gets-less-reliable

[11] Primen. 2001. The Cost of Power Disturbances to Industrial and Digital Economy Companies. Primen. TR-1006274 (Available through EPRI). June 29. Madison WI

[12] Hammachi-LaCommare, Kristina, and Eto, *op. cit.*

synchrophasors and associated applications. Thus synchrophasor research may be providing $145 million in reliability benefits.

Phasor-RTDMS®, a commercial product developed from PIER- funded synchrophasor research, alerted operators to worrisome oscillations on January 26, 2008, and they temporarily shut down a major power line at the center of those oscillations. A blackout probably would have occurred without this action. The danger would not likely have been noticed prior to the California Independent System Operator (CAISO) installing the Phasor-RTDMS® product.

Improving Building and Appliance Efficiency

Upon full implementation, California ratepayers will save nearly $1 billion annually from efficiency research incorporated into California Title 20 Appliance Efficiency Standards and Title 24 Building Standards. These savings will continue to increase as future PIER-funded work supports the standards.

The annual cost savings are based on five research measures that supported the state energy efficiency standards for appliances (Title 20) or buildings (Title 24). These measures included external power supply, residential furnace fan efficiency, television energy use, cool roofs for residential buildings and the residential attic/duct model. PIER research has been used to develop test procedures, support Building and Appliance standards, demonstrate new cooling systems for California's hot and dry climates and guide the development of energy efficient water heaters. These systems will increase the efficiency of homes and businesses in California.

- Cell phone, computer chargers-all new external power supply devices will save Californians an estimated 644 GWh annually (amount of energy used by approximately 80,000 homes in a year). This translates to annual cost savings of $90.2 million.
- The PIER-funded test methods that helped determine the efficiency of external power supplies are used by the federal EPA's Energy Star Program as well as by other countries.

Transportation Research Yields Benefits

Transportation has the biggest carbon footprint of any sector in California. In 2008, 36 percent of the greenhouse gas emissions came from transportation while only 24 percent came from electricity generation (including imports). A full fuel cycle analysis published in the State Alternative Fuels Plan shows that CNG light-duty vehicles provide a 70 percent reduction in greenhouse gas emissions as compared to gasoline vehicles. PIER funded a successful demonstration of the Cummins Westport ISL G natural gas engine which meets the newest US EPA and ARB emission requirements in a PG&E service truck. As a result of this effort between the Energy Commission and ARB, this engine is now commercially available from multiple leading vehicle manufacturers, which produce trucks, yard tractors, street sweepers, school buses, and shuttle buses. Cummins has sold over 400 ISL G engines for vehicles in 2009 and 2010.

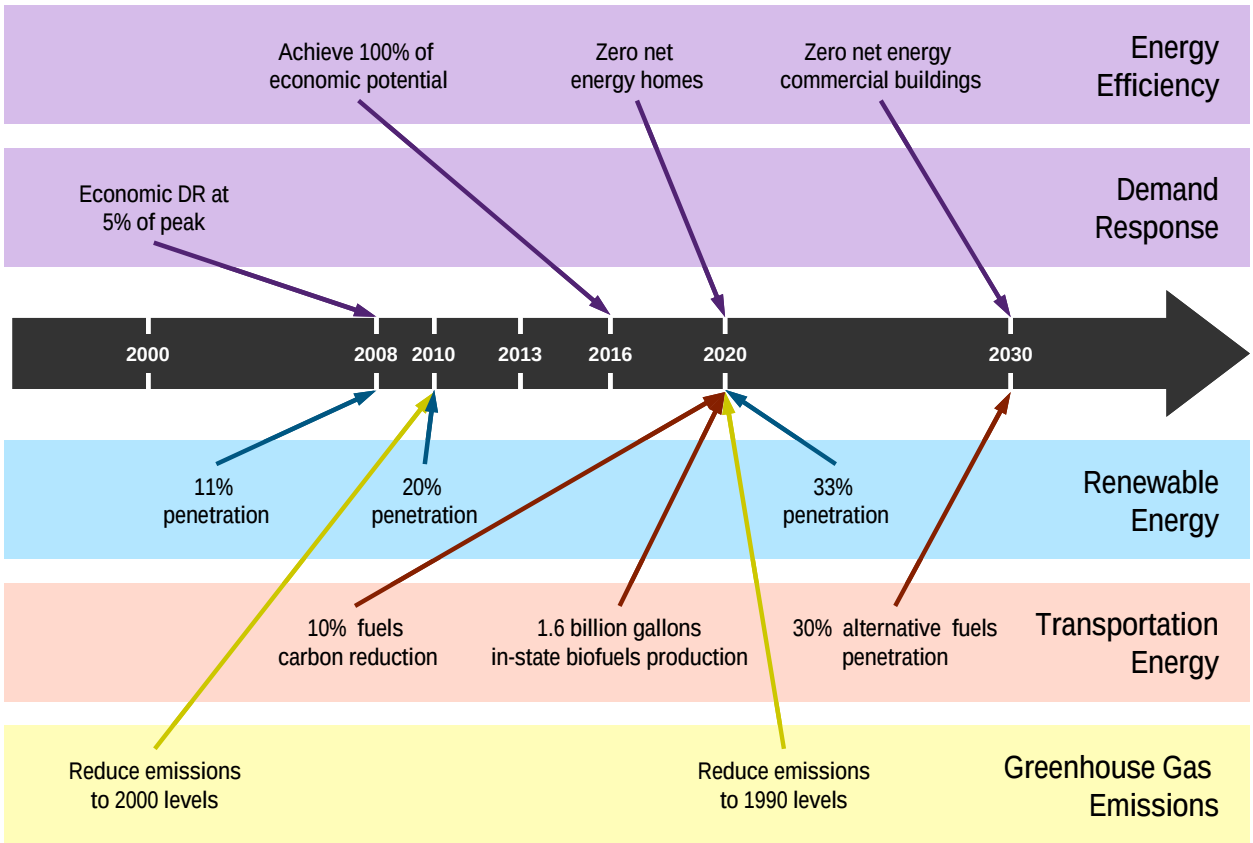
Improving and Modernizing Benefits Assessment

Consistent with recommendations from the PIER Advisory Board, a "PIER Benefits Assessment Workshop" is planned in May 2011 to provide a public forum for information sharing on the methodologies, frameworks and assessments of the benefits of public energy RD&D that are currently used in a number of scenarios. The purpose of the workshop is to refine and improve how PIER benefits are assessed and reported. Sessions on economic, environmental and reliability benefits are planned, in addition to job creation and the benefits of meeting and informing public policy.

CHAPTER 3:
PIER Research 2010, On the Road to Meeting the Goals of 2020 and Beyond

As the state's primary energy policy and planning agency, the Energy Commission makes assessments and forecasts to develop energy policies that conserve resources, protect the environment, ensure energy reliability, enhance the state's economy, and protect public health and safety. In meeting the provisions of SB 1250 (Perata, Chapter 512, Statutes of 2006), the PIER program funds RD&D to address the state's energy policy goals as illustrated in Figure 4.

Figure 4: California Energy Policy Goals



Source: California Energy Commission

In 2010, the Energy Commission used PIER funding for projects that brought advanced energy technologies to California that will help to meet the state's energy policy goals. Illustrated below are examples of promising projects in the following areas: energy efficiency and demand response, renewables, advanced generation, transmission and distribution, transportation and climate/environmental.

Energy Efficiency and Demand Response Technology Projects

Lighting consumes about 43 percent of electricity consumption in California. This presents a huge opportunity for advanced, energy-efficient lighting technologies to be developed and deployed to save a significant amount of energy across California.

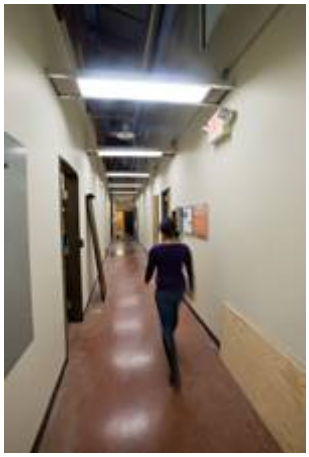
The Energy Commission teamed with manufacturing partners and utilities to develop, demonstrate, and commercialize lighting products and systems for both commercial and residential applications. Key areas of focus were daylighting, demand response systems, integrated lighting and control systems, and solid state lighting products. These projects address state energy policies to meet the zero net energy goals for residential buildings by 2020 and commercial buildings by 2030, plus meeting the green house gas reduction goals of AB 32.

Lights Out in Smart Corridors

The California Lighting and Technology Center (CLTC), in a cooperative effort with Southern California Edison (SCE), San Diego Gas & Electric (SDG&E), and SMUD, is taking the research from exterior spaces and applying it indoors, to corridors, stairwells, hallways, closets, and other unassigned spaces.

A CLTC study at UC Davis found that areas with no occupant ownership represent a significant demand-response (DR) and energy-saving opportunity of approximately 19 percent. Many stairwells and corridors are illuminated continuously regardless of occupancy or activity requirements. Other recent CLTC studies have shown bi-level corridor and stairwell lighting systems possess an energy savings opportunity of 40-50 percent. For example, if all corridors in SCE commercial territory were required to install bi-level/full-dimming controls, it would result in an estimated 1,615 GWh annual reduction (19 percent savings) and an estimated 55 MW reduction of load during demand events.

Figure 5: Smart Corridor



Source: California Lighting Technology Center

The results of these cooperative efforts will provide data to better understand the potential energy savings in corridor and stairwell lighting over typical incumbent lighting. Incumbent

lighting systems in corridors and stairwells are usually equipped with the building's standard, non-dimmable ballast and operated with wall switches or from the panel box.

Efficient Lighting with Sensor Dimming Technology for Daylight Harvesting

Unreliable daylight sensor technology is the main barrier to wide spread adoption in the market place. The goal of this project is to increase the reliability and effectiveness of daylighting control systems for commercial spaces with skylights by improving their daylight sensing capabilities in a cost-effective way. Traditional lighting controls have been either "open loop," where control is based on sensing an external lighting factor such as the outdoor lighting level, or "closed loop," where the control is based on sensing the indoor lighting level. Each approach by itself has reliability problems. This project focused on improving the reliability of daylight sensing.

A self-commissioning dual-loop sensor dimming technology was developed, which solved the short comings of open loop and closed loop daylight harvesting approaches by combining the two technologies into one, creating a more reliable and cost effective daylight sensor.

Figure 6: Self Commissioning Dual Loop Sensor dimming Technology

Source: California Lighting Technology Center

This project was the result of previous PIER research in daylight harvesting controls by the CLTC. The shortcomings discovered during previous PIER sponsored research lead to this new technology. This product will be commercialized and available in the market by early 2011 from various manufacturers.

A CLTC demonstration at Wal-Mart has shown that large retail stores, warehouses, industrial facilities, or commercial spaces with existing skylights and dimmable fluorescent ballasts can save 35percent of electric light load if equipped with this dual loop sensor.

Integrated Classrooms-Retrofit Lighting Systems

Lighting represents 30 percent of total electricity use in educational facilities. Many schools are looking for ways to retrofit the electric lighting in their classrooms to save money and improve classroom lighting. Retrofit lighting solutions were developed by Finelite, Inc., through the CLTC and demonstrated for classrooms to integrate luminaries, sensors, and controls, providing quality lighting for general and audio/visual settings together with white-board lighting. This research gives schools a "good," "better," or "best" way to combine

state-of-the-art luminaries, lamps, ballasts, sensors, and controls into cost effective, retrofit system solutions.

Figure 7: Integrated Retrofit Classroom Lighting

Source: California Lighting Technology Center

The Retrofit Integrated Classroom Lighting System (R-ICLS) was developed and demonstrated in 13 classrooms in three schools in California. Finelite Inc., commercialized the R-ICLS systems. Based on a one percent market penetration and energy savings potential of 20 percent for lighting, electric consumption savings of 4 GWh and demand savings of 0.8 MW could be achieved throughout California. Finelite, Inc. will continue to evaluate the design and system configuration to develop cost-effective classroom retrofit solutions.

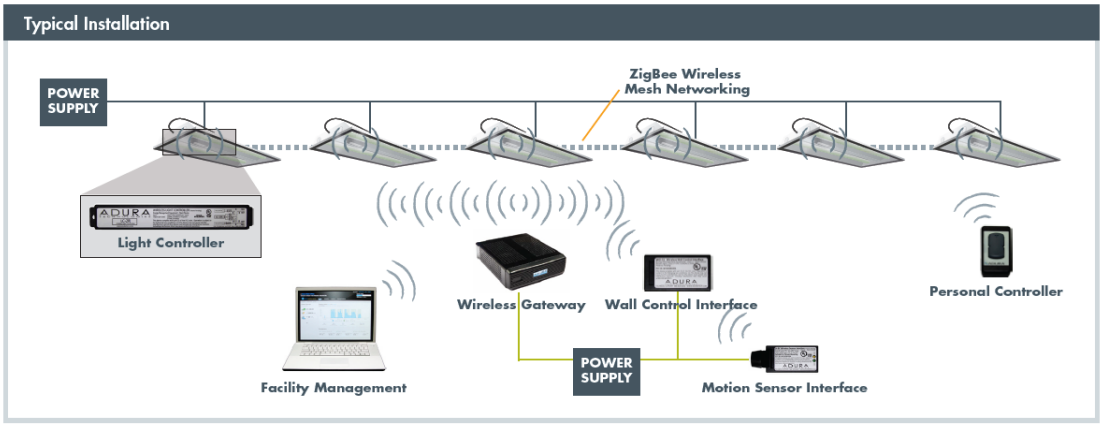
Lights Out in Commercial Buildings

The average commercial building in California spends 35 percent of its total electricity use on lighting systems. This project will develop and commercialize an easy-to-install wireless lighting control system that combines photo sensors and motion sensors with low power wireless communication, and will eliminate the need to be wired into the switchbox or ceiling-mounted near the luminaries. This system can reduce lighting use with a lower installed cost, and improve the reliability of lighting controls by placing sensors in convenient and accessible locations. The system is compatible with any ballast-based lighting system.

This system was developed and demonstrated to save up to 25 percent of energy use in corridors, schools, parking garages, warehouse facilities, private offices and other commercial spaces. This research follows previous work done by Adura Technologies, the CLTC, and the PIER Program. Adura Technologies is a company that originally started with the help of PIER funds. Adura has commercialized the system, and will continue to look at opportunities to refine the lighting control system to make the controls demand response capable and applicable to more spaces. This would further increase energy savings throughout California.

Retrofitting technologies into buildings is normally prohibitively expensive. Wireless controls remove this cost barrier and represent game-changing technologies that are easy to install and cost effective.

Figure 8: Wireless Lighting Controls



Source: Adura Technologies

Source: Adura Technologies, California Lighting Technology CenterIntegration of Electric Lighting Controls with Utility Demand Response Signals

This project is identifying and demonstrating the most cost-effective and reliable combinations of utility demand response (DR) signals and electric lighting controls to implement automated DR capabilities with bi-directional communication capabilities. The resulting systems will allow utilities to get feedback on achieved lighting load reductions during DR conditions and is applicable to all buildings.

SCE, through the CLTC, tested three Advanced Lighting Control Systems from Convia, Lutron, and Universal. All three of the installed systems were able to respond successfully to the requirements of demand response operation and to provide energy savings. Ongoing training for electrical contractors for installing and programming advanced lighting control systems with DR will continue. The potential impact of this system on California's peak energy demand is 7.8 megawatts.

Figure 9: Universal Suspended Lighting System

Source: Southern California Edison

Demand Response for Peak Reduction with Energy Storage

PIER-funded research addresses energy efficiency measures including demand response (DR) which encourages customers to reduce electricity generation during peak use hours, often by shifting use to off-peak hours to when power is cheaper, cleaner and transmission lines are not congested. To avoid a repeat of the 2001 energy crisis and to examine money saving opportunities, PIER funded the Demand Response Research Center (DRRC) to develop, test,

and demonstrate "automated demand response" (AutoDR) and an associated server/client application, "OpenADR."

AutoDR is a logic built into energy management systems, thermostats, some refrigerators, and, increasingly, other energy-using equipment. For example, AutoDR allows an electricity customer to tell his or her thermostat how to respond to variations in electricity price over the day. The thermostat then uses the embedded OpenADR client to visit a utility's server, comparable to a secure Internet website, and procure information of interest such as current and hour-ahead electricity prices or outage information, so the thermostat can follow the customer's instructions on how much to heat or cool. Customers can change instructions or manually override. Many applications reduce rather than move electricity demand; for example a customer may tell lights to dim or every other photocopier to idle when prices get too high. In these ways, automated demand response adjusts peak demand instantaneously by using market incentives rather than direct control.

With continued PIER-funded work, AutoDR has moved from an idea to a tested product, and OpenADR has become a National Institute of Standards and Technology (NIST) recommended standard for Smart Grid. Fifty vendors have built AutoDR logic into their electricity management systems.

OpenADR is now being used to provide 80 MW of peak electricity capacity and is contracted to provide 160 MW by the end of 2011. That will save ratepayers at least $35 million a year, and savings will climb as more OpenADR gets installed in future years. These savings occur because OpenADR reduces a business's peak load 24 percent on average, over four times the 5 to 6 percent projected for regular demand response in a 2007 study.[13] That means companies intending to participate in demand response quadruple the size of their response when they automate that demand response. Conversely, companies investing in AutoDR and OpenADR may have achieved one fourth of their reduction without automating their DR, so it is reasonable to attribute only three fourths of their savings to automation. Open ADR is thus expected to reduce annual peak by 123 MW by the end of 2011, three fourths of the 160 MW installed. Ultimately, 123 MW less of power plant capacity will have to be built or procured, avoiding $35 million a year in power plant construction and fixed maintenance costs that would otherwise be passed on to ratepayers. Because utilities provide OpenADR installation incentives to participants and ratepayers cover utility costs, the benefits to ratepayers not participating in automated demand response programs come to only $31 million a year, or about .01 cents per kWh on their electric bill. Those ratepayers installing OpenADR save more.

Sustainable Performance of Buildings

Saving energy in buildings involves more than developing new technologies. High-efficiency equipment that is not properly installed, calibrated, tested, operated or maintained will typically save far less energy than estimated. There is a critical need to train skilled people to

[13] "Estimating Demand Response Market Potential among Large Commercial and Industrial Customers: A Scoping Study", Ernest Orland Lawrence Berkeley National Laboratory, Goldman, Neenan and Cappers, January 2007.

design, construct, operate, and maintain increasingly complex buildings and systems. The goal of this project is to improve the ability of the buildings industry to deliver and operate energy-efficient commercial buildings by enhancing the education and training of architects, mechanical designers, commissioning providers, service technicians and building operators.

The approach is a high-quality graphic simulation tool for workforce development, teaching operation and maintenance of heating, ventilation, and air conditioning (HVAC), lighting, daylighting, and building envelope systems. The target audiences are students in community colleges and four year colleges and universities, technicians, operators, and design professionals. This project builds on previous collaborations between Sustainable Performance of Buildings and Lawrence Berkeley National Laboratory funded by the National Science Foundation Advanced Technological Education program and by the California Energy Commission.

The result of this project will be a software suite that shows how HVAC, lighting, daylighting, and envelope systems work. The software will be easy to use and will use 3D graphics to display the systems to the student.

For example, a student will be able to watch a 3D visualization for each HVAC system component (for example, fans, heating coil), and see data such as air flow rates and temperatures for those components. A student can manipulate the components, closing or opening a heating coil valve, and see in real-time the effects of those changes on the system. Students will learn how normal component behavior and even system faults affect the system. As an educational tool, for example, professors could introduce a hidden fault and ask a student to diagnose the system based on how the system responded.

Improved technology, on its own, does not necessarily guarantee better energy use characteristics. Therefore, the workforce must understand the technology and how systems work, so the new technology can be installed and maintained properly and result in the expected energy use improvements.

This software will be used in educational environments such as two and four year colleges or utility training programs. The software suite can be integrated into new and existing curricula, and will convey concepts to students through easily understood and attractive graphics. The contractor already teamed up with several entities that have shown interest, including some California Community Colleges and the UC Merced, as well as the U.S. Department of Energy.

Automated Fault Detection for HVAC Energy Efficiency

HVAC equipment can waste large amounts of energy if not tuned properly or if undetected repairs are necessary. The Energy Commission's PIER Program sponsored the development of technology, which can detect faults in HVAC equipment and notify appropriate personnel that repairs are needed. Equipment was developed to diagnose the root cause of a problem, even when numerous problems are detected.

Field Diagnostic Services, Inc. (FDSI) was one of the pioneers in this field and collaborated with the Energy Commission's PIER program to commercialize the technology. FDSI developed a

Service Assistant tool, which instructs HVAC technicians regarding adjustments and repairs needed for rooftop air conditioning systems. With PIER funding, FDSI developed a networked version of the technology, which detects the faults and communicates them to managers over the internet. The software is sophisticated enough to estimate costs of energy wasted, and likelihood of expensive breakdowns from deferred service. This allows managers to prioritize expensive service visits.

Bank of America implemented an improved and expanded system across their 3,200 branch network in 35 states. A team of 3 managers at headquarters is able to monitor the performance of all of the rooftop units, and notify service contractors in distant states when repairs weren't sufficient. The system can even detect when lights were inadvertently left on, for further energy savings.

Figure 10: Automated Fault Detection

Source: Field Diagnostic Services, Inc

A related effort is being researched through another PIER funded project across the entire chain of over 1,400 Target stores in the United States. This system mines existing data from Target's facility management system in Minneapolis for clues on what equipment is not functioning properly. Target can dispatch service personnel with more precise equipment to diagnose the problems completely. These large companies have realized that they can manage energy costs efficiently by detecting and correcting faults in air conditioning systems.

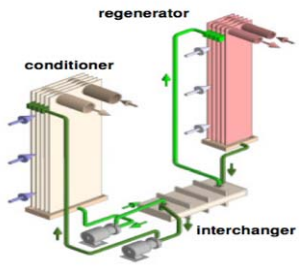
Cool Data Center

The electricity consumed in data centers and telecom systems is estimated to be 3 percent (8.6 billion KWh/year) of California's total and is increasing rapidly. The energy used to provide cooling for data centers can be as much as 45 percent of the total facility power. Air and liquid cooling are the only options for data center cooling. Because of the increasing energy intensity of data centers, air cooling has become more costly and less able to meet the cooling demand. However, there are technical challenges to using liquid cooling in a data center.

The development of this liquid-cooled technology received prior PIER Program funding. Clustered Systems was awarded an Energy Innovation Small Grant to demonstrate the liquid-cooled, cold plate technology with the cold plate attached to a standard server. Clustered Systems then received funding through the California Institute for Energy and Environment to

advance the technology by constructing a server rack using conventional servers adapted for liquid cooling. The current project will further develop the technology and has received funding of almost $3 million from the American Reinvestment and Recovery Act.

Figure 11: Low-flow liquid-desiccant components



Source: University of California, Merced, California

Clustered Systems will develop a prototype Very Dense Liquid Cooled Computer Platform. The prototype consists of two server racks, with twelve shelves each, housing a minimum of 144 modules. The application of liquid cooling to this rack design is estimated to achieve a 17 to 45 percent reduction of energy used for cooling compared to air cooling. The project received ARRA funding to further advance liquid cooling of data centers and will be adopted into high performance computing applications. Estimates indicate that this technology has the potential of reducing cooling energy required in a data center by 45 percent. If all data centers adopted this technology by 2015, annual savings will be approximately one billion kilowatt-hours.

New Refrigeration Technology Gives Cold Shoulder to Energy Bills

Refrigerated warehouses are responsible for about 20 percent of the total electric energy used in the food industry. California has about 246 refrigerated warehouses with approximately 475 million cubic feet of cold storage. The electrical power requirement (estimated at 3 kilowatts/ton) is 360 megawatts, and the total annual power consumption based on 5,000 hours/year is 1,800 million kilowatt-hours. Energy conservation in refrigerated warehouses can produce significant benefits to electric ratepayers, and the food industry.

This project developed technology to remove humidity from air in refrigerated warehouses using a liquid desiccant heat exchanger located close to the evaporator. The project was conducted in a Del Monte Foods™ refrigerated warehouse and Aslan Cold Storage, located in Kingsburg, California.

A liquid-desiccant system, which was tested at a commercial cold storage facility, has the potential to completely eliminate defrosting at refrigerated warehouses, while retaining the conventional finned-tube refrigeration coils that are now widely used. Indoor air was dehumidified using a low-flow liquid-desiccant absorber to lower the dew point of the air that enters the cooling coil to a value that is several degrees lower than the surface temperature of the coil. After absorbing water, the desiccant was regenerated to its original concentration by bringing the weak desiccant in contact with low relative humidity ambient air, without using any external heat source. The desiccant was regenerated using waste heat from the refrigeration system and solar collectors.

The results show that cold humid air inside the refrigerated warehouse could be dehumidified by lowering its dew point temperature to a value near or below the surface temperature of the cold storage evaporator. This technology has the potential to significantly reduce—or even eliminate—ice-formation on the surface of the cooling coil. With the proper maintenance, related to air and liquid desiccant systems, the prototype showed no reliability problems although some signs of corrosion were found in some metallic components. This corrosion most likely occurred when desiccant droplets were entrained in the air stream during abnormal operation, possibly when a poorly supported air filter made contact with the core of the desiccant absorber. The proposed technology is expected to reduce California's power needs by around 400 million KWh annually, if every refrigerated warehouse uses the proposed technology.

Other energy efficiency technology projects that result in ratepayer benefits and meet state energy policy include:

- A wireless control technology demonstration at a Franchise Tax Board data center that reduced cooling energy by 58 percent and total energy use by 15 percent. This translates to annual savings of 475,239 kWh or $43,000. Technology will now be used in 12 other state data centers in California. The technology should result in a 20-25 percent reduction in energy use with an annual savings of 4.7 million KWhs or over $500,000.
- A natural gas-fired drum dryer technology demonstration at the California Garlic Processing Plant (ConAgra) has the potential to save the industry $21 million in annual natural gas costs according to a Gas Technology Institute study. California consumes an estimated 14.4 trillion British Thermal Units (Btu) of energy for drying fruits, vegetables and other food products. Drum dryer technology increased energy efficiency 25-40 percent. This represents a potential savings of $21 million dollars in natural gas costs to California industry based on $1 per 100,000 Btus. Product is now commercially available.

Energy Efficient Community-Scale Development

Within the next 25 years, the U.S. will construct over 213 billion square feet of new space, presenting an opportunity to design and build homes, offices, other commercial and industrial buildings, and public facilities to a new level of energy and resource efficiency and incorporate zero net energy policy goals for residential and commercial buildings. While technologies exist to improve the energy efficiency of individual buildings, little research has been conducted on optimizing energy and resource efficiency at a larger scale. Before sustainable communities can be considered as a viable development option, research is needed to develop tools that will enable the optimization of designs and the resolution of technical and market barriers.

This PIER-funded project allowed researchers at the National Energy Center for Sustainable Communities to study two planned development sites in the City of Chula Vista, California. Their research goal was to explore the potential economic and environmental benefits and costs of different energy technologies, and community design options in large-scale projects.

The energy-efficient alternatives studied included higher efficiency grades of wall and roof insulation, windows, doors, lighting, HVAC equipment including thermal storage, appliances, solar thermal technology, and a district cooling system. In addition, researchers considered the following four alternative development scenarios:

- a builder-proposed baseline
- an energy efficiency package
- an energy efficiency package combined with distributed generation
- an energy efficiency package combined with photovoltaics

The modeling showed that aggregate energy consumption of large-scale development projects could be reduced by as much as 43 percent, peak demand by 45 percent, and carbon dioxide emissions by 33 percent as compared to a Title 24-compliant project.

Renewables Research and Demonstration Projects

Pending re-authorization, immediate research that will be undertaken within the next two years focuses on deployment and integration projects targeted at several key market scales: utility scale, community scale, building scale, and residential scale. This strategy's goal is to increase reliable access to renewable energy, reduce technology integration barriers, improve renewable energy forecasting and storage, reduce the cost of renewable energy, and maximize infrastructure. By focusing on the different market scales, the Energy Commission can close the gap in research for the deployment of renewable energy technologies and accelerate system integration. This strategy also allows the Energy Commission to coordinate and collaborate on infrastructure requirements, resource allocations, and end user needs, and could ultimately accelerate commercialization of renewable energy to meet California's 33 percent Renewable Portfolio Standard (RPS) goals for 2020 and beyond.

Walnut-Powered Farm

This PIER-funded project designed, developed and demonstrated a 50-KWh biopower system to convert walnut shell residue into clean power and heat in a reliable and automated system. This project demonstrated the use of biomass residue as an alternative to fossil-fuel fired distributed generation power system. It also provided economic benefits by reducing the use of fossil fuel (propane and natural gas), and resulted in the reduction of greenhouse gas emissions.

This biomass gasifier system was installed in November 2007 at the Dixon Ridge Farms in Winters, California, the nation's largest grower and handler of organic walnuts (with more than 400 acres of organic walnut farming). The system gasifier converts the walnut shell residue to producer gas, which is a mixture of fuel gases such as hydrogen, carbon monoxide and methane. The gas mixture is ignited in an internal combustion engine, and spins a generator to make utility grade electricity. Waste heat is captured in the form of hot water. A two-year field demonstration was conducted to prove the robustness and reliability of the mechanical design, as well as, the ability of the automation for an operator to control system operation from a remote location. The engine/generator is capable of operating 24 hours a day, six days per week.

The gasifier system uses over one-third of the annual 2.5 million pounds of walnut shell by-product to offset site electrical needs by up to 40 percent during shelling and freezer storage, and provides heat for buildings and walnut drying operations. In its current configuration, the biomass gasifier produces about $40,000 worth of electricity per year as well as off-sets about $12,000 worth of propane that would otherwise be used in walnut dryers.

Figure 12: Dixon Ridge Farms Walnut Shell Powered Co-Generator

Source: California Energy Commission

Dixon Ridge Farms won the Governor's 2008 Environmental and Economic Leadership Award for Climate Change, consisting of "Innovative and forward thinking approaches that reduce greenhouse gas emissions and mitigate the adverse effects of climate change on public health and our vast natural resources." There have been many tours and demonstrations of this technology at Dixon Ridge Farms that have raised public awareness about alternative energy from biomass. Over a thousand people, including the press and television reporters, the state and federal government officials, and representatives from 14 countries have visited the site over the past two years. This project has demonstrated California's leadership in the conversion of a waste biomass material into useful electrical and thermal power.

The small modular biopower system at Dixon Ridge Farms continues to demonstrate the robustness and reliability needed to meet commercial standards. Based on the success of this scaled up system, larger systems are now being developed that will have twice the output of the demonstrated unit, but still retain their automated, modular nature.

Environmental Impacts of Increased Woody Biomass Use in California

The implementation of California's Renewable Portfolio Standard may drive an increase in the use of woody biomass for renewable energy generation. Forest woody biomass utilization will likely have both positive and negative environmental effects. Likely sources of woody biomass within the state that could be used for renewable energy projects include residues from sawmills, timber harvests, tree thinning and fuel reduction projects. While a number of studies have estimated the amount of biomass that could be sustainably harvested, there is little data on the potential environmental impacts of increasing harvest rates from current levels. This project

reviewed the published literature relevant to the potential environmental impacts of different forest management approaches to support increased woody biomass use for energy generation in California, and identified information gaps that exist in understanding the potential impacts.

The study surveys stakeholder sustainability perspectives and recommends woody biomass harvesting guidelines based upon a review of other state's guidelines and evaluates existing forest certification sustainability programs. Environmental benefits from forest biomass harvesting in California forests identified in the study include reduction of wildfire intensity, and insect and pathogens infestations. The major environmental concerns associated with additional biomass harvesting addressed in the literature and in recent guidelines are 1) protecting long-term soil productivity, 2) minimizing harvest related erosion and water quality impairment, and 3) maintaining important wildlife habitat and biodiversity elements across the larger landscape.

Figure 13: Woody Biomass

Source: US Forest Service, Pacific Southwest Region

The results of this study will guide future research necessary to ensure sustainable woody biomass utilization for renewable energy generation. Ratepayer benefits will include greater renewable energy generation, reduced greenhouse gas emissions and healthier forests.

Transportation Projects

Transportation energy research is evaluating and developing second-use applications for vehicle traction batteries for distributed use and will expand this research to include industrial sites, shopping malls, large buildings, and public charging stations. In addition, transportation energy research plans to conduct research to guide the development of standardized battery components for use in both Plug-in Electric Vehicles (PEV) and stationary storage applications. Standardized batteries could further increase PEV battery production volumes, thereby reducing per-unit battery costs while simultaneously allowing the significant public and private investments in PEV battery technology to be more easily deployed and integrated.

Plug-in Hybrid Electric Vehicle Research Center Projects

The PIER-funded Plug-in Hybrid Electric Vehicle (PHEV) Research Center conducted a project to observe the real-life charging and driving behavior patterns of PHEV consumers using plug-in Prius conversions with 20 miles of all-electric range. The project found that PHEV drivers typically plugged in their vehicles after 4 p.m. and left them plugged in until 6 a.m. the next morning. These findings indicate that the majority of vehicle charging can be done at nighttime when power demand is low, and clean renewable wind resources are more abundant. These findings indicate that with proper time-of-use controls to avoid the 4 p.m. to 7 p.m. peak load, rate-based upgrades to the electricity infrastructure may not be necessary to accommodate the near-term adoption and use of PHEVs. The project also found that these consumers achieved fuel economies between 50-80 miles per gallon and were able to reduce their greenhouse gas emissions per mile by about 30 percent as compared to a conventional vehicle with a fuel economy of 28 miles per gallon.

In another project, the PHEV Research Center used real-life consumer driving and charging behavior data to update the Advanced Vehicle Lifetime Emissions Model to compare the energy and greenhouse gas emissions of plug-in hybrid electric vehicles to their gasoline counterparts. Findings from the model indicate that PHEVs could reduce gasoline consumption by 50-90 percent and greenhouse gases emissions by 20-30 percent as compared to their conventional fueled counterparts. In addition, data developed from this model can be used to help set fuel economy standards for plug-in hybrid electric vehicles in California.

Findings from the UC Davis Plug-in Hybrid Electric Vehicle Research Center indicate that PEV batteries—after they are no longer suitable for use in the vehicle—could potentially be repurposed for a second-life use in stationary storage applications, providing valuable services to the grid, the utilities, and electricity customers. The UC Berkeley study *Strategies for Overcoming Battery First-Cost Hurdles* found that revenue streams generated from these second-use applications could be used to significantly reduce the upfront cost of batteries and therefore PEV ownership.

Assess New Transportation and Land-use Patterns in a Carbon-constrained Future

UC Berkeley researchers are using PIER funds to develop methods to determine how much fuel can be saved through community design. While hybrid and electric cars and cleaner fuels will be a large part of the solution to transportation's oil dependence and emissions problems, they will not contribute enough savings to achieve the state's ambitious objectives for a clean and sustainable future. More compact and transit-friendly urban development patterns will become part of the state's strategy for energy efficiency and emissions reduction.

This project is identifying methods to improve the performance of the Energy Commission's transportation energy analysis and forecasting models by the development of land use model. These models will provide California's major metropolitan regions with an independent estimate of the combined fuel-saving potential of land use and transportation measures. This information will also provide state and local agencies with an assessment of policy options that

will enable them to effectively pursue land-use and transportation strategies that reduce energy use and emissions.

These projects will help the Energy Commission improve its modeling, will help other agencies incorporate energy analysis into their work, and will point the way to more effective state, regional and local energy and emissions reduction policies and actions .

Findings from previous and on-going research have shown that integrating plug-in electric vehicles (PEVs) with the electric grid may prove extremely challenging for both the transportation and electricity sectors. Automotive-grade lithium batteries and Smart Grid are the key technologies that are on the forefront of addressing these challenges. Over the next five years, transportation energy research will explore strategies to reduce and restructure the high cost of automotive-lithium batteries; provide new tools, methods, and technologies to develop vehicle recharging networks that effectively interact with a Smart Grid; and determine optimal conditions for the deployment of PEV rollout schedules, recharging infrastructure, time-of-use electricity rates, and smart charging technologies. Smart Grid research will help integrate the growing number of electric vehicles and hybrid electric vehicles into the daily operation of the grid.

Climate/Environmental Projects

California's long history of environmental responsibility in its energy sectors continues to be driven by a commitment to protect land, air and water quality and reduce dependence on foreign oil. California's aggressive yet forward-thinking energy policy goals, namely the renewable portfolio standard and greenhouse gas reduction targets, are rooted in environmental protection. A significant challenge in permitting renewable energy projects is often the lack of data necessary to complete permitting requirements. For example, in 2010 the Energy Commission approved nine concentrating solar developments representing 4,124 megawatts. Four of these projects are currently being legally challenged over the lack of environmental review due to lack of appropriate scientific information. Research is needed in this area to provide scientifically credible data to inform decision makers. The Energy Commission will perform energy related environmental research that continues to focus on climate change science, removing barriers to greater penetration of renewable energy and emerging technologies, maintain or improve resource conservation, air quality, public health, water management, and environmental justice as effected by energy generation, transmission, distribution and use.

Projects in 2011 will reduce resource consumption, and will help promote Governor Brown's energy plan to build 12,000 megawatts of localized electricity generation—either onsite or close to where energy is consumed—that can be constructed quickly and with relatively low environmental impact.

A new project—one that will begin in 2011, titled *The Potential Energy Scenarios for California and their Environmental Consequences*—will address how California will meet projected electricity demand through generation, storage, transmission, and distribution through 2050. This project will model the electricity system under different environmental assumptions, and also estimate

the potential location of new energy development to minimize environmental impacts. This proactive approach to will help avoid permitting delays and potential litigation, such as those currently experienced for solar developments in California's deserts.

Reduced Biological Impacts of Solar Energy Development in the California Desert

If California is to achieve its RPS goals, utility-scale solar projects must be developed. Such developments have large land requirements and, if located in the desert, can impact water supplies, ecosystems and species. The Energy Commission and California Department of Fish and Game (DFG) are developing a Desert Renewable Energy Conservation Plan (DRECP) for the Mojave Desert and Colorado Desert of California.

Figure 14: DRECP Planning Area Map

Source: California Department of Fish and Game

To advance the DRECP, and facilitate environmental review and permitting, the Energy Commission provided PIER funding for six projects that are coordinated with DFG and the Energy Commission's Siting Division. The research goal is to remove barriers and delays in the siting of renewable energy in the desert. It will benefit the state and ratepayers by advancing the state's RPS goal and facilitating the completion of the DRECP, which will help ensure that the desert's renewable energy projects can provide clean energy and jobs to benefit California's ratepayers in an environmentally responsible manner.

Indoor Environmental Quality and HVAC Efficiency Trade-Offs for Businesses

The California Energy Commission establishes energy efficiency standards for buildings (Title 24) and appliances (Title 20). These standards are updated periodically to allow consideration and possible incorporation of new energy-efficiency technologies and methods. When updated, however, the building efficiency standards must ensure that the new requirements maintain or improve indoor air quality necessary for the building occupants' health and safety.

This project evaluated sources of indoor air pollution, the relationship between indoor pollution levels and energy consumption, and approaches for improving indoor air quality in small and medium commercial buildings, an area where rapid growth is occurring and major

opportunities for improvement are available. This study monitored approximately 37 small and medium-sized commercial buildings, including a sample of buildings primarily built between 1978 and 2006.

Figure 8: Commercial Buildings

Source: Ash Leshger

The key findings from this study are: (1) current Title 24 codes for heating, ventilation, and air conditioning equipment and mechanical ventilation appear to not always be enforced, resulting in a lack of mechanically-supplied outdoor air, (2) some buildings have very limited or no maintenance conducted on their heating ventilation air conditioning units, (3) California commercial buildings have significant uncontrolled leakage, a condition that has been addressed in California homes in recent years, (4) indoor levels of most pollutants are below regulatory or recommended health protective levels (although formaldehyde was found to consistently exceed chronic exposure levels), and (5) particle filters are generally of low efficiency.

This research will help provide the needed benchmarks in assessing the energy and indoor air quality performance of buildings and will provide the basis for developing more energy efficient and effective indoor air quality measures and technologies that the Energy Commission can use in developing building energy efficiency standards. Ratepayers will benefit from this project from the improved protection of indoor air quality and greater building energy savings.

California Time-of-Use Water Meter Study Links Water and Energy Demand

California water agencies bill their customers based on the volume of water they use. Currently, there is no method of separating the water used by customers during the hours of electric utility peak electrical demand periods from the water used by customers during non-peak periods. Because the water is billed on a monthly volume-use basis instead of a time-of-use basis, it is difficult to know how much of this water use occurs during times of electrical systems peaks. As a result, there are no incentives for water customers to curtail water use during times of peak electrical loads. In addition, the water pumping electrical loads are required to operate during times of peak electrical loads to supply this water demand.

This project assessed the impact of a combination of time-of-use (TOU) water meters with incentives on water consumption patterns for representative members of water system customer classes during peak electricity demand periods. The project assessed the resultant change in peak water agency electrical demands. The research purpose was to determine

whether reductions in peak period water use could be a viable means by which other water agencies in California and elsewhere can reduce peak electrical demand.

This project determined the availability and cost of water end-use customer time using TOU water meters. It provided a test case installation and monitoring demonstration project to determine if TOU water meters are a viable demand side option for water agencies to be able to reduce their own peak electrical demand by encouraging their customers to shift water use out of the peak electrical periods. This reduces the electrical pumping loads from peak demand periods.

Three customer classes in the City of Palm Desert, California, were selected for participation in this study: Residential, Business (commercial), and Irrigation customers. The study was composed of two groups in each customer category: a Control group, which had the TOU meters installed, and an Intervention (test) group, which had TOU meters installed and which was given instructions to minimize water use during the electric utility (Southern California Edison) summer on-peak period. This period was defined as 12 noon to 6 p.m. weekdays from June 1 through October 2, 2009. The Intervention group was given an incentive of $25 per month. Both Control and Intervention groups had their water usage recorded by the TOU meters on a 15-minute interval basis.

Residential Intervention customers reduced their peak period water usage by more than 50 percent as compared to the Control group. The Residential Intervention group also reduced total water use by an average of 17 percent during the course of the study. Business and Irrigation groups did not demonstrate statistically significant water consumption changes. Reductions in peak and total water use for the Residential Intervention group persisted after the study was completed. This study also demonstrates how to determine the water embedded energy (kWh per million gallons) of a water agency and the impact of reducing on-peak water deliveries on the water system electricity consumption.

Saving Energy with Novel Nanoscale Materials for Sludge Dewatering

Wastewater treatment consumes about 2 billion kilo-watt hours per year in California. Approximately 40 percent of this energy use is for sludge treatment and disposal. One of the reasons sludge treatment is energy intensive is due to the large amount of energy required to remove water after aeration. Water removal is required to lower the volume to reduce hauling and disposal costs. Facilities ship the sludge hundreds of miles by truck for disposal, which significantly increases the carbon footprint of wastewater treatment in addition to the energy used to dewater the sludge.

This project will research the use of nanoscale materials to improve the dewatering processes. The goal is to increase the volume of water removed while using less energy. Currently, dewatering processes increase the percent of solids in sludge from 3 to 4 percent to approximately 25 percent. The proposed project will increase the percent of solids in dewatered sludge to approximately 30 percent. This increase in water removal would save approximately 30 percent of the energy in the dewatering process (approximately 240 million KWh). It would

also reduce the amount of natural gas needed to dry the sludge and reduce the amount of fuel and other shipping and disposal costs to remove the sludge.

Reduce Energy Requirement for Wastewater Treatment by Using Vortex Technology with Ultraviolet (UV) Light

Wastewater disinfection by UV radiation technology has high capital and maintenance costs and intense energy requirements. One reason for the high cost and energy requirement is that conventional UV treatment directly contacts the UV lamps in untreated water, which causes fouling. Another reason is that UV treatment uses banks of lamps arranged in modules that require heavy lift equipment to service. Treatment is also done in deep concrete channels that require expensive linings to prevent bacteria growth.

This project demonstrates an alternative UV treatment system that will eliminate the problems with traditional designs. This technology consists of creating a strong vortex inside a vertical tube, where the water will swirl upward around a core of air. The UV lamp is outside the tube, eliminating the fouling problem. The tube is light-weight Teflon with high UV transmissivity and the vortex brings the water in close range to the lamp, reducing the intensity and energy costs requirements. The centrifugal force of the vortex separates sediments that settle to the bottom of the tube where they cannot impede the UV radiation and increase energy requirements. This technology has been demonstrated on a small scale and is ready for pilot testing.

Life-Cycle Energy Assessment of Alternative Water Supply Systems

In California, a significant amount of energy is required for each step of the water use process, from moving water from its source to treatment, consumption and disposal. The water sector, including water and wastewater systems account for approximately 19 percent of the electricity used within the state. To meet state mandated greenhouse gas reduction goals, water and wastewater system managers must be able to benchmark the energy intensity of their water and wastewater systems and to assess the energy consequences of system changes. To achieve such a goal, this project developed and validated two lifecycle models, the Water Energy Sustainability Tool (WEST) for drinking water utilities, and the Waste Water Energy Sustainability Tool (WWEST) for wastewater systems to assess all phases of water and wastewater management, from material manufacturing, construction through operation and maintenance by quantifying the material and energy inputs, as well as environmental outputs from the system.

Both models are based upon spreadsheets and can be used to understand the implications of not only water and wastewater infrastructure changes, but also the environmental costs of alternative water supply and treatment options, water conservation measures and alternative wastewater treatment and disposal options, including sludge disposal.

Water and wastewater design decisions are made based on several factors, including economic, engineering, and political concerns. Previously, the comprehensive and system wide life-cycle environmental effects of water and wastewater systems have not been a factor in management decisions. Providing a user friendly way to assess the environmental effects of their systems will

allow easier identification of less energy intense infrastructure and management options and benefit ratepayers through the potential for reduced costs. By spring of 2011, WEST and WWEST will be combined in a web-based tool.

Smart Grid Projects

California is considered the "Smart Grid State" by most of the world. Over the next three to four years, the Energy Commission PIER Program will work actively with—and learn from—over 20 Smart Grid projects in California that resulted in ARRA funding and that represent over $1.2 billion in business enterprises for California. The PIER program will provide lessons learned, program updates, technology transfer and assistance with commercialization for many of these new and emerging technologies. This effort will open a new horizon of commercial opportunity for California businesses to not only field products in California, but to become the leader in selling these Smart Grid solutions throughout the nation and the world.

California Utility Vision and Roadmap for the Smart Grid of Year 2020

There are varying perspectives on what constitutes a Smart Grid. Perspectives range from an emphasis on infrastructure to an emphasis on applications in the electric power industry. A comprehensive California view of the Smart Grid is needed, to best meet future energy needs at lowest cost. Also, clarity and direction are needed to develop a comprehensive RD&D plan supporting Smart Grid deployment in the California. Critical technology areas and research gaps need to be identified to achieve priorities for RD&D.

The envisioned California Smart Grid of 2020 will link electricity with communications and automated control systems to create a highly automated, responsive, and resilient power delivery system that will both optimize service and empower customers to make informed energy decisions. A Smart Grid with these characteristics would support California's energy policy goals, including increased penetration of renewable resources, reduced greenhouse gas emissions, increased energy efficiency, implementation of demand response, increased use of distributed energy resources, maintained and/or enhanced grid reliability, and electrification of transportation. The Smart Grid would also provide greater protection from cyber security attacks and safeguard customer privacy and worker safety.

California electric utilities will face challenges while implementing the Smart Grid of the future. Among these challenges are systems interoperability, communications and common information model standards, implementation schedules, well-defined interfaces, and adapting to legacy systems. In addition to technology issues are cost benefit justifications, risk capital investment, and regulatory and stakeholder approval processes. To meet these challenges, California needs to develop a common definition of what the Smart Grid of the future will be in California and then develop a roadmap of activities to get there. Stakeholder consensus on the appropriate standards, codes and protocols needs to be obtained. PIER is ideally suited to facilitate this coordination among California's public and private utilities and the CAISO.

This project obtained and documented the perspectives of the three largest utilities serving over 75 percent of the California ratepayers. This information will be used to develop a common California Smart Grid vision and a roadmap to achieve this vision by 2020. The project resulted

in a final report, which was approved by California's three largest utilities as a California-wide Smart Grid vision and roadmap definition document. The final report also preserved the individuality of each California utility through documentation of individual utility perspectives, where those perspectives were found to differ.

The report details findings in six domains of technical expertise: Communications Infrastructure & Architecture; Customer Systems; Grid Operations & Control; Renewable & DER Integration; Grid Planning & Asset Efficiency; and Workforce Effectiveness. These domains define a structure of technical areas under which the project provides further findings on vision, baseline, technology readiness roadmaps, gaps and recommendations.

This project also addressed the California Public Utilities Commission's (CPUC) Order Instituting Rulemaking (OIR) #R.08-12-009 to "Consider Smart Grid Technologies Pursuant to Federal Legislation and on the Commission's own Motion to Actively Guide Policy in California's Development of a Smart Grid System." Additionally, this research will help the Energy Commission develop information for the requirements currently defined under Senate Bill 17 (Padilla).

Renewable Energy Secure Communities

Through the PIER program, the Energy Commission is taking a systems approach towards community scale demonstrations. This approach will position California to meet future energy goals. These integrated energy systems provide the ability to minimize environmental impacts, enable the maximum use of renewable energy, maximize the benefits of energy efficiency and support economic development of California's diverse regions and communities.

Environmentally sound energy technologies are key to developing these systems. These technologies need to be integrated into community scale energy systems, such as Smart Grids and microgrids, to create Renewable Energy Secure Communities (RESCO) that achieve California's aggressive long-term energy goals. These large scale projects allow researchers to leverage many benefits and reduce overall cost.

In 2008, the Energy Commission released the first RESCO solicitation to cross-leverage between natural gas and electricity research funding sources. This very successful solicitation attracted over 50 proposals, of which 12 were awarded funding. The work performed to date on these projects has led the state closer to achieving its renewable goals. The Energy Commission will release more solicitations to develop additional RESCO projects that integrate and optimize the interplay of renewable energy sources, efficiency and demand response measures, and reduce energy consumption.

Zero Net Energy New Residential and Commercial

In 2008, California set bold energy-use reduction goals by targeting zero net energy (ZNE) use in all new residential buildings by 2020. Research on ZNE for new homes and businesses will provide a more precise definition of "zero net energy," and will help to support future ZNE developments. Also lighting and plug loads are two potential electricity end-uses that will undergo more research in both technology and standards to reduce energy consumption. To meet California's bold goals, much work will be needed to gather and synthesize information

about the essential planning, elements, conditions, and tools that are necessary to create successful zero net energy projects.

Advanced Energy Storage

The Energy Commission will evaluate the application of advanced energy storage at community scale, as well as residential scale and utility scale. The PIER program will continue demonstrating the multiple uses of energy storage and their applications to provide Smart Grid services. These will include integrating renewable resources with energy storage and DR in communities and on the grid.

Smart Grid Demonstration of Renewable Energy Secure Community at the Santa Rita Jail, Alameda County, California

The researchers at the Santa Rita Jail RESCO project are integrating the energy generation capabilities (11.5 kilowatts of new wind turbines, 1.2 megawatts of existing solar photovoltaics, an existing 1.0 megawatt fuel cell cogeneration system and the 2.4 kilo volt-ampere (kVA) backup emergency generation system) under a Smart Grid environment. This project also demonstrates demand response with the integration of a 2MW/4MWh advanced energy storage battery that qualifies for the Self-Generation Incentive Program (SGIP).

The researchers designed a new solar thermal system to generate up to 45,000 therms of hot water, and integrate that with the existing cogeneration capabilities of the fuel cell that feeds the jail's centralized high-efficiency, low-nitrous oxide hot water boiler. The integration activity will enable the jail's generation systems to interconnect with the utility grid to support "islanding" with minimal energy load disruption.

The Santa Rita Smart Grid's plug and play compatibility characteristics make the integration of the new battery system with the existing power conditioning system possible so that electricity demand during summer peak is decreased to zero. Thereby, the jail will have the potential to export energy and reduce congestion and reliability issues on the local distribution grid by up to a 15 percent reduction on the feeder circuit (peak load).

The Santa Rita Jail researchers plan the battery installation and commissioning for the summer of 2011, followed by a two-year data monitoring activity by the National Renewable Energy Lab (NREL) to be completed in late 2013. The Jail's energy efficiency initiatives remain in place as the researchers continue working toward resolving energy independence and system reliability issues in this high demand secure community, which houses 3,700 inmates. This broad and highly technical cutting edge research and demonstration will likely enable future applications under the PIER-funded RESCO model.

Performance Testing Protocols and a Database for Distributed Generation Systems Helps Customers Make Informed Choices

Distributed generation (DG) technologies are emerging as a viable complement to centralized power production. DG, also called on-site generation or decentralized energy, generates electricity from relatively small energy sources as compared to a power plant. These technologies are anticipated to be an important part of California's strategy—and the nation's

strategy—to improve energy efficiency and reduce energy-related environmental impacts, including global climate change.

This PIER-funded project, which was completed in 2010, will promote the adoption of DG and combined heat and power (CHP) units by providing performance data comparisons for power generating systems. These include microturbine generators, engine generator sets, small turbines, and fuel cell power systems. The database is meant to encourage appropriate DG and CHP applications that provide real benefits to system owners. The project facilitated adoption by providing globally accessible information—via the internet—of CHP systems. The collected data follows common protocols and provides a comparable platform. This data should encourage appropriate DG/CHP applications that provide real benefits to system owners. Performance information is provided by the development of four final protocols: a laboratory protocol, a field protocol, a long-term monitoring protocol, and a case study protocol. Their application, together with the resulting data, is provided on two public searchable databases.

This project, a highly collaborative effort with industry, government, non-government organizations, and researchers, produced workable and concise performance protocols, and made performance records publicly available. The data now available are a rich resource providing the basis for informed market decisions regarding the use of DG/CHP systems. It will enable a higher rate of successful installations. Work with the New York State Energy Research and Development Authority (NYSERDA) has resulted in substantial data being made available beyond the original goal of this project, including a large amount of daily and hourly reported data.

Optimization Tool Helps Customers Decide When Their Storage Will Provide Cost Benefit Value

The Energy Commission funded a storage viability and optimization tool that helps the end-user to determine if energy storage and photovoltaics (PV) together are appropriate for their facility. This technology is currently available for public use on the Lawrence Berkeley National Laboratory website. Users include universities, private companies, and utilities.

This web-based calculator provides basic guidance on analyzing storage technologies and PV. Since the industrial, agricultural and water sectors encompass a broad range of facilities with different characteristics, the tool starts by asking the user to select a load profile from a group of example facilities. These examples may be modified by the user to fit a site's unique circumstances. After the load profile selection, the user will be prompted to select other parameters until all are specified. Based on the user selections, the solution set will be adjusted to provide estimated results to the user.

This tool was developed to help to determine if a site is suitable for deploying energy storage technologies. This tool provides an estimate of the cost, charge and discharge times, (operational schedule), and the economic and environmental benefits (for example, reduction of carbon dioxide emissions). The results can be used by end-users to determine if a more rigorous and involved analysis of energy storage (with or without PV) is warranted. Currently, there are

no free tools available that are reliable, easy to use, or web-based to allow easy access for the user.

This tool helps the state implement increased use of distributed generation in California to meet the goal of 33 percent renewable energy generation by 2020. It is estimated that a significant amount of that increase will be PV deployment; which needs energy storage to overcome the intermittence of PV and for excess capacity storage.

Tools for Online Analysis and Visualization of Operational Impacts of Wind and Solar Generation

To facilitate California's goal of 20 percent to 33 percent renewable resource penetration without compromising system reliability, a tool intended for use by the California Independent System Operator (CA ISO) power grid operator is under development. The tool predicts and displays generation capacity and ramping requirements for the next three to five hours affected by uncertainties in forecasts of loads and renewable generation.

The CAISO's Integration Of Renewable Resources: Operational Requirements and Generation Fleet Capability report noted that the "integration of variable energy resources will require… capability to provide load-following and regulation in wider operating ranges and at ramp rates that are faster and of longer sustained duration". Current procedures for selecting balancing capacity are deterministic, and do not take into consideration the uncertainties. To assist CAISO in making operational decisions the University of California's California Institute for Energy and Environment is developing tools that will forecast the ability of on-line dispatchable resources to meet expected capacity and ramp requirements. The result will be an advisory recommendation with specific actions. The advantages of implementing the tools for online analysis of wind and solar include:

1. Improved situational awareness for system operators regarding the possible range of upward and downward capacity and ramp
2. Early warning about possible generation resource deficiencies giving them time to commit additional generators
3. Improved grid reliability and control performance
4. Potential for reduced operational costs

A software package - "Ramping Tool – Version 1" – was delivered to CAISO in fall 2010. This full-featured and functional tool meets the requirements of the CAISO. Feedback from use and evaluation of this application is being used to further refine the tool.

Modeling Validation Benefits of Distributed Energy Resources to Power Grid

This project demonstrated tools that can be used by a utility to ideally site distributed energy resources. These tools can identify beneficial projects and quantify their benefits for California.

The key feature of the Energynet® methodology is the simulation of the power system in full detail, with all distribution and transmission equipment integrated into a single model, to allow

the direct observation of the grid impacts of individual distribution-connected generation and storage.

This project completed the research and development, and performed a full-scale final demonstration of the practicality and capabilities of the Energynet® electric power system modeling methodology developed by New Power Technologies in a large utility system. DER is defined as generation, storage, and load control technologies located close to where electricity is used (for example, a home or business) to provide an alternative to, or an enhancement of, the traditional electric power system.

DER projects, in the right locations and with the right characteristics and operating profiles, can improve the performance of an electric power system by reducing power losses, improving reliability and power quality, and increasing load-serving capability. The benefits of individual DER can vary significantly depending on location, but can be objectively and rigorously determined using the electric power system modeling methodology tools as demonstrated in this research. These methods, which include various applications of GRIDfast™ optimization software, can also be used to assess the direct impacts and benefits of operational measures such as revised control settings or layout and traditional capital improvement projects. The direct benefits of such diverse system improvement measures can be objectively compared in economic terms.

There is the desired ability to accommodate high penetrations of intermittent renewable DG as well as distributed storage and quantify their benefits for California. The application of advanced grid analytics that were used in this project should readily enable California's utilities to accommodate the DER while reducing risk to the power system and unnecessary cost burdens on customers. With the commercial availability of Energynet® electric power system modeling methodology developed by New Power Technologies, and advanced analytical software such as GRIDfast™, California utilities have more tools they can use to help determine the best placement of DER and achieve the governor's distributed generation goals.

Advanced Generation

To capitalize on this potential for new energy resources, advanced generation research projects will focus on demonstrating hybrid generation and fuel flexible projects that combine, integrate, and demonstrate different power generation technologies, including storage, and/or the use of two or more fuels for the same technology (for example, gas turbine generation combined with fuel cell generation) that will help reduce costs and emissions, and increase efficiency and reliability. This research is designed to help the state achieve key energy policy goals , such as the AB 32 Scoping Plan goal of 4,000 MW of installed capacity, greenhouse gas reduction targets outlined in AB 32 and Governor's Executive Orders, the Renewables Portfolio Standard (S-14-08 and S-21-09), and Energy and efficiency targets established in *IEPR*, Energy Action Plan, and Governor Brown's energy plan.

Prepared For the Future

In summary, the Energy Commission's PIER program is prepared for the future. The Energy Commission is evaluating the changing energy marketplace and will update the PIER Program to meet California's energy goals for the next decade. Active stakeholder and scientific community engagement will remain an important part of this process. This process will be initiated in spring 2011 and will examine the role of the American Recovery and Reinvestment Act funding, advances in science and technology, the changing regulatory and competitive marketplace, and new legislation that passed since the last review in 2006. The strategic vision from this process is expected to be completed in early 2012.

The Energy Commission will focus on the integration of energy technologies. This approach adds value by integrating new technologies with existing legacy systems so they become part of a state-wide upgraded, modernized infrastructure capable of meeting California's energy policy goals.

The Energy Commission's research role in the future energy system for California remains in the forefront. The evolving state-wide energy system may be comprised of a series of interconnected microgrids, each unique. The Energy Commission is well positioned to perform ongoing and future research to ensure that these microgrids are interoperable, capable of two-way communication and be able to share resources with each other. The sum is greater than the individual parts.

Going forward, the Energy Commission will use PIER funds for research focused on sustainable energy systems that can be integrated into microgrids. These systems may include the use of advanced energy storage with dispatchable loads and renewable distributed generation to provide renewable energy-secure communities. Sustainable energy systems will enable California communities to use geographically-convenient renewable energy resources and efficiently use other energy resources to minimize greenhouse gas emissions. Sustainable energy systems are also Smart Grid enabled to allow for the integration of energy efficiency strategies and programs, demand response programs, renewable energy, energy storage, and clean advanced generation. Additionally, they enable sustainable transportation systems and fuels, minimize adverse land impacts and ensure the preservation of clean air and water in California. Sustainable energy systems enable California to achieve zero net energy status and to minimize the production of greenhouse gasses and wastes. Energy Commission-funded research will prepare California to a clean energy future through research investments that will help meet the state's greenhouse gas emission goals, continue improving the Smart Grid, achieve a higher penetration of renewable resources, move toward zero net energy-smart communities, and create careers in modern clean technology industries for a sustainable California economy.

Pending re-authorization, the Energy Commission will continue to anticipate and serve the energy needs of California's ratepayers by administering the PIER program to perform research that provides environmental benefits, lowers system costs, and provides reliable and secure energy services and products.

Finally, the Energy Commission commits to sustained and active engagement of policymakers and stakeholders in the development and implementation of research priorities, as well as effective technology transfer activities.

Appendix A:
2010 Individual Projects

This appendix contains a summary of the project work initiated during the calendar year of 2010. The table includes the SB 1250 goals, agreement number, company name, project title, project amount, and start date. PIER research projects initiated in 2010 totaled approximately $71.7 million. The difference can be attributed to projects from 2010 that were not signed until 2011.

The table below shows the total project funding and number of projects initated in 2010 for each SB 1250 goal.

Details of Calendar Year 2010 Projects by SB 1250 Policy Goals					
SB 1250 Goal	**Agreement Number**	**Company Name**	**Project Title**	**Project Amount (dollars)**	**Start Date**
Advanced Electricity Generation	500-09-012	US Geological Survey	Carbon sequestration and GHG emissions in intentionally flooded corn fields in the Delta	$449,145	5/5/2010
Advanced Electricity Generation	500-09-015	UC Irvine	Fuel Flexible Turbine System	$300,000	3/15/2010
Advanced Electricity Generation	500-09-034	Lawrence Berkeley National Laboratory	Potential Impacts from Geologic Carbon Sequestration on Groundwater Resources in Central Valley of California	$490,000	6/14/2010
Advanced Electricity Generation	500-09-035	The Regents of the University of California, Davis	The potential of biochar soil amendments as a carbon sequestration method in California agriculture	$700,000	5/24/2010
Advanced Electricity Generation	500-09-036	Lawrence Berkeley National Laboratory	More accurate prediction of generation impacts through better characterization of particulate matter and ozone chemistry	$300,000	5/17/2010

Details of Calendar Year 2010 Projects by SB 1250 Policy Goals					
SB 1250 Goal	**Agreement Number**	**Company Name**	**Project Title**	**Project Amount (dollars)**	**Start Date**
Advanced Electricity Generation	500-10-010	UC Irvine	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	$300,000	8/30/2010
Renewables	500-98-014	Semprius, Inc.	CPV Module with Zero Cost Thermal Management	$95,000	9/8/2010
Advanced Electricity Generation	500-98-014	UC Davis	Microbial Fuel Cells to Generate Electricity from High-Solids Food-Processing Wastes	$94,381	10/11/2010
Advanced Electricity Generation	500-98-014	J. Craig Venter Institute	Microbial Fuel Cells for Sustainable Wastewater Treatment	$95,000	10/11/2010
Advanced Electricity Generation	500-98-014	UC Riverside	Wireless Sensors for Real-Time Monitoring of Induction Motors	$93,586	10/11/2010
Other	BOA-99-249-R	The Regents of the University of California, - CIEE	Develop Model for National Center for Clean Energy Workforce (NCCEW)	$264,458	2/3/2010
Advanced Electricity Generation	BOA-99-250-R	The Regents of the University of California, - CIEE	WESTCARB Geological Sequestration Field Project Assessments	$248,858	3/15/2010
Advanced Electricity Generation	PIR-09-012	Altex Technologies Corporation	Boiler Burner Energy System Technology ("BBEST") for Firetube Boilers	$1,493,581	6/21/2010

Details of Calendar Year 2010 Projects by SB 1250 Policy Goals					
SB 1250 Goal	**Agreement Number**	**Company Name**	**Project Title**	**Project Amount (dollars)**	**Start Date**
Advanced Electricity Generation	PIR-09-013	UC Irvine	Economical Dispatch of CCHP Systems with Emissions Constraints and Thermal Load Following Capability	$412,634	4/26/2010
Advanced Electricity Generation	PIR-09-014	Makel Engineering, Inc.	Biogas Fueled HCCI Generation for Combined Heat and Power Systems	$580,706	4/12/2010
Advanced Electricity Generation	PIR-09-015	UC Irvine	Low Emissions Exhaust Enthalpy Control System to Optimize DG/CCHP Systems	$666,285	4/12/2010
Advanced Electricity Generation	PIR-09-016	Altex Technologies Corporation	Waste Vegetable Oil Driven CHP for Fast Food Restaurants	$1,435,575	8/16/2010
Advanced Electricity Generation	PIR-09-018	National Fuel Cell Research Center - UC Irvine	Development and Demonstration of a Novel High-Temperature Fuel Cell Absorption Chiller CCHP System	$1,480,000	10/25/2010
Advanced Electricity Generation	PIR-10-036	Porifera Inc.	Carbon Nanotube Membranes for Energy Efficient CO2 Separation	$115,397	12/1/2010
Advanced Electricity Generation	UC MRA-02-087	Lawrence Berkeley National Laboratory	Roadmap on Innovative Technologies and Concepts for Beneficial CO2 Use	$220,593	11/8/2010
Climate/ Environmental	500-09-016	California Department of Water Resources	Adaptation Initiatives for Sea Level Rise in California	$95,000	1/18/2010
Climate/ Environmental	500-09-025	Scripps Institution of Oceanography - UC San Diego	Climate Analysis, Monitoring and Modeling: Phase IV	$1,100,000	3/1/2010

Details of Calendar Year 2010 Projects by SB 1250 Policy Goals					
SB 1250 Goal	**Agreement Number**	**Company Name**	**Project Title**	**Project Amount (dollars)**	**Start Date**
Climate/ Environmental	500-09-032	Pacific Northwest National Laboratory	Improving Regional Climate Models: Aircraft Collection of Data	$800,000	5/1/2010
Renewables	500-09-033	UC Davis Center for Watershed Sciences	Hydropower response to earlier spring snowmelt runoff	$299,949	6/30/2010
Climate/ Environmental	500-09-037	The Regents of the University of California, - CIEE	Adaptation options for California's natural and managed ecosystems	$1,257,586	6/1/2010
Climate/ Environmental	500-09-038	The Regents of the University of California, - CIEE	Climate Vulnerability and Adaptation Study for California	$2,535,927	6/7/2010
Advanced Electricity Generation	500-09-045	Bevilacqua-Knight, Inc.	WESTCARB PHASE III - BKI	$3,941,354	6/30/2010
Renewables	500-09-047	National Oceanic and Atmospheric Administration	Meteorological Observations of Precipitation Processes	$1,105,000	8/9/2010
Energy Efficiency	500-09-049	Lawrence Berkeley National Laboratory	Healthy Zero Energy Buildings Program	$3,400,000	8/9/2010
Climate/ Environmental	500-10-007	The Regents of the University of California, - CIEE	Visualizing Climate Change Risk and Adaptation Options for California: CalAdapt	$549,975	8/16/2010
Advanced Electricity Generation	500-10-011	United States Carbon Sequestration Council	West Coast Regional Carbon Sequestration Partnership - Membership in United States Carbon Sequestration Council	$35,000	8/2/2010

Details of Calendar Year 2010 Projects by SB 1250 Policy Goals					
SB 1250 Goal	**Agreement Number**	**Company Name**	**Project Title**	**Project Amount (dollars)**	**Start Date**
Advanced Electricity Generation	500-10-024	Arizona Geological Survey	West Coast Regional Carbon Sequestration Partnership, Phase III - Arizona Geological Characterization	$232,350	12/1/2010
Climate/ Environmental	BOA-99-252-R	The Regents of the University of California, - CIEE	CalAdapt Operational Protocol	$58,700	4/22/2010
Energy Efficiency and Demand Response	500-09-022	Lawrence Berkeley National Laboratory	Energy and Indoor Environmental Quality (IEQ) Retrofits In Low-Income Apartments	$1,750,000	2/1/2010
Energy Efficiency and Demand Response	500-09-026	Lawrence Berkeley National Laboratory	High Performance Building Façade Solutions - Phase 2	$3,000,000	3/15/2010
Energy Efficiency and Demand Response	500-09-030	Sacramento Municipal Utility District	2010 Emerging Technologies Summit	$50,000	4/1/2010
Energy Efficiency and Demand Response	500-09-042	Lawrence Berkeley National Laboratory	Healthy Homes - Exposure to Unvented Combustion Gases	$1,263,300	6/15/2010
Energy Efficiency and Demand Response	500-09-044	Gas Technology Institute (GTI)	Advanced Foodservice Appliances for California Restaurants	$1,985,502	6/30/2010
Energy Efficiency and Demand Response	500-09-046	Institute for Sustainable Building Performance (DBA) Institute for the Sustainable Performance of Buildings	Education Software for Workforce Development	$1,986,715	6/30/2010

Details of Calendar Year 2010 Projects by SB 1250 Policy Goals					
SB 1250 Goal	**Agreement Number**	**Company Name**	**Project Title**	**Project Amount (dollars)**	**Start Date**
Energy Efficiency and Demand Response	500-09-050	UC Davis	Demonstration of a Vortex Technology for Wastewater Disinfection with UV Light	$150,000	8/9/2010
Energy Efficiency and Demand Response	500-09-052	Rensselaer Polytechnic Institute	Lighting Research Center Partnership	$60,000	7/15/2010
Energy Efficiency and Demand Response	500-10-013	E Source Companies LLC	Building Technologies Technical Briefs and Market Outreach	$507,330	8/30/2010
Energy Efficiency and Demand Response	500-10-014	Bruce Wilcox	Central Valley Research Home Program	$1,882,091	9/27/2010
Energy Efficiency and Demand Response	500-10-015	Davis Energy Group, Inc.	Large Scale Residential Retrofit Program	$1,224,994	9/15/2010
Energy Efficiency and Demand Response	500-10-016	American Council for an Energy Efficient Economy	ACEEE 2010/2011 Conferences	$30,000	8/25/2010
Energy Efficiency and Demand Response	500-10-019	Benningfield Group	Unique Multifamily Code-Relevant Measures for the 2014 Title 24 Energy Standards Update	$1,270,830	10/11/2010
Energy Efficiency and Demand Response	500-10-025	The Regents of the University of California, San Diego	Natural Ventilation for Energy Savings in California Commercial Buildings	$1,900,000	11/22/2010
Energy Efficiency and Demand Response	500-98-014	Lightwave Photonics, Inc.	Growth of Cavity Light Emitting Diode on a Reflective Substrate	$95,000	9/8/2010

Details of Calendar Year 2010 Projects by SB 1250 Policy Goals					
SB 1250 Goal	**Agreement Number**	**Company Name**	**Project Title**	**Project Amount (dollars)**	**Start Date**
Energy Efficiency and Demand Response	500-98-014	Ambient Micro	Battery Prognostics for Small Scale Distributed Resource Applications	$94,984	10/11/2010
Renewables	500-98-014	Trustees of the California State University - San Diego	An Innovative Design for Cost and Energy Efficient Solar Cells	$95,000	10/11/2010
Energy Efficiency and Demand Response	500-98-014	SeaBotix Inc.	Photo Thermal Voltaic Skylight	$95,000	10/11/2010
Energy Efficiency and Demand Response	BOA-99-246-R	The Regents of the University of California, - CIEE	Phase II Work - Center for Resource Efficient Communities (CREC)	$227,410	1/12/2010
Energy Efficiency and Demand Response	BOA-99-254-S	California Lighting Technology Center - UC Davis	Expanding PIER Partnerships: New Concepts for Development and Demonstration	$92,997	4/30/2010
Energy Efficiency and Demand Response	MRA-02-084	The Regents of the University of California, - CIEE	PIER State Partnership for Energy Efficiency Demonstrations	$1,800,000	3/22/2010
Energy Efficiency and Demand Response	PIR-09-003	Abengoa Solar Inc	Advanced Energy Delivery for Food Processing: Direct Steam Generation in Parabolic Trough Solar Collectors	$396,984	6/21/2010
Energy Efficiency and Demand Response	PIR-09-004	Gas Technology Institute (GTI)	Integrated Waste Heat and Wastewater Recovery DOME for Food Processing Applications	$400,000	6/7/2010
Energy Efficiency and Demand Response	PIR-09-008	Gas Technology Institute (GTI)	Solar Assisted Gas Hot Water Heating for Food Processing Industry	$381,402	6/18/2010

Details of Calendar Year 2010 Projects by SB 1250 Policy Goals					
SB 1250 Goal	**Agreement Number**	**Company Name**	**Project Title**	**Project Amount (dollars)**	**Start Date**
Energy Efficiency and Demand Response	PIR-09-020	One Cycle Control, Inc.	One-Cycle Control Peak Load Reduction (OCC-PLR) System	$400,000	9/7/2010
Transmission and Distribution	PIR-10-001	Premium Power Corporation	Demonstration of Zinc-Flow Energy Storage System	$394,082	9/20/2010
Energy Efficiency and Demand Response	PIR-10-008	Kennedy/Jenks Consultants, Inc.	The Use of Novel Nanoscale Materials for Sludge Dewatering: A Field Demonstration	$299,956	10/11/2010
Energy Efficiency and Demand Response	PIR-10-011	Cascade Clean Energy, Inc.	CASCADE Clean Energy System for Water and Wastewater	$400,000	9/27/2010
Energy Efficiency and Demand Response	PIR-10-016	American Biodiesel, Inc. dba Community Fuels	Integrated system for reducing water consumption and wastewater discharge of biodiesel production facilities in California	$349,524	9/20/2010
Energy Efficiency and Demand Response	PIR-10-018	mc2 Consulting, Inc.	Advanced Software for Demand and Energy Reduction in California Pipelines	$399,565	9/13/2010
Energy Efficiency and Demand Response	PIR-10-021	Gas Technology Institute	Reclamation of Wastewater for Cooling Tower Operations at the Gills Onions Processing Plant in Oxnard, California	$400,000	11/10/2010
Energy Efficiency and Demand Response	PIR-10-022	Electric Power Research Institute (EPRI)	Variable Airflow Management with Direct Expansion (DX) Computer Room A/C	$400,000	9/20/2010

Details of Calendar Year 2010 Projects by SB 1250 Policy Goals					
SB 1250 Goal	**Agreement Number**	**Company Name**	**Project Title**	**Project Amount (dollars)**	**Start Date**
Energy Efficiency and Demand Response	PIR-10-052	Federspiel Controls	Data Center Energy Efficient Cooling Control Demonstration	$250,000	12/15/2010
Energy Efficiency and Demand Response	PO-09-564	Consortium For Energy Efficiency	Consortium for Energy Efficiency Membership	$2,900	1/1/2010
Renewables	500-07-038	WateReuse Foundation	Renewable Energy Technologies and Energy Efficiency Strategies: Guidelines for Water Desalination and Reuse Systems to Optimize Energy Use and Reduce Greenhouse Gas Emissions	$100,000	1/1/2010
Renewables	500-07-038	WateReuse Foundation	Evaluation and Optimization of Emerging and Existing Energy Recovery Devices for Desalination and Wastewater Membrane Treatment Plants	$112,500	8/19/2010
Renewables	500-09-017	Lawrence Berkeley National Laboratory	Linking Water and Energy for the American River System	$500,000	1/18/2010
Renewables	500-09-020	U.S. Geological Survey, Southwest Biological Science Center	Assessing the Long-term Survival and Reproductive Output of Desert Tortoises at a Wind Energy Facility Near Palm Springs, California.	$319,936	2/1/2010
Transmission and Distribution	500-09-027	Pacific Gas and Electric Company	Pacific Gas & Electric Energy Storage Demonstration and Compressed Air Energy Storage Study	$2,800,000	6/15/2010

Details of Calendar Year 2010 Projects by SB 1250 Policy Goals					
SB 1250 Goal	**Agreement Number**	**Company Name**	**Project Title**	**Project Amount (dollars)**	**Start Date**
Renewables	500-09-028	The Pinchot Institute for Conservation, H. John Heinz III Center for the Envrionment	Pinchot Institute Bio energy Bio Fuels Sustainability Co-sponsorship	$20,000	2/18/2010
Renewables	500-09-031	USDA Forest Service, Sierra Nevada Research Center, Pacific Southwest	Analysis of Forest Biomass Removal on Biodiversity	$1,149,361	6/1/2010
Renewables	500-09-040	Advanced Power and Energy Program - UC Irvine	Air Quality Implications of Renewable Energy Options	$499,980	6/7/2010
Renewables	500-09-043	UC San Diego	Data Collection and Analysis of the Factors Affecting High-Elevation Precipitation Regimes in California	$1,300,000	6/21/2010
Renewables	500-10-017	The Regents of the University of California, Davis	Mapping Habitat Distributions of Desert Rare Plants from Optimized Data	$580,907	10/11/2010
Renewables	500-10-020	The Regents of the University of California, Davis	Use of Habitat Suitability Models and Head-Start Techniques to Minimize Conflicts between Desert Tortoises and Energy Development Projects in the Mojave Desert	$238,310	11/1/2010
Renewables	500-98-014	Paula Moon & Associates	Proof-of-Concept of Co-Production of Electrical Power and Lithium from Geothermal Fluids	$95,000	8/25/2010
Renewables	500-98-014	UC Davis	A light-assisted Biomass Fuel Cell for Renewable Electricity Generation	$95,000	9/3/2010

Details of Calendar Year 2010 Projects by SB 1250 Policy Goals					
SB 1250 Goal	**Agreement Number**	**Company Name**	**Project Title**	**Project Amount (dollars)**	**Start Date**
Renewables	500-98-014	ApproSolar School of Physics, University of Exeter(U.K.)	Solar heat engine driven hydraulic ram for low cost irrigation	$95,000	9/8/2010
Renewables	500-98-014	Wind Harvest International	Modeling Blade Pitch and Solidities in Straight Bladed Vertical Axis Wind Turbines	$50,000	9/8/2010
Renewables	500-98-014	San Jose State Research Foundation	Wind Power Generation on High Rise Buildings in Urban Centers	$50,000	9/8/2010
Renewables	500-98-014	Robert A. Hogue	Low Cost Energy Storage for Solar Thermal Power Plants	$42,245	9/8/2010
Renewables	500-98-014	UC Los Angeles	Innovative Blade Design for Next Generation Wind Turbines	$95,000	10/11/2010
Renewables	500-98-014	MetSpar	Meteorological Buoy Technology for Offshore Wind Resource Assessment	$95,000	10/11/2010
Renewables	500-98-014	Texas A&M University	A Low-Cost Inverter with Battery Interface for Photovoltaic-Utility System	$95,000	10/11/2010
Renewables	500-98-014	Solar Red	All-AC, plug-and-play photovoltaic system	$95,000	10/11/2010
Renewables	500-98-014	Roshan Energy	Solar Electric Power from Heat Pulses Applied to Silicon	$95,000	10/11/2010
Renewables	500-98-014	PLANT Solar	Solution Processed Solar Cells from Abundant, Non-Toxic Materials	$95,000	10/11/2010
Renewables	BOA-99-248-R	The Regents of the University of California, - CIEE	Energy Resource Forecasting and integration Analysis	$323,446	1/7/2010

Details of Calendar Year 2010 Projects by SB 1250 Policy Goals					
SB 1250 Goal	**Agreement Number**	**Company Name**	**Project Title**	**Project Amount (dollars)**	**Start Date**
Renewables	PIR-10-003	University of California, San Diego	High Solar PV Penetration Modeling	$500,000	12/6/2010
Renewables	PIR-10-047	BMP Ecosciences	Population Viability and Restoration Potential for Rare Plants Near Solar Installations	$753,100	11/22/2010
Transmission and Distribution	500-09-021	Jet Propulsion Laboratory-California Institute of Technology	Roadmapping the California Smart Grid Through Risk Retirement	$499,999	4/26/2010
Transmission and Distribution	500-09-039	University Enterprises, Inc (on behalf of CSU, Sacramento)	CSUS Smart Grid Center	$2,000,000	6/1/2010
Transmission and Distribution	500-10-026	R.W. Beck, Inc.	Defining the Pathway to the California Smart Grid of 2020 for Publicly Owned Utilities	$475,000	12/6/2010
Transmission and Distribution	MRA-02-085	The Regents of the University of California, - CIEE	Application of Advanced Wide Area Early Warning Systems with Adaptive Protection	$200,000	7/19/2010
Transportation	500-09-019	CALSTART, Inc.	The California Hybrid, Efficient and Advanced Truck (CalHEAT) Research Center	$3,000,000	1/18/2010
Transportation	500-09-041	Institute of Transportation Studies - UC Davis	Plug-in Hybrid & Electric Vehicle Research Center	$2,780,000	6/30/2010
Transportation	500-09-051	UC Riverside	Alternative Fuels and Vehicle Compatibility Research	$1,200,000	8/9/2010

Details of Calendar Year 2010 Projects by SB 1250 Policy Goals					
SB 1250 Goal	**Agreement Number**	**Company Name**	**Project Title**	**Project Amount (dollars)**	**Start Date**
Transportation	500-10-009	UC Los Angeles	Methodology to Estimate the Net Energy and Greenhouse Gas Emission Savings from Policies Intended to Reduce Vehicle Travel	$550,000	8/30/2010
Transportation	500-98-014	Rochester Institute of Technology	A Natural Gas Fueled HCCI Engine for Hybrid Vehicles	$94,967	10/11/2010
Transportation	BOA-99-242-R	The Regents of the University of California, - CIEE	Tools to help local governments identify the most effective transportation energy efficiency projects for funding under the American Recovery and Reinvestment Act.	$200,000	1/29/2010
Transportation	UC MRA-02-086	University of California	Addressing Barriers to Electric Fuel Scale-up in California	$200,000	8/16/2010