CALIFORNIA
ENERGY
COMMISSION

PUBLIC INTEREST ENERGY RESEARCH PROGRAM

2007 – 2011 ELECTRICITY RESEARCH INVESTMENT PLAN

COMMISSION REPORT

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Arnold Schwarzenegger, *Governor*

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ABSTRACT

The California Public Utilities Code 384.1 states that on or before March 15, 2006, the Energy Commission shall prepare and submit to the appropriate policy and fiscal committees of the Legislature a report setting forth a long-term research priority, program management, and staffing plan for the Public Interest Energy Research (PIER) Program, which is part of the PIER Program established pursuant to Section 25620.1 of the Public Resources Code and funded through the Research Development, and Demonstration Fund. This report, along with the PIER Staffing Plan, is designed to comply with the requirements set forth in the California Public Utilities Codes 384.1 and 399.7.

The planning process for developing this five-year plan is characterized as closely tied to policy, integrated and inclusive. The entire five-year plan has been structured around current state energy policy, as well as complementing current policy with future policy issues. This five-year plan is integrated with the natural gas five-year plan and staffing management plan that are simultaneously being developed. The team charged with the development of the plan consists of 26 key PIER staff, divided into three task forces (Electricity, Natural Gas, and Program Management). Additional perspective from key stakeholders, both within and outside the Energy Commission, was obtained through hundreds of interviews and multiple workshops. This document is a culmination of those interviews and meetings and reflects the thoughts and opinions of dozens of individuals from multiple stakeholder groups.

KEYWORDS

Public Interest Energy Research, PIER, Public Interest Energy Research Development and Demonstration, Electricity Research Investment Plan

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EXECUTIVE SUMMARY

Energy Issues Important to Californians

As directed by current State energy policy described in the *Energy Policy Report*, the *Energy Action Plan*, and other State policy initiatives, and incorporating emerging issues from major trends and drivers, the Public Interest Energy Research (PIER) program has identified five key energy issues important to California. For each issue, PIER defined strategic objectives to accomplish during the next five years.

1. Affordable, comfortable, and energy-smart choices for daily life and a strong California economy.
    a. Reduce energy cost and improve performance of efficiency end-use systems.
    b. Develop energy-efficient technologies for unique California conditions.
    c. Reduce water use and improve efficiency of alternative water sources, treatment, and delivery.
    d. Develop end-use cost-effective demand response technologies that support peak reduction goals.
    e. Develop knowledge base for future decision-making and informed end-use policy relative to electricity.

2. Clean and diverse electricity supply that optimizes California's resources.
    a. Reduce cost and improve system and environmental performance of solar, wind, biomass, geothermal, and hydroelectric technologies.
    b. Reduce cost and improve system and environmental performance of alternative generation systems.
    c. Develop adequate generation resources that are diverse and flexible.
    d. Develop knowledge base for future decision-making and to inform electricity supply policy.

3. Clean and diverse transportation system in California.
    a. Double the combined Corporate Average Fuel Economy (CAFE) standard for new passenger cars and light-trucks by 2020 (2003 *Energy Policy Report*).
    b. Increase the percent of on-road non-petroleum fuel use to 20 percent by 2020 and 30 percent by 2030 (2003 *Energy Policy Report*).
    c. Reduce greenhouse gas[1] emissions to 2000 level by 2010, to 1990 level by 2020, and to 80 percent below 1990 level by 2050 (Governor Executive Order S-3-05 included in Appendix G).
    d. Advance technology that provides petroleum reduction, greenhouse gas, and air quality benefits and supports the long-term transition to a transportation system based on alternative fuels such as hydrogen.

[1] Defined by the Intergovernmental Panel on Climate Change to include: CO_2, CH_4, N_20, CF_4, C_2F_6, CHF_3, SF_6, $C_2H_2F_4$, $C_2H_4F_2$, $CFCl_3$, CF_2Cl_2, $CClF_3$, $C_2F_3Cl_3$, $C_2F_4Cl_2$, C_2F_5Cl, CCl_4, CH_3CCl_3, $C_2H_3FCl_2$, $C_2H_3F_2Cl$, $CClF_2Br$, CF_3B.

e. Expand California's goods movement industry and infrastructure in a manner that will increase mobility and relieve congestion, and improve air quality and protect public health (Governor's Goods Movement policy statement).
f. Reduce air pollution by up to 50 percent (Governor's Environmental Action Plan).

4. Integrated electricity system that is reliable and secure.
    a. Enable the optimal integration of renewables, distributed generation, demand response, and storage to the power system.
    b. Improve capacity, utilization, and performance of transmission and distribution system.
    c. Improve cost and functionality of components to integrate demand response, distributed generation, and electricity storage into the system.
    d. Improve security and reliability of electricity system.
    e. Support improvement of tariffs and regulations for demand response, distributed generation, storage, and renewables.
    f. Facilitate transmission siting process.
    g. Develop knowledge base for future decision-making and informed delivery, integration, and infrastructure policy relative to electricity.

5. Environmentally sound electricity system in California.
    a. Understand the nature/significance of climate change; its relationship to electricity generation and use; development of strategies for greenhouse gas reduction; and strategies for mitigation/adaptation of impacts.
    b. Improve the understanding of, and develop solutions for, reducing biological, land use, air-quality, and water-related impacts of the electricity system and contribute to a sustainable energy future.
    c. Develop knowledge base for future decision-making and informed environmental policy relative to electricity.

Benefits and Challenges Ahead for PIER

The PIER program is extremely important and valuable to California. To date, PIER has invested $488 million in projects related to buildings end-use efficiency; industrial, agriculture, and water (IAW) end-use efficiency; renewables; environmentally preferred advanced generation; energy systems integration; and environmental impacts of energy. This five-year investment plan defines a stronger link to state energy policy. It will expand research activities in transportation, transmission, and distribution. It will redirect the IAW end-use efficiency area to focus on the energy-water nexus. It will also shift the Renewable Portfolio Standards support to implementation of the regulations.

California has a distinctive demographic and geographic profile, as well as vulnerabilities to natural and man-made disasters, that require California-focused energy solutions. In addition, policymakers in California need unbiased, accurate, and timely information to drive effective energy policymaking. Moreover, technology and

scientific research investment decisions that have a clear public benefit need to be made with minimum bias.

PIER brings great benefits to Californians. Key benefits include lower energy costs, achieved through the more efficient use of energy and the improved utilization and performance of the delivery system, and a clean and environmentally friendly energy system, based on renewable energy sources, that is cost-competitive with traditional oil- and gas-fueled generation technologies. Other benefits are increased reliability of electricity service, reduced volatility of energy prices, reduced health risk from poor indoor and outdoor air quality, reduced footprint from energy infrastructure, increased availability of water resources, reduced biological impacts, and reduced impact from climate change.

PIER PROGRAM OVERVIEW

PIER History

Before deregulation of its electric services industry, California led the nation in a wide variety of energy-related research, development, and demonstration (RD&D) activities, thereby developing and using some of the cleanest and most efficient energy technologies in the world to date. This RD&D achievement was accomplished through a three-way collaborative effort among the government, the private sector, and the State's regulated energy utilities, thus ensuring that both public and private goods were produced for the benefit of California's citizens.

As the State moved forward, the California Public Utilities Commission (CPUC) observed that "the need for activities performed in the public interest will continue in the future, but the role of electric utilities as providers of these services is less clear" (D95-12-063). In preparing for impending competition, the State's major investor-owned electric utilities reduced their RD&D budgets, from nearly $135 million in 1991 to less than $62 million by 1996, and the CPUC indicated that only those utility RD&D activities that continue to support "regulated functions" should be funded through rates in the future (Decision 95-12-023).

However, the CPUC stated that those RD&D activities that serve a "broader public interest…should not be lost in the transition to a more competitive environment" (D95-12-023). To address this concern, the California Energy Commission (Energy Commission) recommended that a surcharge on retail sales be collected to provide for public goods RD&D efforts in the future (D95-12-023). The Energy Commission also emphasized that this public goods charge "should collect funds only for public goods research, not…for regulated or competitive research functions" (D95-12-023).

In 1996, the Legislature established the Public Interest Energy Research (PIER) Program at the Energy Commission, funding the program with payments from investor-owned utility (IOU) ratepayers. Assembly Bill (AB) 1890 was enacted to ensure that the benefits obtained from important public purpose programs, such as public interest energy RD&D, would not be lost in the newly deregulated environment. Starting on January 1, 1998 (and now extended through 2011), California Public Utilities Code Section 381 required that California's electric investor-owned utilities collect at least $62.5 million annually to fund energy-related RD&D activities.

Requirement for Electricity Five-Year Plan

The California Public Utilities Code 384.1 states that on or before March 15, 2006, the Energy Commission shall prepare and submit to the appropriate policy and fiscal committees of the Legislature a report setting forth a long-term research priority, program management, and staffing plan for the Public Interest Energy Research

Program, that is part of the Public Interest Research, Development, and Demonstration Program established pursuant to Section 25620.1 of the Public Resources Code and funded through the Public Interest Research, Development, and Demonstration Fund. The report shall do all of the following:

(1) Designate, in priority order, between 5 and 10 areas of research.
(2) Evaluate the current and projected funding and workload through 2011.
(3) Identify, based on the priorities established by the Energy Commission, an effective and efficient program management structure, staffing, and funding requirements to adequately manage the projected workload.
(4) Consider the appropriate mix of contract consultants and state employees, considering required technical expertise and overall costs.

The evaluation shall consider the manageability of an increasing number of projects and whether the number of projects should be limited, which areas of research have proven most productive, and which structural changes provide a greater degree of operational independence and research leadership to address the long-term problems identified by the Independent Review Panel in its March 2004 report.

The report required by this section may be included in the five-year investment plan report required by Subdivision (b) of Section 399.7, if provided to the appropriate policy and fiscal committees of the Legislature by March 15, 2006.

Moreover, the California Public Utilities Code 399.7 (b) states that the Energy Commission shall prepare and submit to the Legislature, on or before March 1, 2001, an initial investment plan for these moneys, addressing the application of moneys collected between January 1, 2002, and January 1, 2007. The initial investment plan shall address the recommendations of the *PIER Independent Review Panel Report*, dated March 2000, to either transform the RD&D program within the Energy Commission or to administer it through, or in cooperation with, an external organization. The initial investment plan shall include criteria that will be used to determine that a project provides public benefits to California that are not adequately provided by competitive and regulated markets. On or before March 31, 2006, the Energy Commission shall prepare an investment plan addressing the application of moneys collected between January 1, 2007, and January 1, 2012.

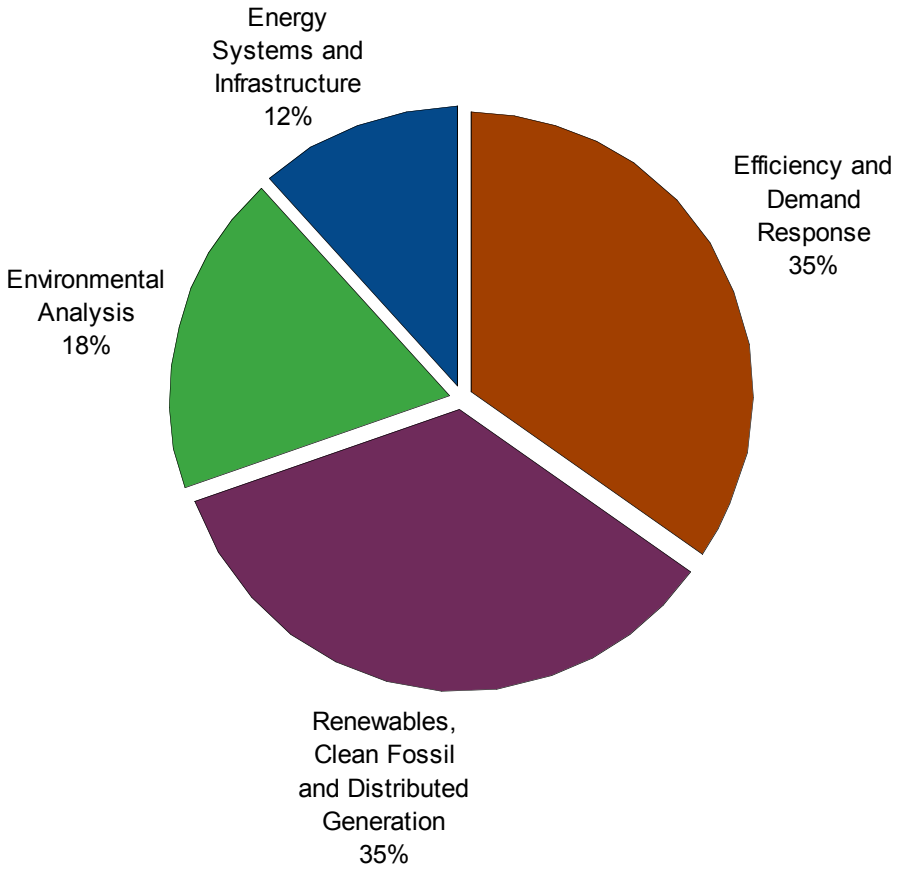
Along with the PIER Staffing Plan, this report is meant to comply with the requirements set forth in the California Public Utilities Codes 384.1 and 399.7.

Historic Research Funding

During the last five years, the PIER program has prioritized research funding according to the preferred loading order established in the *Energy Action Plan* and the *Energy Policy Report*. The program has focused primarily on research to support efficiency, demand response, renewables, clean fossil, and distributed generation. Together these areas represent 70 percent of PIER funding during the last five years (Figure 1). In

addition, PIER has funded research to address the environmental impacts of all the different elements of the California energy system, including climate change, indoor and outdoor air quality, land use, biological, and water-related impacts. Furthermore, PIER has funded research to address energy infrastructure issues and the integration of energy systems. Through this document there are sidebars with examples of completed research projects and their benefits.

Figure 1: Proportion of Funding by Research Area for Last Five Years



Notes: Numbers from PIER Information Management System (PIMS) database. Total contracts funded by PIER between 1/7/00 and 6/30/05.

During the next five years, PIER will continue to fund research in these areas as it is defined and prioritized in the following sections of this five-year plan. The five-year plan also defines the need to fund research to identify and address the impacts of transportation on the electricity system.

As the PIER program moves forward with the implementation of the Electricity Five-Year Plan, each program area will develop detailed roadmaps to translate the strategic objectives and research solutions into solicitations and proposed research projects. The program will go through an annual budgeting process and select a portfolio of short-, medium- and long-term investments in research projects and related outcomes. The program will revisit the portfolio every year as it goes through its budgeting cycle.

Process for Developing Electricity Five-Year Plan

The planning process for developing this five-year plan is characterized as closely tied to policy, integrated and inclusive. The entire five-year plan has been structured around current state energy policy, as well as complementing current policy with future policy issue. This five-year plan is integrated with the natural gas five-year plan and program management plan that are simultaneously being developed. The team charged with the development of the plan consists of 26 key PIER staff, divided into 3 task forces (Electricity, Natural Gas, and Program Management). Additional perspective from key stakeholders, both within and outside the Energy Commission, was obtained through hundreds of interviews and multiple workshops. This document is a culmination of those interviews and meetings and reflects the thoughts and opinions of dozens of individuals from multiple stakeholder groups.

PIER Mission and Vision

The PIER program has developed improved mission and vision statements. The program developed the improved statements to respond to the program's legislative mandate as well as inspire staff, guide planning efforts, describe the desired end-state of the program, and communicate to stakeholders the purpose and objectives for the program. Figure 2 describes the new PIER mission and vision statements, as well as the desired energy context and organizational values.

Figure 2: California Energy Context, Mission Statement, Vision Statement and Values

California Energy Context

California provides clean, affordable, reliable, and resilient sources of energy where consumers have choices that meet their needs, businesses prosper, and the state's beauty and environmental integrity are preserved.

PIER Mission Statement

The PIER program provides advanced energy innovations in hardware, software, systems, exploratory concepts, supporting knowledge, and balanced portfolio of near, mid, long-term energy options for a sustainable energy future in California.

PIER Vision Statement

Sustainable energy choices for utilities, State and local government, and large and small consumers in California.

PIER Values

Legislative Mandate

- Improves the quality of life of Californians by protecting public health and providing environmentally sound, safe, reliable, and affordable energy services and products.
- Undertakes public interest energy RD&D projects that are not adequately provided for by competitive and regulated energy markets.
- Advances energy science and technology of value to Californians.

Processes

- Responds to energy problems important to Californians.
- Informs and responds to state policy.
- Provides environmental stewardship and natural resource protection.
- Anticipates energy issues that California will face.
- Provides leadership to develop affordable, innovative, and sustainable solutions.
- Maintains integrity, objectivity, and trust as California's gateway for new energy technologies.
- Strives towards excellence in solutions, management, and administrative processes.
- Attracts, retains, and motivates the most talented staff.
- Balances a portfolio of incremental, breakthrough, and radical innovations.

Stakeholder Collaboration

- Works with stakeholders to plan research and transfer technology.
- Maximizes resources through valuable partnerships.
- Funds the best and brightest researchers.

Role of Policy, Technology, and Public Interest Research

The PIER program plays a key role in technology development and informing energy policy. PIER performs research that enables the development and market adoption of new energy technologies that respond to current energy policy and provide significant benefits to Californians. PIER also performs research that provides valuable input to policymakers regarding science and technology, resulting in enhanced and timely policy development, including research required to develop regulations, tariffs, and incentives. In addition, PIER performs research on emerging energy issues that will lead to the development of future state energy policy.

The PIER program is legislatively mandated to perform only public interest energy research. The legislation provides general guidance as to what should be considered public interest energy research (See Figure 3). However, the PIER program required a more specific set of criteria that could be used in selecting a wide range of potential projects across the different program areas. As a result, PIER has developed an improved set of criteria consistent with current PIER legislation to evaluate if a project meets the public interest mandate. As Figure 4 shows, each proposed project needs to pass three tests to meet the public interest criteria and be eligible for PIER funding. The Public Interest screening is the first step in the project selection process. If a proposed project meets the public interest screening criteria, it will then be evaluated against additional project selection criteria (such as alignment of the project with PIER's strategic objectives, value to ratepayers, contribution to research roadmap as well as others) used by PIER program managers to select the best projects to fund.

Figure 3: Legislative Guidance on Public Interest Research

WARREN -ALQUIST ACT

CHAPTER 7.1. PUBLIC INTEREST ENERGY RESEARCH, DEMONSTRATION, AND DEVELOPMENT PROGRAM

25620. Findings and declarations; environmentally sound, safe, r eliable, and affordable energy services and products

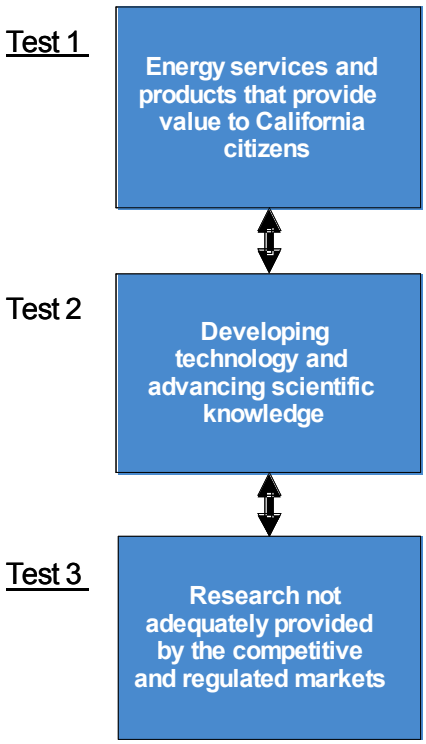
The Legislature hereby finds and declares all of the following:
(a) It is in the best interests of the people of this state that the quality of life of its citizens be improved by providing environmentally sound, safe, reliable, and affordable energy services and products.

(b) To improve the quality of life of this state's citizens, it is proper and appropriate for the state to undertake public interest energy research, development, and demonstration projects that are not adequately provided for by competitive and regulated energy markets.

(c) Public interest energy research, demonstration, and developm ent projects should advance energy science or technologies of value to California citizens and should be co nsistent with the policies of Section 399.7 of the Public Utilities Code.

(d) The commission should use its adopted "Five -Year Investment Plan, 2002 Through 2006 for the Public Interest Energy Research (PIER) Program (Volume 1) " (P600 -01-004a, March 1, 2001) to ensure compliance with the policies and provisions of Section 399.7 of the Public Utilities Code in the administration of public interest energy research, demonstration, and development program s.

Figure 4: Public Interest Screening Criteria



TEST PASSED IF ANSWER IS "YES" TO ANY QUESTION BELOW

- Does the research seek to improve the affordability of energy se rvices and products?

or

- Does the research seek to improve the safety and/or reliability of energy services and products?

or

- Does the research seek to reduce the impact on or restore the en vironment through energy services and products?

TEST PASSED IF ANSWER IS "YES" TO EITHER QUESTION BELOW

- Does the research effort develop, demonstrate, or help to commer cialize new or improved technologies [1]?

or

- Does the research advance scientific knowledge upon which new te chnologies, services, products, or policies can be developed?

TEST PASSED IF ANSWER IS "YES" TO EITHER QUESTION BELOW

- Is the research focusing on science or technology that would oth erwise not be developed during the desired time frame for the intended applica tion?

or

- Is the research addressing a public need for which there is insu fficient research activity in competitive and regulated markets?

[1] Technology includes hardware, software, systems, exploratory con cepts, and supporting knowledge.

The PIER program will continue to improve and refine public interest research screening criteria in 2006. As California investor-owned utilities (IOUs) seek to reestablish regulated research programs, it will be important to clarify the definition of regulated, competitive, and public interest energy research. PIER will work with IOUs, State regulators, private industry, and other stakeholders to clarify the definition and relationship among these classifications of energy research. Moreover, for transportation-related research, the PIER program will work to define the dual benefits criteria so that research provides electric ratepayer benefits as well as benefits to the transportation system.

ENERGY ISSUES IMPORTANT TO CALIFORNIA

Policy Shaping California's Energy Future

Chapter 7.1 of the Warren-Alquist Act states that "it is in the best interests of the people of California that the quality of life of its citizens be improved by providing environmentally sound, safe, reliable, and affordable energy services and products". State legislators and policymakers are continuously looking to improve energy services and products to achieve these objectives. They set the direction for California through a series of laws and policy initiatives that cover a wide range of energy issues. The PIER program provides the research to support these efforts. In addition to supporting California issues, PIER also informs federal energy and environmental policy.

The *Energy Policy Report* is the recognized publication required by law to recommend energy policy. It is developed every two years, with an update in-between, by the Energy Commission in collaboration with such organizations as the CPUC, California Environmental Protection Agency (Cal EPA), and California Independent System Operator (CA ISO). It defines the energy issues that the State will need to address over the coming years. It also identifies areas of policy, regulatory, and technology research that the PIER program will need to address. The *Energy Policy Report* development process includes extensive participation for key industry stakeholders (for example, 56 public workshops were held during the development of the 2005 *Energy Policy Report*). The 2005 *Energy Policy Report*, published November 2005, addressed the following issues:

- Electricity needs and procurement policies.
- Demand-side resources, distributed generation, and other electricity supplies.
- Transmission challenges.
- Renewable resources for electricity generation.
- The challenges and possibilities of natural gas.
- Integrating water and energy strategies.
- Transportation fuels.
- Global climate change.
- California-Mexico border region energy issues.

The *Energy Action Plan* is a policy implementation plan that also provides guidance on state energy policy. Jointly developed by the Energy Commission and the CPUC, with input from the CalEPA, CA ISO, and the Business, Transportation, and Housing Agency, the *Energy Action Plan* is meant to provide direction on the implementation of energy policy. This plan also identifies areas where public interest energy research is required. The *Energy Action Plan II,* adopted September 2005, identified the following key actions for energy R&D:

- Energy efficiency technologies transformation to tools and standards.

- Demand response technologies, including communication and control, planning tools, end-use technologies, and validation methodologies.
- New technologies for renewables and greenhouse gas mitigation, including efficiency, renewable generation, and energy storage.
- Natural gas RD&D to address biogas and syngas, storage reservoir management, safety and efficiency; and high quality natural gas.
- Efficiency improvements of petroleum-fueled vehicles; availability and use of non-petroleum fuels.
- Clean coal technology R&D, and CO2 sequestration.
- Cost-effective dry cooling technologies and minimization of once-through cooling practices.
- Transmission technology development to maximize efficient use of the bulk electricity grid.
- Participation of the Biomass Collaborative with the Interagency Working Group's efforts on an integrated and comprehensive State policy on biomass that encompasses electricity, natural gas and transportation fuel substitution potential.
- Climate Change – Consequence evaluation of climate change and adaptation and mitigation strategies for California.

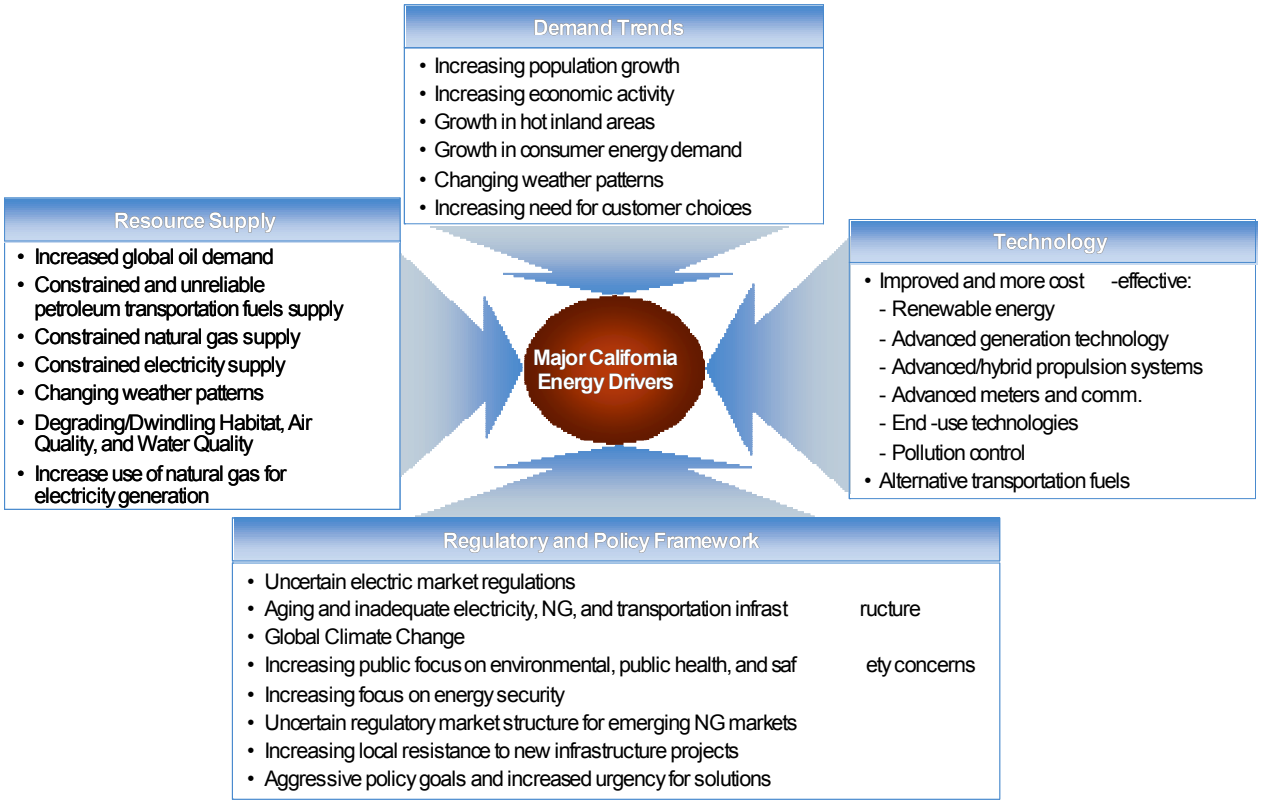
In addition to these reports, the PIER program supports additional State energy policy initiatives from the Governor and regulatory agencies (for example, Energy Commission Siting and Standards divisions, CPUC, California Air Resources Board).

Throughout this document, specific policy statements from the *Energy Policy Report*, *Energy Action Plan*, and other energy policy initiatives that are guiding PIER research will be identified. A summary of the energy policy supported by PIER research can be found in Appendices A – E.

Trends and Drivers

In addition to following direction from State energy policy, the PIER program continuously looks at trends and drivers shaping the energy sector and the related emerging policy and technology issues that will call for new environmentally sound, safe, reliable, and affordable energy services and products. In the process of developing this five-year plan, PIER identified 26 energy trends and drivers and used them to develop the Research Solutions described in the following pages. Figure 5 lists the trends and drivers grouped into four categories: Demand Trends, Resource Supply, Technology, and Regulatory and Policy Framework.

Figure 5: California Energy Trends and Drivers



Demand Trends

There are significant trends impacting the demand for energy in California. Specifically, the population and economic development in hot inland areas require new energy infrastructure, increase home energy consumption and peak demand spikes, and increase driving distances and use of transportation fuel. In addition, the growth of the entire western region population increases demand for electricity, natural gas, and transportation fuels and will put pressure on the infrastructure unless the growth can be slowed by decreased per capita consumption.

Resource Supply

The availability and stability of the electricity and natural supplies, including in-state generation, importation from other western states (for example, coal, renewables, hydroelectric power from Northwest) and Baja California, Mexico, and the importation of liquefied natural gas (LNG) will impact prices and increase price volatility. In addition, changing weather patterns will likely reduce the available snow pack to be used for hydroelectricity.

Regulatory and Policy Framework

Uncertainty exists in the direction of regulatory control and the effects in the competitive markets. This uncertainty includes but is not limited to tariff structures and the fact that current approaches to calculate life cycle costs do not consider fuel costs. Furthermore, the application for existing regulations and consumer and government support for new

regulations to protect the environment (for example, Renewable Portfolio Standards, efficiency standards, local air quality emission regulations) will have implications to infrastructure constraints, energy prices, and protection of the environment, public health, safety, and environmental justice.

Technology
Technology breakthroughs in performance and cost, along with the wide adoption of advanced technologies for generation, meters, communication, and transportation, will provide additional energy supply options, increased environmental benefits, and reduced life cycle costs.

Key Energy Issues

As directed by current State energy policy, and incorporating emerging issues from trends and drivers, the PIER program has identified five key energy issues important to California. These issues are:

- Affordable, comfortable, and energy-smart choices for daily life and a strong California economy.
- Clean and diverse electricity supply that optimizes California's resources.
- Clean and diverse transportation system in California.
- Integrated electricity system that is reliable and secure.
- Environmentally sound electricity system in California.

The following sections will identify key policy directives, as well as define PIER strategic objectives and PIER research solutions for each of the five key energy issues over the 2007 to 2011 period.

AFFORDABLE, COMFORTABLE, AND ENERGY-SMART CHOICES FOR DAILY LIFE AND A STRONG CALIFORNIA ECONOMY

Current State Policy

The *Energy Action Plan /Energy Policy Report* Loading Order for Efficiency and Demand Response, as well as CPUC energy efficiency and peak demand goals, provide key policy guidance to research toward achieving affordable, comfortable, and energy-smart choices for daily life and a strong California economy. More specifically, the key goals the state has defined are:

- CPUC cumulative goals of nearly 27,000 gigawatt hours of electricity savings and nearly 7,000 megawatts of peak demand reduction for period 2004 – 2013 (CPUC D04-09-060) from a 2004 baseline of 218,000 gigawatt hours and 45,000 megawatts respectively (Energy Commission Staff Energy Forecast 2006-2016, September 2006).
- Twenty percent reduction in energy consumption in state buildings by 2015 (Executive Order S-20-04)

Policy related to end-use efficiency defined the need to reduce use and increase efficiency of electricity used in existing buildings, promote programs that reduce peak demand, reduce overall electricity in State buildings, and invest in emerging technologies that improve efficiency. Policy related to peak load management and demand response defined the need to develop improved end-use technologies and encourage consumer behavior to reduce power usage during peak hours.

In addition, policy emphasizes that PIER should identify opportunities and support programs to reduce electricity demand related to the water supply system during peak hours and opportunities to reduce the energy needed to operate water conveyance and treatment systems, as well as pursue cost-effective load management and demand response programs on California's water systems. A list of relevant policies can be found in Appendix A.

Integrated Classroom Lighting System

Problem
Typical classroom lighting does not meet the functional needs of teachers or students and is expensive to operate. The modern classroom requires a range of lighting scenarios, from full lighting for traditional teaching to various levels of dimming for audiovisual presentations.

PIER Solution
The Integrated Classroom Lighting System (ICLS) is made up of efficient light fixtures, high-efficiency fluorescent light sources, and user-friendly controls. The system saves energy and improves the learning environment.

Benefits
The system cuts classroom energy use in half while providing light when and where it is needed. It also allows the instructors to adjust the lighting to meet changing activity needs. The financial payback is immediate. In coordination with utility emerging technology programs, the system has been successfully introduced to the industry. The system is currently being installed at classrooms of the Los Angeles Unified School District.

Trends and Drivers

Demand trends are a key concern for PIER in this area as it anticipates future needs. Increasing population growth will lead to increased demand for electricity unless it can be mitigated by further efficiency gains. A significant portion of the state's growth of population is occurring in hot inland areas, increasing energy consumption and peak demand spikes. Furthermore, there is increasing pressure from consumers to select their energy services from a set of energy products and services options. Other trends that could have a significant impact in this area include changing weather patterns, constrained supply of electricity and wide adoption by energy consumers of real-time energy management and dynamic control systems.

PIER Strategic Objectives

To support the state in accomplishing these policies and goals, as well as anticipate future needs, the PIER program has defined five strategic objectives that will provide California with affordable, comfortable and energy-smart choices for daily life and a strong state economy:

1. ***Reduce energy cost and improve performance of efficiency end-use systems (residential, commercial, industrial, agricultural).*** This objective is directly tied to helping the state meet the aggressive efficiency goals, as well as supports the implementation of efficiency as the first option in the *Energy Action Plan /Energy Policy Report* loading order.
2. ***Develop energy-efficient technologies for unique California conditions and industries.*** This objective will also help the state meet the aggressive efficiency goals and the implementation of efficiency as the first option in the *Energy Action Plan* /*Energy Policy Report* loading order. Moreover, it will help address issues related to population and economic growth in hot inland areas.
3. ***Reduce water use and improve efficiency of alternative water sources, treatment, and delivery.*** In addition to supporting the efficiency goals, this objective supports the policy to reduce electricity demand related to the water supply.

Tuning of Canal Automation in Irrigation Districts

Problem
Most irrigation districts have limited to no ability to deliver surface water to farms using flexible water delivery schedules. Without this flexibility farmers converting to drip irrigation technologies tend to use groundwater resources. Pumping from groundwater sources is more energy intensive.

PIER Solution
PIER funded development of canal automation techniques. Canal automation refers to a control mechanism that allows a gate or pump to independently change its position or setting in response to measurements taken on-site. Improved canal automation makes the process of controlling canals easier. It cuts down on energy and labor needed to travel to sites for monitoring and making changes permits irrigation districts to make quick changes to flow rates and distribution in response to farmers' needs. It conserves water both on-farm and from irrigation district canal spills and saves electricity in the process.

Benefits
More than 470,000 megawatt hours per year of electricity savings can result from reduced use of electricity from irrigation district surface and groundwater pumping as well as from on-farm groundwater and booster pumping when irrigation districts adopt the canal automation technologies.

4. ***Develop end-use cost-effective load management and demand response technologies.*** This objective supports the aggressive peak demand reduction goals. It will also help mitigate the impact of increased peak demand spikes due to the growth in hot inland areas.
5. ***Develop knowledge base for future decision-making and informed end-use policy relative to electricity.*** This objective will address the trends, technology gaps, and emerging energy issues to provide policymakers with the knowledge required to develop effective future policy in this area.

PIER Research Solutions

To achieve these strategic objectives, the PIER program identified research solutions. The solutions were prioritized into primary, secondary, and tertiary areas of RD&D based on relevance to State policy, critical technical gaps, and the potential impact of emerging trends and drivers.

Dynamic Characterization of Power Quality for Enhanced Reliability in California Food Processing Industry

Problem
Increased automation in the food processing industry makes it quite susceptible to power quality fluctuations. Minor interruptions can cause days of plant shutdown, large economic losses and impact the ability of California industries to compete in the global marketplace.

PIER Solution
PIER worked with industry and engineering experts to identify a representative industrial site to complete detailed analysis. In-line monitoring systems were installed at the Del Monte plant in Modesto to collect real-time performance data. Overall process sensitivities to different power quality disturbances were defined. Recommended actions were developed for the entire food processing industry using not only the information gathered at the site but also by comparing the results to the lessons learned in other industries, such as California's Semiconductor Manufacturing industries, to identify the best possible solutions.

Benefits
This effort provided the California food processing industry the baseline data necessary to make its production process more robust and capable of withstanding a wider range of electrical power disturbances without suffering production losses, thus increasing productivity and their global competitive position.

Primary Areas of RD&D

- Reduce first costs and operational costs of energy efficient technologies and systems for buildings and industries.
- Increase efficiency of existing building systems and industrial processes (for example, develop replacement/retrofit products, improve operational strategies, identify intervention tactics).
- Develop energy efficient end-use technologies and strategies for unique California conditions and industries (for example, climate, construction practices, state standards).
- Understand linkages between water and electricity to reduce water use, improve the energy efficiency of treatment and delivery of alternative water sources, and develop water-related energy storage.

Secondary Areas of RD&D

- Develop technologies and strategies that reduce peak demand (for example, Zero Energy New Homes, low-energy cooling and industrial refrigeration systems).
- Develop end-use load management and demand responsive technologies that support power reliability and dynamic tariffs, as well as the integration of advanced metering (for

example, programmable communicating thermostats, lighting controls, analysis tools).
- Develop sustainable building technologies, designs and systems, including sustainable building construction practices and integration of environmental and generation issues in efficient building design.

Tertiary Areas of RD&D

- Develop improved (more energy efficient) information systems and consumer electronic technologies.
- Develop advanced irrigation practices related to water conservation and recovery.
- Develop commissioning, benchmarking and diagnostic tools, standard practices, and specifications for energy efficiency.
- Develop technologies to further the understanding of consumer behavior and market issues.

Design Guide: Big Savings on Small HVAC Systems

Problem
Small packaged heating, ventilation, and air-conditioning (HVAC) systems, the most common for small commercial buildings, are notorious for a host of problems that result from inadequate design, installation, maintenance, and operation, requiring 25 to 35 percent more energy.

PIER Solution
The Small HVAC System Design Guide, available from PIER, discussed solutions to common problems in the design, operation, and maintenance of small rooftop HVAC systems.

Benefits
Several organizations are using the guide in training programs for mechanical systems designers. The research also led to two code changes to the California 2005 Title 24 standards on acceptance requirements for non-residential buildings and non-residential duct sealing and insulation.

Benefits to Californians

As the PIER program works to enable affordable, comfortable, and energy-smart choices for daily life and a strong California economy, Californians will gain important benefits. The most important benefit is lower energy costs that will be achieved through the more efficient use of energy. Efficient use of energy results in lower energy consumption, as well as lower energy prices through a shift in the supply/demand equilibrium market price and reductions in system peak demand. Other benefits include: lower water cost to homes and businesses through more efficient use of energy in the delivery and treatment of water; increase in the state's competitive position to attract and retain industry and create jobs; and increase in indoor comfort.

CLEAN AND DIVERSE ELECTRICITY SUPPLY THAT OPTIMIZES CALIFORNIA'S RESOURCES

Developing Tools that will Help California's RPS Efforts

Renewable Models
Initiated well before the Renewable Portfolio Standards (RPS), PIER analysis provided critical information on types and amounts of renewables, how they can be used to help meet electricity needs by 2010 and 2017, and how to implement them to obtain additional public benefits.

Coordination with Regulators
PIER is coordinating with other Energy Commission divisions, the CA ISO, the CPUC, and IOUs to ensure products can help meet SB 1038 and SB 1078 requirements.

Current State Policy

The Renewable Portfolio Standards (RPS), the *Energy Action Plan /Energy Policy Report* Loading Order for renewables and distributed generation (including combined heat and power), the Governor's Ten Point Energy Plan, and the Western Governors' Association Resolution provide key policy guidance to research toward achieving a clean and diverse electricity supply that optimizes California's resources. Specific goals are:

- 20 percent renewables by 2010, 33 percent renewables by 2020 (2003 and 2004 *Energy Policy Report*).
- 1 million solar roofs by 2018 (CPUC California Solar Initiative).
- 30,000 megawatts of clean and diverse resources in West by 2015 (Western Governors' Policy Resolution 04-14).

Electricity generation from renewable resources is a key component of current energy policy. It is the next element in the *Energy Action Plan /Energy Policy Report* loading order after efficiency and demand response. The *Energy Policy Report* also identified the need to repower aging wind facilities, simplify the RPS process, and support biomass development. *Energy Policy Report*/*Energy Action Plan* loading order has DG as the next element after renewables, and the *Energy Policy Report* is promoting combined heat and power as a viable end-use efficiency strategy for businesses. Moreover, the *Energy Policy Report* and *Energy Action Plan* support advanced coal R&D, including capturing and storing carbon dioxide. A list of relevant policies can be found in Appendix B.

Trends and Drivers

Regulatory framework, resource availability, and technology drivers are a key concern in this area. The application of existing regulations and consumer and government support for new regulations to protect the environment will continue to drive the use of renewable resources in the generation of electricity. Improved and more cost-effective renewable energy technology will contribute to resource adequacy and wide adoption of these technologies. Electricity supply constraints, leading to increased prices and price volatility, could also have a significant impact in this area.

PIER Strategic Objectives

To support the state in accomplishing these policies and goals, and to anticipate future needs, the PIER program has defined four strategic objectives that will provide California with a clean and diverse energy supply that optimizes the state's resources:

1. ***Reduce cost and improve system and environmental performance of solar, wind, biomass, geothermal, and hydroelectric technologies.*** This objective is directly tied to help the state meet RPS goals, the California Solar Initiative, and the Governor's commitment to develop clean and diverse energy resources. It will also help meet the *Energy Action Plan /Energy Policy Report* loading order, address future regulations to protect the environment, and promote the wide adoption of renewables. It will also help mitigate natural gas resource constraints, global climate change, and environmental impacts.
2. ***Reduce cost and improve system and environmental performance of alternative generation systems.*** This objective will help meet the *Energy Action Plan /Energy Policy Report* loading order, the *Energy Policy Report* and *Energy Action Plan* support for clean coal and combined heat and power, and the Governor's commitment to develop clean and diverse energy resources. It will also help address electricity supply constraints.
3. ***Develop adequate generation resources that are diverse and flexible.*** This objective will help meet the Governor's commitment to develop diverse energy resources. It will also provide consumers with a broader set of choices of energy products and services.
4. ***Develop knowledge base for future decision-making and to inform electricity supply policy.*** This objective will address the trends, technology gaps, and emerging energy issues to provide policymakers with the knowledge required to develop effective future policy in this area.

Performance Testing and Reporting Protocols for DG Systems

Problem

No uniformly accepted procedures for testing the performance of distributed generation (DG) and DG/combined heat and power (CHP) systems exist, resulting in the slower adoption of DG/CHP and the efficiency and transmission and distribution relief that well designed and properly sited DG/CHP systems can offer.

PIER Solution

PIER is collaborating with energy agencies from other states and the US Department of Energy in a stakeholder-driven program to develop DG/CHP performance testing and reporting protocols.

- Testing protocols have been prepared for three prime movers (reciprocating engines, microturbine generators, and industrial turbines) as applied in laboratory testing, field testing, and long- term monitoring. A reporting protocol for case studies has been prepared also.
- A searchable database to host data and reports generated using the protocols has been established at the National Renewable Energy Laboratory.
- Testing protocols for fuel cells are being prepared.

Benefits

The National Database is being populated with reliable data on the performance of DG and DG/CHP systems. Interested parties can query the database to make comparison among prime movers offered by different vendors to compare different types of prime movers and to learn how DG/CHP systems operate in different applications. The data are especially useful for understanding technologies as they emerge from PIER-funded RD&D.

PIER Research Solutions

To achieve these strategic objectives, the PIER program identified research solutions. The solutions were prioritized into primary, secondary, and tertiary areas of RD&D based on relevance to state policy, critical technical gaps, and the potential impact of emerging trends and drivers.

Primary Areas of RD&D

- Reduce lifecycle cost of electricity from renewable resources (biomass, geothermal, wind, solar, and hydroelectric) by reducing capital, operational, and maintenance costs and by improving performance.
- Improve renewable energy reliability, quality, and environmental performance.
- Improve cost-effectiveness, thermodynamic efficiency and fuel flexibility, as well as the reliability, availability, maintainability, durability and environmental compliance of alternative generation systems (advanced reciprocating internal combustion engines, advanced turbines, fuel cells, and fuel cell/turbine hybrids).
- Support development of advanced coal technologies, including capturing and storing CO_2.
- Develop technologies to utilize waste fuels, heat and pressure.
- Improve existing renewable energy facilities to increase peak capacity and improve system reliability.
- Support the environmentally sound re-powering of aging wind facilities and aging power plants.

Food Processing Wastewater Biogas to Electricity

Problem
The food processing industry is paying high fees to discharge the wastewater to the sewer due to high biological oxygen demand (BOD) and suspended solids (SS) concentration in the wastewater.

PIER Solution
PIER created an economically feasible solution to energy and waste issues facing food processors. Specific solutions included:
- Improving the perception of anaerobic digestion technology as a viable solution to waste and energy issues in the food processing industry.
- Collecting and using anaerobic digester biogas to economically produce electricity and heat.

Benefits
- Energy saving of about $60,000/year.
- BOD and SS levels reduced by 85 percent, corresponding to a total annual saving of about $85,000/year.

Secondary Areas of RD&D

- Expand distributed generation to help provide generation in areas of highest value (for example, high-demand, high-grid-congestion areas, network peak demand).
- Evaluate and help capture of environmental benefits and adverse impacts from renewable energy production.
- Develop improved combined cooling, heat, and power (CCHP) systems (for example, industrial applications, modular systems).
- Develop and demonstrate innovative generation technologies: hybrid combinations, novel cycles, mixed fuels, co-firing, and biomass gasification.
- Explore and implement electric energy storage technologies to make renewable energy more dispatchable.

Tertiary Areas of RD&D

- Develop co-production technologies (for example, fuel and electricity).
- Develop improved technologies for exploration and use of geothermal resources.

Benefits to Californians

As the PIER program works to enable a clean and diverse electricity supply that optimizes California's resources, Californians will gain important benefits. The most important benefit is that Californians will have a clean and environmentally friendly energy system, based on renewable energy sources, that is cost-competitive with traditional oil- and gas-fueled generation technologies. Other benefits include reduced dependence on out-of-state/international resources, reduced volatility of energy prices, and a reduction in the total number of new power plants required to meet the growing energy needs of California.

Wind Energy Forecasting

Problem
To meet scheduling and dispatching needs, a near real-time wind energy forecasting and "look-ahead" tool is necessary.

PIER Solution
PIER reduced wind energy forecast errors and developed a forecast deployment strategy that included both short- and long-term forecasts to help CA ISO meet its operating needs.

Benefits

- Demonstrated short-term regional forecast system (near real time, one to three hours ahead).
- Reduced Long-Term Regional Forecast System (day ahead, 1- 48 hours) errors 20-30 percent over persistence forecasting.

CLEAN AND DIVERSE TRANSPORTATION SYSTEM

Current State Policy

Transportation issues have been historically outside the mandated direction of the PIER program. However, recent legislation, SB 76, states that "Funds deposited in the Public Interest Research, Development, and Demonstration Fund may be expended for projects that serve the energy needs of both stationary and transportation purposes if the research provides an electricity ratepayer benefit."

The Energy Commission and Cal EPA, in separate proceedings, have evaluated the state's most critical transportation energy issues and engaged stakeholders and other agencies to develop policy and action recommendations to address these issues. The Energy Commission and Cal EPA have developed policy and action recommendations for the Governor aimed at achieving a clean and diverse transportation system that meets increasing fuel demand through efficiency improvements and alternative fuels:

- Double the combined Corporate Average Fuel Economy (CAFE) standard for new passenger cars and light-trucks by 2020 (2003 *Energy Policy Report*).
- Increase the percent of on-road non-petroleum fuel use to 20 percent by 2020 and 30 percent by 2030 (2003 *Energy Policy Report*).
- Reduce greenhouse gas[2] emissions to 2000 level by 2010, to 1990 level by 2020, and to 80 percent below 1990 level by 2050 (Governor Executive Order S-3-05 included in Appendix G).
- Advance technology that provides petroleum reduction, greenhouse gas, and air quality benefits and supports the long-term transition to a transportation system based on alternative fuels such as hydrogen.
- Expand California's goods movement industry and infrastructure in a manner that will increase mobility and relieve congestion, and improve air quality and protect public health (Governor's Goods Movement policy statement).
- Reduce air pollution by up to 50 percent (Governor's Environmental Action Plan).

PIER is guided by the *Energy Policy Report* recommendations and public processes that engage the research community to develop its transportation research strategies. A list of relevant policies can be found in Appendix C.

[2] Defined by the Intergovernmental Panel on Climate Change to include: CO_2, CH_4, N_20, CF_4, C_2F_6, CHF_3, SF_6, $C_2H_2F_4$, $C_2H_4F_2$, $CFCl_3$, CF_2Cl_2, $CClF_3$, $C_2F_3Cl_3$, $C_2F_4Cl_2$, C_2F_5Cl, CCl_4, CH_3CCl_3, $C_2H_3FCl_2$, $C_2H_3F_2Cl$, $CClF_2Br$, CF_3B.

Trends and Drivers

Transportation accounts for half of all energy used in the state and is responsible for nearly half of all greenhouse gas emissions in the state. Transportation also is the largest source of air pollution, emitting nearly 70 percent of smog-forming pollutants. Demand for gasoline and diesel has grown nearly 50 percent in the past 20 years and is continuing, even in the face of record prices. Population growth, consumer preference for less efficient vehicles, increasing traffic congestion and driving distances, lack of alternative fuels, and adequate mass transit options are contributing to this demand for fuel. Since California is almost entirely dependent on petroleum for transportation uses and imports more than 60 percent of its supply, the state is increasingly vulnerable to the economic impacts caused by the growing global competition for petroleum. Moreover, the state's increasing reliance on imported gasoline to meet demand exacerbates fuel price volatility.

PIER Strategic Objectives

To support the state in accomplishing these policies and goals, as well as anticipate future needs, the PIER program has defined four strategic objectives that will provide California with a clean and diverse transportation system:

1. ***Identify advanced transportation research opportunities that optimize the goals of reducing petroleum dependence, enhancing energy, and economic security, and expanding environmental and public health benefits.*** By pursuing petroleum reduction opportunities within California that also maximize economic, environmental, and public health objectives the state can galvanize broader public and private resources, create price competition within the transportation market, and accelerate the pursuit of reducing our dependence on petroleum.
2. ***Develop and demonstrate technologies to improve efficiency within the transportation system.*** Increasing vehicle fuel economy is the most cost-effective means to reduce gasoline use, greenhouse gas emissions, and vehicle pollution. Since CAFE standards are the purview of the federal government, the state must look to other strategies to enhance the efficient use of gasoline and diesel fuels. These include development of vehicle efficiency technologies that can be adopted by the industry, demonstrating innovative mass-transit applications, and commercializing systems that conserve gasoline and diesel fuel.
3. ***Develop and demonstrate alternative fuels, vehicles, and fueling infrastructure.*** Another important strategy the state can directly affect is diversification of the fuel supply. In this regard, priority should be given to fuel blends (for example, non-petroleum fuels blended with gasoline and diesel) that can be used in existing engine systems and fueling infrastructure. Renewable fuel blends should be of particular importance given the potential to

produce these fuels from in-state resources and provide economic value to California. However, given the significant long-term potential to reduce petroleum use, greenhouse gas emissions, and vehicle pollution, the state should support all reasonable non-petroleum fuel and technology options.

4. ***Develop the knowledge base and advanced analytical tools for future decision-making and informed transportation policy.*** This strategy fills a critical gap in energy policy by more clearly defining the relationships between transportation energy supply and demand and the affects on consumer behavior, market behavior, and land-use planning.

PIER Research Solutions

To achieve these Strategic Objectives, the PIER program used the *Energy Policy Report* recommendations to identify research solutions for transportation. The solutions represent areas of RD&D based on relevance to state policy, critical analytical and technical gaps, and the potential impact of emerging trends and drivers.

In the first half of 2006, the PIER program will start a series of planning meetings with key stakeholders and other state transportation agencies to prioritize and refine the research solutions. In parallel, PIER also expects to select and fund several near-term transportation research projects that provide clear benefits to California electricity ratepayers as required by SB76 and address urgent state transportation policy mandates. These mandates include needs to reduce California's petroleum dependency, reduce California's contributions to greenhouse gasses, and reduce air quality impacts from the transportation sector. Decisions on priorities will also be dictated by the amount of public research funds allocated to transportation. The Energy Commission intends to use a broad interpretation of electricity ratepayer benefits as they apply to transportation research projects. For example, transportation projects that improve efficiency or reduce air emissions or reduce greenhouse gasses or increase alternative fuels use would be considered for funding. However, project proponents will be expected to identify benefits to electricity ratepayers.

Advanced Energy Pathways

Problem
The future of the electricity and natural gas sectors is strongly linked to the energy pathways that the state may choose for the different sectors of the economy. The potential energy pathways for the transportation sector in particular such as plug-in hybrids and the use of hydrogen as a transportation fuel could severely affect the natural gas and electricity systems by increasing or decreasing the prices and availability for these two energy carriers.

PIER Solution
The purpose of this on-going research is to conduct an integrated analysis that compares the costs and benefits of alternative transportation fuel pathways from the perspective of electricity and natural gas sectors, greenhouse gas emissions, tailpipe emissions, gasoline consumption, cost-effectiveness, technical challenges, infrastructure issues, safety issues, and policy implications.

Expected Benefits
The findings from this project are expected to provide policymakers with as comprehensive a view as possible of the various pathways and their costs and benefits.

Areas of RD&D

- Develop and demonstrate advanced fuel efficient transportation technologies and fuel switching strategies that result in a cost-effective reduction of on-road and off-road petroleum fuel use in the short and long term.
- Develop and demonstrate alternative transportation fuels that can augment available transportation fuel supplies with non-petroleum sourced fuels, can optimize their efficiency, environmental and public health benefits, and commercial viability over the mid and long term.
- Develop and demonstrate technologies for the in-state production of renewable and non-petroleum transportation fuels that can augment transportation fuel supplies, provide state economic and ratepayer benefits, reduce air pollutant and greenhouse gas emissions, and increase on- and off-road transportation fuel diversity.
- Develop and demonstrate options for alternative fuel distribution, infrastructure development and deployment, and examine technologies such as plug-in hybrids, truck stop, marine port and airport electrification and accelerate storage and distribution technology development for non-petroleum alternative fuels.
- Develop and demonstrate mitigation strategies that address the environmental and economic impacts of non-petroleum alternative fuel production, distribution and utilization, and accelerate the deployment and refinement of highly efficient transportation technologies.
- Develop and demonstrate advanced planning tools, processes and regulatory models that integrate fuel choices and demand considerations and innovative mass-transit strategies in local land-use and transportation planning.
- Develop technologies and tools to further understand consumer behavior and preferences and how these are affected by fuel choices and market conditions.

Benefits to Californians

To meet the state's growing population and economic demands, ensuring a reliable, clean, and affordable transportation system is vital. The Energy Commission has started an integrated analysis of the costs and benefits of alternative transportation fuel pathways and implications of these pathways on electricity and natural gas sectors, greenhouse gas emissions, tailpipe emissions, gasoline consumption, cost-effectiveness, technical challenges, infrastructure issues, safety issues, and policy implications. The findings from this research are expected to provide policymakers with a comprehensive view of relative costs and benefits from an energy system perspective. In the years ahead, as the PIER program works to enable a clean and diverse transportation system, Californians will gain important benefits that include reduced impact from global climate change, reduced health risks related to poor air quality, reduced volatility of transportation fuel prices, and reduced economic impact from dependence on foreign oil.

INTEGRATED ELECTRICITY SYSTEM THAT IS RELIABLE AND SECURE

Current State Policy

Enabling the integration of renewables, demand response, distributed generation, and electric energy storage into the delivery infrastructure to support the RPS, Loading Order, and Governor's Ten Point Plan (see Appendix F) provides key policy guidance to research toward achieving an integrated electricity system that is reliable and secure.

A key policy in this area covered by the *Energy Policy Report* is the integration of intermittent and remotely located renewables. The *Energy Policy Report* and *Energy Action Plan* address the need for energy storage and transmission technologies. The *Energy Policy Report* also defined the need to improve transmission planning and permitting.

The *Energy Policy Report* requires utilities to implement transparent distribution planning and construct distribution systems that are more compatible with distributed generation and combined heat and power systems. The *Energy Policy Report* and *Energy Action Plan* support metering and communication technologies, standards, and dynamic tariffs for demand response. The *Energy Policy Report* also supports incentives to promote customer and utility owned distributed generation and combined heat and power systems. A list of relevant policies can be found in Appendix D.

DG Interconnection Standards

Problem
No clear rules or standards for the interconnection of distributed generation (DG) equipment, resulting in high interconnection costs and long lead times, limiting DG penetration.

PIER Solution
PIER established the Rule 21 working group with the participation of IOUs, regulatory agencies, equipment manufacturers, and project developers. The group worked to:
- Resolve technical safety issues.
- Establish technology and size neutral review process.
- Enable insertion of new generation into grid.
- Identify testing and certification requirements.

Benefits
Standard interconnection times have been reduced by 80 percent, estimated savings during the first two years were above $25 million.

Trends and Drivers

The regulatory framework and technology advances have significant impact in this area as it anticipates future policy needs. The poor state of current infrastructure, lack of investment in new infrastructure, lack of collaboration, and regulatory constraints to develop new infrastructure result in reduced capacity and higher energy prices. There is also increasing focus on energy security and protection against natural and terrorist threats to energy infrastructure. Technology breakthroughs in performance and cost of advanced meters, broadband communications, and information technologies will provide increased throughput from infrastructure.

PIER Strategic Objectives

To support the State in accomplishing these policies as well as to anticipate future needs, the PIER program has defined seven strategic objectives that will provide California with a safe, secure, and reliable energy system:

Automated Demand Response in Commercial and Industrial Facilities

Problem
Current demand response strategies require facility personnel to develop poorly understood response strategies with manual controls.

PIER Solution
PIER established the Demand Response Research Center with the participation of utilities, system operators, regulatory agencies, and other stakeholders. The DRRC has a series of projects. One project is working to:
- Automate demand response through Internet based communications and existing controls.
- Conduct demonstrations directly linked to utility demand response programs.
- Publish a guide to end-use control strategies and evaluate demand response capabilities in existing facilities.

Benefits
- More consistent demand response savings from full automation – preliminary tests of 23 sites yielded 8 percent average load reduction with a maximum reduction of 42 percent.
- Greater demand response with field tests of existing controls.
- Standardized automation signaling infrastructure supports multiple demand response programs.

1. ***Enable optimal integration of renewables, distributed generation, demand response, and storage to the power system.*** This objective will help meet the RPS and peak demand reduction goals, as well as the loading order. It will directly address the *Energy Policy Report* issue of integrating intermittent and remotely located renewables, as well as the need for energy storage and transmission technologies.
2. ***Improve capacity, utilization, and performance of transmission and distribution system.*** This objective will help meet the *Energy Policy Report* and *Energy Action Plan* need to improved transmission technologies, as well as the *Energy Policy Report* request for transparent distribution planning and support for distributed generation and combined heat and power.
3. ***Improve cost and functionality of components to integrate demand response, distributed generation, and electricity storage into the system.*** This objective will address the *Energy Policy Report* and *Energy Action Plan* request to support storage, metering, and communication technologies. It will also promote technology breakthroughs in performance and cost of advanced meters, broadband communications, and information technologies that will provide increased throughput from energy infrastructure.
4. ***Improve security and reliability of electricity system.*** This objective will address the increasing focus on energy security and protection against natural and terrorist threats to energy infrastructure.
5. ***Support improvement of tariffs and regulations for demand response, distributed generation, storage, and renewables.*** This objective will address the *Energy Policy Report* requested support for incentives to promote customer and utility owned renewables, distributed generation, and combined heat and power. It will also help promote the development of storage technologies.

6. ***Facilitate transmission siting process.*** This objective covers the *Energy Policy Report* defined need to improve transmission planning and permitting. It also addresses the trend of an aging and inadequate infrastructure.
7. ***Develop knowledge base for future decision-making and informed electricity delivery, integration, and infrastructure policy.*** This objective will address the trends, technology gaps, and emerging energy issues to provide policymakers with the knowledge required to develop effective future policy in this area.

PIER Research Solutions

To achieve these strategic objectives, the PIER program identified research solutions. The solutions were prioritized into primary, secondary, and tertiary areas of RD&D based on relevance to state policy, critical technical gaps, and the potential impact of emerging trends and drivers.

Primary Areas of RD&D

- Increase the intelligence and responsiveness of the transmission and distribution system to more effectively enable optimal integration and use of renewables, demand response, distributed generation, and storage.
- Support integration of intermittent and remotely located renewables into the system.
- Improve cost and functionality of demand response, storage, and distributed generation integration components.
- Analysis of appropriate market mechanisms for renewables, demand response, distributed generation, CCHP, storage, transmission, distribution, and security (for example, rates and tariffs, markets and utility planning, incentives, regulation, financial).
- Provide new technologies and tools to expand capability of existing transmission and distribution (for example, real-time ratings and operations, better asset utilization).
- Develop an electric system (cyber and physical) that is resilient to natural and man-made events, self-diagnosing, and self-healing.

Secondary Areas of RD&D

- Develop a regulatory business case for increased use of automation, demand response, renewables, and distributed

MULTI-AREA REAL-TIME RATINGS

Problem
Power transfer into or out of an area typically occurs over multiple parallel transmission lines. A thermal rating limitation on one line can cause the total power transfer to be limited by much more than just the single line limit. The result can be energy supply shortages, low voltages in the region, and reduced reliability margins.

PIER Solution
PIER is funding the Multi-Area Real-Time Transmission Line Rating Study to evaluate the use of real-time ratings (RTR) to ease constraints on power transfer and voltage. The Sacramento control area is the test bed, and SMUD, WAPA, and PG&E transmission lines constitute the key paths into it. RTR technologies can allow operators to monitor in real time the actual condition of the line, safely permitting current loadings higher than the standard static line ratings normally allowed.

Benefits
Results to date indicate that on a key constrained line, a one megawatt increase in rating facilitated by RTR results in a net of 14 megawatts increased import into the region. Increases in transmission line ratings are possible over 90 percent of the time in the summer months, and curtailments of local hydro plants can be avoided a large part of the time.

generation on the distribution system that promotes efficiency and reliability while reducing cost.

- Provide new planning tools and processes for technical and policy participants, which will result in successful and timely expansion of the transmission system through existing and new corridors (for example, economic transactions that result from transmission congestion).
- Develop the analysis and enabling technologies to provide varying levels of electricity service.

Demand Response Enabling Technologies Development

Problem
Demand response infrastructure controls and communications products are too expensive and complex to be deployed ubiquitously.

PIER Solution
In 2002, PIER established the Demand Response (DR) Enabling Technology Development (ETD) project to solicit disruptive technology ideas from world-class researchers in universities and R&D institutions outside the power industry that could be used to develop a new generation of controls and communication products. To be funded, R&D proposals must meet the following requirements:
- Proposed technologies have to have the potential to lower product costs by a factor of 10 while increasing product functionality by a factor of 10.
- The R&D had to leverage other government and industry funding.
- R&D teams had to be collaborative and multi-disciplinary.

Early Results
- Low-power, low-cost radios that can run on energy scavenged from the ambient environment, running at ~100 □-watts average power.
- Mesh-network radios that include a □-processor, silicon-based oscillators and printed circuit board antennas on about 2 square millimeters of silicon, costing <$1.

Tertiary Areas of RD&D

- Analyze the environmental and economic implications of shifting from solely central station power to distributed generation and central station power.
- Analyze technical and economic interdependencies between electricity and natural gas infrastructure.
- Develop new transparent distribution planning models.

Benefits to Californians

As the PIER program works to enable an integrated electricity system that is reliable and secure, Californians will gain important benefits. The most important benefit is the increased reliability of electricity service. The increased reliability will result from a modernized and secure electric transmission and distribution system that provides more energy options to the grid managers and recovers faster when unavoidable problems occur. Another important benefit will be the reduced cost of electricity resulting from improved utilization and performance of the delivery system.

ENVIRONMENTALLY SOUND ELECTRICITY SYSTEM

Regional Climate Change Modeling

Problem
Long-term planning requires a qualitative understanding of how climate may change in California. There is also an urgent need to try to estimate the likelihood of the different climate scenarios projected for California.

PIER Solution
PIER is in the process of developing probability climate projections for California with the level of temporal and geographical resolution needed to estimate impacts at the sub-regional or local levels. PIER researchers are also developing the tools needed to generate probabilistic climate projections based on the outputs of multiple global climate models and the enhanced numerical and statistical regional climate models.

Benefits
Long term planning in California such as the *Energy Policy Report* and the 2010 State Water Plan will use the probabilistic climate projections being developed by PIER. In addition, PIER researchers will estimate potential impacts and identify coping or adaptation strategies using these projections. PIER will report these findings in the biennial reports on climate change science required by the Governor's Executive Order of June 2005.

Current State Policy

The *Energy Policy Report* and *Energy Action Plan* goals, Governor's Executive Order and Ten Point Electricity Plan, and pertinent laws and regulations provide key policy guidance to achieve an environmentally sound electricity future. Specifically, the key goal the state has defined is:

- By 2010, 2020, and 2050, reduce greenhouse gas emissions to 2000 levels, 1990 level, and 80 percent below 1990 levels, respectively (Governor Executive Order S-3-05).

In addition to this goal, Governor policy defines the need to assess global climate change impacts to water supply, public health, agriculture, coastline, and forestry. The *Energy Policy Report*, *Energy Action Plan*, and Governor also define the need to develop climate change mitigation and adaptation technologies.

The federal and California Endangered Species Acts protect plants and animal resources from adverse effects due to development. The Migratory Bird Treaty Act prohibits the taking, killing, or possessing of migratory birds that applies to birds colliding or being electrocuted by energy structures. California and federal Clean Air Acts limit the amount of pollutants (for example, ozone, respirable particulate matter PM_{10}, fine particulate matter $PM_{2.5}$) in ambient air. The Clean Water Act protects water resources and requires all large electric generation facilities to reduce impingement mortality of all life stages of fish and shellfish. A list of relevant policies can be found in Appendix E.

Trends and Drivers

Regulatory trends will have the largest impact in this research area. Global climate change issues will lead to consumer and government support for regulations and incentives to reduce emissions of greenhouse gases. Urban development and pressures of growing economy and population are significantly impacting sensitive

habitat, air quality, and water quality. The application of existing regulations and consumer and government support for new regulations to protect the environment will have implications on energy infrastructure constraints, energy prices, and protection of the environment, public health, safety, and environmental justice. Moreover, pollution control technologies like emerging electro-technology could provide performance and cost improvements to restore environmental quality.

Spray Enhanced for Air Cooled Condensers

Problem
Generating electricity with dry cooling can save millions of gallons of water per day, but when temperatures spike, efficiency drops dramatically.

PIER Solution
PIER supported the R&D to develop the solution to use a small amount of water during the hottest part of the day to pre-cool the air entering the condenser.

Benefits
PIER demonstrated that water spray enhancement on air-cooled condensers can improve efficiency by 3-5 percent on hot days, saving up to 70 percent of the efficiency loss.

PIER Strategic Objectives

To support the state in accomplishing these policies and goals, as well as anticipate future needs, the PIER program has defined three strategic objectives that will provide California with an environmentally sound energy system:

1. ***Understand the nature/significance of climate change; its relationship to electricity generation and use; development of strategies for greenhouse gas reduction; and strategies for mitigation/adaptation of impacts.*** This objective will help achieve the greenhouse gas reduction goal. It will address *Energy Policy Report*, *Energy Action Plan*, and Governor policies to assess climate change impacts and develop mitigation and adaptation technologies. It will also address the increasing consumer support to reduce emissions of greenhouse gases.
2. ***Improve the understanding of, and develop solutions for, reducing biological, land use, air quality, and water-related impacts of the electricity system and contribute to a sustainable energy future.*** This objective will help meet current environmental regulation as defined in various policy documents, including the Endangered Species Acts, The Migratory Bird Treaty Act, The California and federal Clean Air Acts, and the Clean Water Act. It will help develop new regulations to protect the environment. It will also help develop emerging pollution control technologies.
3. ***Develop knowledge base for future decision-making and informed environmental policy relative to electricity.*** This objective will address the trends, technology gaps, and emerging energy issues to provide policymakers with the knowledge required to develop effective future policy in this area.

PIER Research Solutions

To achieve these strategic objectives, the PIER program identified research solutions. The solutions were prioritized into primary, secondary, and tertiary areas of RD&D based on relevance to state policy, critical technical gaps, and the potential impact of emerging trends and drivers.

Primary Areas of RD&D

- Develop strategies and technologies to reduce direct and indirect greenhouse gas emissions associated with electricity in California.
- Create tools for assessing impacts of Global Climate Change (GCC) on key sectors (for example, ecosystems, energy, and infrastructure) and develop robust mitigation and adaptation strategies.
- Improve understanding and develop solutions to reduce air quality, biological, land use, public health and water impacts of electricity generation, transmission, distribution, and use, and contribute to a sustainable energy future.
- Develop methodologies (for example, indoor emissions testing protocols) to improve regulatory processes (for example, transmission siting) and inform future state environmental/energy policy.

Lifecycle Assessment of Wildland Biomass

Problem
Biomass could help California meet its RPS targets, but the environmental benefits of biomass are not yet realized in the economies of scale in the current markets.

PIER Solution
PIER is funding the effort led by the USDA Forest Service to develop a life-cycle assessment model that could help stakeholders assess the environmental and economic life-cycle impacts and benefits of using forest fuels treatment by-products for biomass power.

Benefits
The life-cycle assessment calculates the impacts and benefits of fuel treatments for use in biomass power generation in California. Optimal biomass management will help to reduce the forest fires in California, increase the amount of clean generation in the state, and help California meet RPS requirements.

Secondary Areas of RD&D

- Improve understanding of state-specific environmental and economic tradeoffs resulting from emerging (for example, renewable, distributed generation) energy technology.
- Develop methodologies for designing and establishing sustainable communities.
- Improve methodologies for assessing the environmental and economic implications of fuel choices and interdependence (conventional and alternative) in electricity, natural gas, and transportation.
- Develop tools for assessing and improving indoor environmental quality.

Tertiary Areas of RD&D

- Support technological performance and cost improvement research for air/water pollution control.
- Develop innovative electro-technologies (for example, soil remediation) for mitigating impacts and restoring environmental quality.
- Develop life-cycle analytical techniques for assessing site-specific environmental impacts from energy facilities.
- Develop methods for assessing the environmental and economic tradeoffs of conventional and alternative energy and transportation infrastructure.

- Support national research initiatives (for example, implementation of 316(a) and (b) regulations of the Clean Water Act) designed to protect and restore critical environmental resources.

Benefits to Californians

As the PIER program works to enable an environmentally sound electricity system, there are a series of resulting health and environmental benefits. These benefits include: reduced health risk from poor indoor and outdoor air quality, reduced footprint from energy infrastructure, increased availability and quality of water resources, reduced biological impacts, and reduced impact from climate change.

CROSS-CUTTING THEMES

The five energy issues described in the previous section are not the only management perspective that PIER will use to identify research solutions. Based on input from stakeholders and internal analysis of the five program areas, PIER has identified several cross-cutting themes that are common throughout the five key energy issues. PIER is currently conducting research that cross-cuts several areas (for example, sustainable communities, indoor air quality) but will need to further address cross-cutting themes in an integrated fashion. PIER will continue to identify and evaluate potential research solutions with regard to the five key energy issues, as well as the current cross-cutting themes and other cross-cutting themes that are identified.

These cross-cutting themes include but are not limited to:

- ***Coordination of energy efficiency, renewables, load management and demand response, distributed energy resources, storage, and transmission and distribution solutions.*** There are interrelated and interdependent aspects to all of these end-use, supply, and delivery areas. In the past, solutions tended to be developed with a focus in one area without significant regard to options in the others. This can result in sub-optimized solutions.

- ***Integration of electricity, natural gas, and transportation science and technology issues***. These areas are inherently interrelated and the trade-offs in proposed solutions and proposed research projects will be assessed. For example, the program will explore the combined peak of electricity and natural gas consumption.

- ***Carbon Management***. Increasingly environmental management, fuel selection, and energy use management involve the effective management of carbon in the fuel and in the resulting by-products of energy generation. This cross-cutting element will provide an integrated systems perspective for assessing trade-offs and interrelationships.

- ***Customer choice and behavior.*** Consumer choice and behavior are not fixed or rigid, and they are important (and not always well understood) variables in the overall energy equation.

- ***Water – energy connection.*** There are many interrelationships between water and energy that need to be explored and defined, and RD&D solutions implemented to optimize the energy savings, economics, and availability.

- ***Competitiveness of California economy.*** All energy research needs to be assessed regarding their impact on California's business competitiveness.

- ***Sustainable Communities.*** Sustainable Communities is defined as a community that meets the needs of its citizens without sacrificing the ability of future

generations to meet their own needs. The goal of energy sustainability is the harnessing of resources that: (1) are not substantially depleted by continued use; (2) do not emit substantial pollutants or other hazards to the environment; and (3) do not involve the perpetuation of substantial health hazards or social injustices. There are many interrelated issues associated with the development of sustainable communities that need to be explored and defined and RD&D solutions implemented to optimize the solutions. Among them, California needs to provide a constant flow of clean and affordable energy solutions to support its low-income citizens and ratepayers**.**

- ***Safety and security of energy supply system.*** Recent terrorist attacks and natural disasters have raised the safety and security concerns related to the energy supply system.

- ***Efficiency, stability, and reliability of energy supply system.*** There are many interrelationships, linkages, and trade-offs among these energy system elements.

The use of cross-cutting themes will provide PIER with a more robust framework to identify appropriate research options and best meet California's energy needs.

IMPLEMENTING RESEARCH SOLUTIONS THROUGH STAKEHOLDER PARTNERSHIPS

Information for Energy Policy Development

There are two main vehicles for the implementation of PIER research results: energy policy and market adoption. Generally, energy policy provides guidance for PIER research. However, in some cases PIER research also informs policymakers as they develop energy policy. For example, PIER staff works closely with the Energy Commissioners and provides technical input, based on PIER research results and technical expertise, in the development of the *Energy Policy Report*. They also provide input into the development of the *Energy Action Plan*.

In addition to these major policy reports, PIER research supports the development of regulations, incentives, and tariffs. PIER works closely with the Energy Commission Efficiency and Renewables Division, Facilities Siting Division, Fuels and Transportation Division, California Public Utilities Commission, and the California Air Resources Board. PIER also collaborates extensively with other regulatory agencies: Air Pollution Control Districts, Department of Water Resources, Department of Fish and Game, and Department of Forestry.

PIER has Developed Partnerships with Key Renewable Energy Players to Tie Technology Development to California Needs

Municipal Utility Alliances
Focused on developing renewables that meet municipal utility electricity needs (SMUD, Hetch-Hetchy/PRP).

Local Government Partnerships
Use local renewable resources to address local environmental and growth issues (Yolo, San Francisco, San Diego).

Industry Connections
- Works with industry leaders with market connectedness, assets, and vision (PowerLight, GE, AstroPower, Clipper, Western United Dairymen)
- Collaboratives (biomass, wind, solar, geothermal).

Other Government Programs
Leverages expertise and funding to help expedite development of effective renewable technologies (NREL, CARB, CIWMB, EPA).

Delivering Technology Research to the Marketplace

As with informing policy, PIER actively engages stakeholders in the definition, development, and market adoption of technology research to ensure the implementation of research results. While still focusing on public interest research not adequately provided by competitive and regulated markets, the eventual market adoption of PIER technology development is required in order for PIER technology research to capture the expected benefits to Californians. The best approach to ensure market adoption is to encourage the PIER-sponsored technology developers (for example, technology RD&D organizations funded by PIER) to work closely with energy services and product manufacturers, distributors, IOUs, energy services providers, and consumers to ensure commercialization of technologies.

The collaboration with these technology stakeholders is done at various levels. PIER programs have advisory committees formed by members from various stakeholder groups that provide guidance regarding the research roadmaps as well as help evaluate projects and identify opportunities to increase the adoption of the research results. PIER has also formed and sponsored industry councils and/or working groups that are focused on a particular issue (for example, Title 24 Building Standards collaboration, Energy Efficiency Emerging Technologies Coordinating Council, Interconnection Rule 21 Working Group).

In addition, PIER has helped key emerging technologies overcome technical as well as other hurdles encountered during the transition from research to commercialization. PIER staff also worked actively with major California industrial, agricultural, and commercial associations to ensure the energy needs of California business are addressed in PIER research (for example, California Manufacturing and Technology Associations, Silicon Valley Leadership Group, and California League of Food Processors)

Emerging Technologies Coordinating Council

ETCC
The Emerging Technologies Coordinating Council (ETCC) is a group of representatives from the California Energy Commission, Pacific Gas & Electric, Southern California Edison, Southern California Gas, and San Diego Gas & Electric, charged with administrating California utility ratepayer-funded programs for energy-related research and energy-efficient emerging technologies.

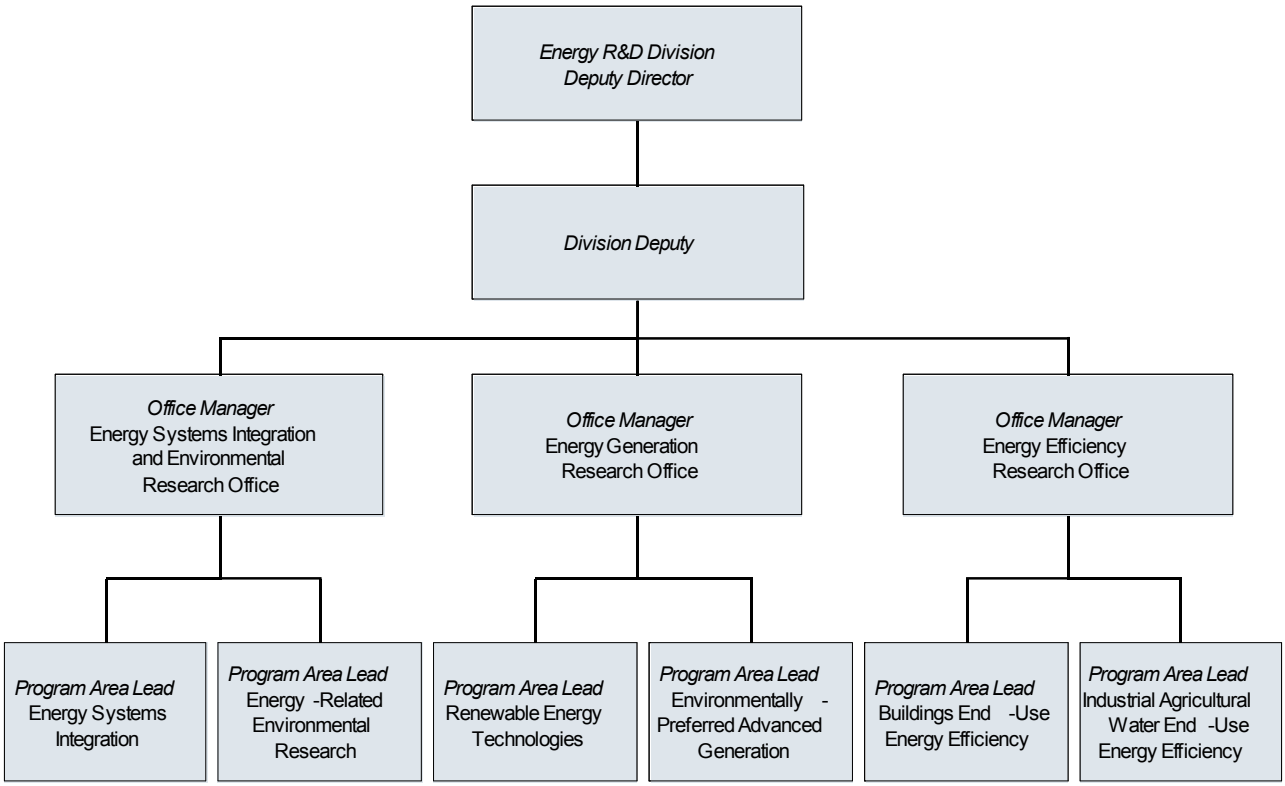
Mission
The Emerging Technologies Coordinating Council coordinates among its members to facilitate the application of energy-efficient emerging technologies that will transform the market and benefit California ratepayers.

MANAGING THE PIER PROGRAM

Organizational Structure

The PIER program leadership comprises a PIER director, a PIER deputy director, three office managers, and six program area leads (Figure 6). The organizational structure and mechanisms to manage transportation research have not been determined at this point. This structure, implemented in 2005, is the result of PIER's efforts to continuously improve the management of the program as well as respond to recommendations that the Independent Review Panel made in its March 2004 report. This new structure provides a strong framework for internal collaboration through regular inter-office coordination meetings at the senior levels where opportunities can be more readily identified and seized upon.

Figure 6: PIER Organizational Structure



Key Operating Processes

PIER has taken advantage of the legislatively mandated five-year planning effort to assess its experiences and performance and develop a plan to continuously improve key operating processes. A task force composed of staff across PIER and Energy Commission support functions including Contracts, Legal, Human Resources, and Audit

was formed to assess PIER's operating processes and provide improvement recommendations. As part of the program management assessment, objectives in PIER's key operating process were captured and shared with internal and external stakeholders (Figure 7).

Figure 7: Objectives in Key Operating Processes

Key Operating Process	PIER Objectives
Stakeholder Coordination and Outreach	• PIER will have a consistent and coherent external communications strategy for each key stakeholder group (policymakers , energy industry, and end -users). • PIER will have a strong working relationship with other divisions at the Energy Commission.
Contracting	• PIER and support functions will work toward common goals in a nimble, efficient, and effective manner.
Human Resources	• PIER will be staffed with highly motivated and capable research project managers who actively collaborate across program areas. • PIER will have access to a diverse range of experts for periods to support its research and program management objectives.
Research Planning	• Research will reflect current concerns and find solutions to future needs. • Coordinated research planning will take place across PIER program areas and roll up into an overall PIER -wide research plan with little additional work. • Coordinated resource allocation roll up into an overall PIER budget.
Research Implementation	• PIER will continuously increase the amount of public interest benefits achieved through funded projects. • The basis of research implementation across the program areas will have a consistency and logic that is easily explained and defensible.

Staff and Resources

The PIER program currently uses 59 person years (PY) of permanent staff resources to manage the program workload. Staff works on planning programs, preparing solicitations, reviewing and selecting proposals to receive funding, preparing contracts or grants, managing projects; monitoring energy technology development, preparing reports on the status of projects and the program, establishing and maintaining information management systems, and coordinating with other stakeholders. Resources are classified into three groups based on primary responsibility: program management and supervision; administration, contract, and legal support; and project management. Nearly two-thirds of PIER staff are primarily engaged in project management activities.

Contract consultant resources provided through the technical support contracts are critical to the efficient operation of the PIER program as they help fill in the gaps in expertise deemed critical to the effective execution of PIER's mission. They support all

aspects of project administration, within statutory limits, in the various program areas where they are found. In addition, contractor staff with database management expertise has played an invaluable role in the day-to-day administration of the PIER Information Management System (PIMS) database.

The Inter-jurisdictional exchange (IJE) is another valuable contract mechanism frequently used by PIER. Through IJEs, unique expertise is brought into the PIER program from other public organizations, both state and federal. IJE staff works at the Energy Commission on fixed-term contracts with limited renewability. Thus, like other contract staff resources, IJEs do not provide permanent staffing solutions for PIER.

Partnerships

Contract research organizations used by the PIER program, such as the University of California Office of the President's (UCOP) California Institute for Energy and Environment (CIEE), play an important role in supplementing the program management capabilities available to the program. CIEE staff working for PIER plays a critical role in the operation of the Transmission Research Program, Demand Response Enabling Technologies Development, Air Quality Research, and Environmental Exploratory Grant Program efforts. In addition, the California State University, San Diego (SDSU), Foundation manages the mechanisms that allow for the effective operation of the Energy Innovations Small Grant Program, for which the PIER program area lead is the only permanent Commission staff assigned to this highly successful program.

The PIER program continuously scans public and private organizations for research activities in the areas of interest to PIER to build on the expertise and innovations from other research organizations. The PIER program also works extensively with the US Department of Energy (DOE) and the national laboratories (for example, NREL, LBNL, LLNL) to leverage resources and co-fund research projects. Moreover, the PIER program is planning the development of an Advisory Committee, with participation of individuals representing key stakeholder groups that will work with the program on various planning activities.

CONCLUSION

Benefits of PIER

The PIER program has provided value to California. To date, PIER has invested more than $300 million in 600 projects related to buildings end-use efficiency; industrial, agriculture, and water end-use efficiency; renewables; environmentally preferred advanced generation; energy systems integration; and environmental impacts of energy. PIER research has contributed to addressing key energy issues in each of these areas. However, this five-year investment plan defines a stronger link to state energy policy. It will expand research activities in transportation and Transmission & Distribution. It will redirect the IAW end-use efficiency area to focus on the energy-water nexus. It will also shift the Renewable Portfolio Standards support to implementation of the regulations.

The state cannot rely on federal government public interest energy research nor can it rely solely on research developed by industry or utilities. California has a unique demographic and geographic profile and commercial sector and industrial sector mixes, as well as unique vulnerabilities to natural and man-made disasters that require California-focused energy solutions. In addition, California policymakers need unbiased, accurate, and timely information to drive effective energy policy-making. Moreover, technology and scientific research investment decisions that have a clear public benefit need to be made with minimum bias.

California continues to lead other states in the development of energy policy and technology. Only New York and recently Texas have programs comparable to PIER. PIER brings great benefits to Californians, including:

- Lower energy costs, achieved through the more efficient use of energy and the improved utilization and performance of the delivery system
- A clean and environmentally friendly energy system, based on renewable energy sources, that is cost-competitive with traditional oil- and gas-fueled generation technologies.
- Reduced dependence on out-of-state/international resources and reduced volatility of energy prices.
- Reduced cost of electricity that will result from reduced volatility of transportation fuel prices and reduced dependence on foreign oil.
- Increased reliability of electricity service. This increased reliability will be the result of a modernized and secure electric transmission and distribution system.
- Reduced health risk from poor indoor and outdoor air quality, reduced footprint from energy infrastructure, increased availability and quality of water resources, reduced biological impacts, and reduced impact from climate change.

Challenges Ahead for PIER

As the PIER program works during the next five-years to achieve its strategic objectives and deliver expected benefits to Californians, it will need to manage and overcome significant challenges along the way. While there is much uncertainty about future challenges, some issues that PIER will need to actively monitor are:

- ***Increasing Complexity.*** The 2001 energy crisis has highlighted the complexity of the energy system in California. Moreover, there are increasing levels of energy policy being developed in the state that PIER needs to support.

- ***Changing Priorities.*** State policy attempts to balance the often conflicting interests of Californians (for example, environmental protection with low cost energy). Forces outside the state (for example, economic recession) can often shift the interests and result in changes to policies and research priorities.

- ***Competition for Funding.*** Investment in electric transmission and distribution technologies has significantly reduced over the last 20 years. California IOUs are requesting funding from the CPUC to reestablish regulated research programs. PIER will work with the IOUs to coordinate IOU-regulated R&D with public interest R&D. However, the outcome is still uncertain. On another side, the state and federal budget deficits continue to grow, and various energy programs are expected to struggle to receive funding.

- ***Global/Out-of-State Energy Prices.*** In the short- and medium-term, California will be subject to the volatility of international and out-of-state energy resource prices, including oil, natural gas, and LNG. PIER will continue to develop energy solutions that are sensitive to this energy resource volatility.

- ***Program Management.*** In its June 2005 report to legislators, the PIER program's IRP noted the challenges in applying the principles of superior R&D management at the Energy Commission, an organization governed by civil service rules. Going forward, PIER will need to continue to improve the structure and operating processes within the California Energy Commission as well as work to assess external organizational options.

APPENDICES

Appendix A

Policies Relevant to Energy RD&D For: Affordable, Comfortable, and Energy-Smart Choices for Daily Life and a Strong California Economy

- Warren Alquist Act, Chapter 7.1 - Undertake public interest energy RD&D not adequately provided for by competitive and regulated energy markets that improve the quality of life of Californians by providing environmentally sound, safe, reliable, and affordable energy services and products.
- *Energy Action Plan /Energy Policy Report* - Loading order with energy efficiency, demand response, and DG.

Efficiency

- *Energy Policy Report* – Reduce use and increase efficiency of electricity used in existing buildings.
- *Energy Policy Report* – Promote EE programs that reduce peak demand.
- Governor – reduce overall electricity use in state buildings (Green Buildings Initiative), schools, non-executive branch agencies, and commercial buildings.
- Governor – Invest in emerging technologies that improve the efficiency and effectiveness of energy supplies and infrastructure.

Demand Response

- *Energy Policy Report* – Support DR with dynamic tariffs, advanced metering, communications systems.
- *Energy Action Plan* – Standards, control and communications technologies, planning models, end-use techs, validation methodologies.
- Governor – Encourage technology, rate designs, and consumer behavior to reduce power usage during peak hours.

Cal / Baja Border Region

- *Energy Policy Report* - Implement a “loading order” to encourage development of the most efficient, clean, and cost-effective energy options to meet demand.

Water and Energy Connection

- *Energy Policy Report* – Reduce use and increase efficiency of electricity used in water sector.
- *Energy Policy Report* – Integrate water and energy strategies.
- *Energy Policy Report* - Develop policy to promote self-generation of water and wastewater utilities, expedite and reduce the cost of interconnection eliminating economic penalties such as standby charges, and remove size limitations for net metering.
- *Energy Policy Report* - Identify and implement retrofits in the water system that increase efficiency and provide energy and peak savings.
- *Energy Policy Report* - Examine opportunities to shift water loads off-peak.

Goals

- CPUC cumulative goals of 27,000 GWH of energy savings and nearly 7,000 megawatts of peak demand reduction for period 2004 – 2013.

- 20 percent reduction in energy consumption in state buildings by 2015.

Table with Joint Staff Electricity Saving Goals, CPUC D04-09-060

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
					Annual Savings (gigawatt hours / year)					
PG&E	572	639	735	862	1,016	1,062	1,070	1,214	1,318	1,434
SCE	726	811	933	1,094	1,290	1,348	1,358	1,541	1,672	1,820
SDG&E	230	257	296	347	409	428	431	489	531	578
Total	1,528	1,707	1,963	2,304	2,715	2,837	2,858	3,243	3,521	3,831

					Cumulative Savings over the Decade (gigawatt hours)					
PG&E	572	1,211	1,946	2,808	3,824	4,886	5,956	7,170	8,488	9,922
SCE	726	1,537	2,470	3,564	4,854	6,202	7,560	9,101	10,773	12,593
SDG&E	230	487	783	1,130	1,539	1,967	2,398	2,887	3,418	3,996
Total	1,528	3,236	5,199	7,503	10,218	13,055	15,913	19,156	22,677	26,508

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
					Cumulative Peak Savings (megawatts / year)					
PG&E	149	335	506	730	994	1,270	1,548	1,864	2,207	2,579
SCE	189	400	642	927	1,262	1,612	1,965	2,366	2,801	3,274
SDG&E	60	127	204	294	401	512	624	751	889	1,393
Total	397	862	1,352	1,950	2,657	3,394	4,137	4,981	5,896	6,892

Baseline for Electricity Saving Goals, California Energy Commission, California Energy Demand 2006-2016, Staff Energy Forecast, September 2005, Energy Commission-400-2005-034-SF-ED2

Energy Consumption (gigawatt hours)	SDG&E	SCE	PG&E	Total
2004	19,627	97,389	101,147	218,163

Peak Demand (megawatts)	SDG&E	SCE	PG&E	Total
2004	4,071	20,546	20,760	45,377

Appendix B

Policies Relevant to Energy RD&D For: Clean and Diverse Electricity Supply That Optimizes California's Resources

- Warren Alquist Act, Chapter 7.1 - Undertake public interest energy RD&D not adequately provided for by competitive and regulated energy markets that improve the quality of life of Californians by providing environmentally sound, safe, reliable, and affordable energy services and products.

Renewables

- *Energy Action Plan /Energy Policy Report* - Loading order with renewables.
- Renewables Portfolio Standard program requires IOUs to have 20 percent renewables by 2017.
- *Energy Policy Report* – Repowering aging wind facilities.
- *Energy Policy Report* – Accelerate RPS goals.
- *Energy Policy Report* – Simplify, streamline and expedite RPS process.
- *Energy Policy Report* – Support biomass development.
- *Energy Policy Report* – Hydrogen production from renewables.
- Governor – Million solar roof initiative.
- *Energy Action Plan* – RD&D renewable generation technologies and accelerate RPS goals.
- SB 90 – Support existing and emerging renewable technologies.

DG/CHP

- *Energy Policy Report* – Promote combined heat and power (CHP) as a viable efficiency strategy for businesses.
- SB 1298 - DG technologies must be certified by ARB or permitted by one of California's 35 Air Districts before use or operation.
- SB 1298 – Adopt a DG Certification Program, including uniform emission standards and provide guidance to the Districts for permitting of electrical generation technologies.

Other Generation Technologies

- Governor – Western Governors' Association clean and diversified energy resolution to develop 30,000 megawatts of clean energy in the West by 2015 from resources such as energy efficiency, solar, wind, geothermal, biomass, clean coal technologies, and advanced natural gas technologies.
- *Energy Action Plan* and *Energy Policy Report* – Support advanced coal R&D, including capturing and storing carbon dioxide.
- *Energy Policy Report* – Reaffirm 1978 finding that high-level waste disposal technology has neither been demonstrated nor approved.

Cal / Baja Border Region

- *Energy Policy Report* - Develop programs to reduce demand and develop indigenous renewable resources.

Goals

- 20 percent renewables by 2010, 33 percent renewables by 2020.
- Million solar roofs by 2018.
- Provide 30,000 megawatts of clean and diverse resources in West by 2015.

Appendix C

Policies Relevant to Energy RD&D For: Clean and Diverse Transportation System

- Warren Alquist Act, Chapter 7.1 - Undertake public interest energy RD&D not adequately provided for by competitive and regulated energy markets that improve the quality of life of Californians by providing environmentally sound, safe, reliable, and affordable energy services and products.
- SB 76 – Allows for transportation research that provides direct benefits by making electric service safer, more reliable, or less costly, and provides benefit to ratepayers by promoting energy efficiency, reduction of health and environmental impacts from air pollution, reduction of greenhouse gas emissions, and increased use of alternative fuels.
- AB 2076 – Reduce emissions and the dependency on oil.
- AB 1493 - By January 2005, adopt regulations to achieve the maximum feasible reduction of vehicle greenhouse gas emissions and provide automakers with maximum flexibility in developing cost-effective compliance methods.
- CARB - Alternative plan to comply with AB 1493 greenhouse gas emission regulations that allows for use of alternative fueled vehicles including compressed natural gas, liquid petroleum gas, ethanol, electric vehicles, and hydrogen-fueled vehicles.
- *Energy Policy Report* – Develop partnerships with auto manufacturers to demonstrate viability and promotion of plug-in hybrid electric vehicles.
- *Energy Policy Report* – California must pursue a diverse portfolio of fuels and advanced transportation technologies that address both current supply and demand problems and build a sustainable foundation for the eventual move to a hydrogen transportation fuel economy.
- *Energy Policy Report* – Using renewable diesel fuels, gas-to-liquid fuels, battery-electric and hybrid-electric vehicles, and hydrogen-fueled vehicles, California could significantly reduce petroleum demand, criteria pollutants, toxic air contaminants, and greenhouse gas emissions. These fuels and technologies presently suffer from higher cost and/or limited availability and need to be more effectively integrated into energy and air quality policies.
- Governor 03/04 *Energy Policy Report* Response – Significant reduction of gasoline and diesel use and increase the use of alternative fuels.
- Governor Executive Order S-3-05 – Greenhouse gas emission reduction targets.

Goals

- Energy Commission/ARB: Reduce gasoline and diesel fuel demand to 15 percent below 2003 demand by 2020.
- Energy Commission/ARB: Increase percent of non-petroleum fuel usage to 20 percent by 2020 and 30 percent by 2030.
- Governor: By 2010, 2020 and 2050 reduce greenhouse gas emissions to 2000 levels, 1990 level and 80 percent below 1990 levels respectively.

Appendix D

Policies Relevant to Energy RD&D For: Integrated Electricity System that is Reliable and Secure

- Warren Alquist Act, Chapter 7.1 - Undertake public interest energy RD&D not adequately provided for by competitive and regulated energy markets that improve the quality of life of Californians by providing environmentally sound, safe, reliable, and affordable energy services and products.
- *Energy Action Plan /Energy Policy Report* – Loading order with demand response, renewables, and DG.
- *Energy Policy Report* – Improve existing transmission infrastructure to improve congestion and reliability.

Integration to System

- Governor – Accommodate renewable assets efficiently into grid operation to ensure that consumer costs will not be raised unnecessarily.
- *Energy Policy Report* – Integrate intermittent and remotely located (Tehachapi and Imperial Valley) renewables into the system.
- *Energy Policy Report* – Require utilities to design and construct distribution systems that are more DG and CHP compatible.
- *Energy Policy Report* – Open and transparent distribution planning.
- *Energy Policy Report* – Transmission infrastructure to access renewables.
- *Energy Policy Report* – For water facilities, reduce the cost of interconnection, eliminate standby charges, and remove size limitations for net metering.
- *Energy Policy Report* – Shift water loads off peak through use of storage, TOU pricing, and advanced metering.
- *Energy Policy Report* – Increase utilization of existing pumped-storage facilities.
- *Energy Action Plan* – RD&D on energy storage and transmission technologies to support policy goals.
- SB 90 – Support existing and emerging renewable technologies.

System Planning

- *Energy Policy Report* – Integrated transmission and corridor planning and permitting process.

Demand Response

- *Energy Policy Report* - Support DR with dynamic tariffs and metering and communications systems.
- *Energy Action Plan* – Standards, control & communications techs, planning models, end-use techs, validation methodologies.

Markets and Incentives

- *Energy Policy Report* - Incentives (for example, Earned Rate Adjustment Mechanism) for IOUs to promote customer and utility-owned DG and CHP.
- *Energy Policy Report* – Compensate IOUs to provide scheduling services to CHP operators.
- *Energy Policy Report* - Improve CHP access to wholesale markets.

Cal / Baja Border Region

- *Energy Policy Report* - Ensure that planning, permitting, construction and operation of electricity infrastructure are coordinated.

Appendix E

Policies Relevant to Energy RD&D For: Environmentally Sound Electricity System

- Warren Alquist Act, Chapter 7.1 - Undertake public interest energy RD&D not adequately provided for by competitive and regulated energy markets that improve the quality of life of Californians by providing environmentally sound, safe, reliable, and affordable energy services and products.

Reduce GHG Emissions

- Governor – Greenhouse gas emission reduction targets.
- *Energy Policy Report* – Support strategies to reduce greenhouse gas emissions from utility procurement.
- *Energy Policy Report* – Use CHP as a means to provide air quality and greenhouse gas reduction emissions benefits.
- *Energy Policy Report* - Report greenhouse gas emissions from new plants.
- *Energy Policy Report* - Include greenhouse gas reductions in procurement decisions.

Assess Impacts GCC

- Governor – Assess GCC impacts to water supply, public health, agriculture, coastline, and forestry.
- *Energy Policy Report* – Assess climate change impact on power generation and demand.

GCC Mitigation/Adaptation

- Governor – Mitigation and adaptation efforts will be necessary to prepare for global warming.
- *Energy Action Plan* – RD&D on greenhouse gas mitigation technologies.
- *Energy Policy Report* - Include climate change strategies in state planning.

Cal / Baja Border Region

- *Energy Policy Report* - Ensure that planning, permitting, construction and operation of electricity infrastructure comply with the highest level of environmental requirements.
- *Energy Policy Report* - Implement a cross-border emissions credit trading and offsets program.

Environmental Stewardship

- *Energy Policy Report* - Use sustainable building designs.
- Governor – Invest in emerging technologies that improve the environmental impact of energy supplies and infrastructure.
- California Environmental Quality Act: Requires evaluation of direct, indirect, and cumulative impacts of developments including power generation and transmission projects.
- AB 1576 – Nunez - It is in the public interest for the state to facilitate investment in the replacement or repowering of older, less-efficient electric generating facilities to improve local area reliability and enhance the environmental performance, reliability, efficiency, and cost-effectiveness of these facilities. Certificates approved by the Energy Commission for the replacement or repowering of older, less-efficient electric generating facilities should achieve improvements in environmental performance to the maximum extent practicable, including

reductions in air emissions and water use and discharge, compared to the replaced or repowered facility.

Air Quality

- California ambient air quality standards – Table of Standards in Section 70200 of Title of the California Code of Regulations
  - Ozone (O_3)
    - 1 hour – 0.09 ppm
    - 8 hour – 0.070 ppm
  - Respirable Particulate Matter (PM_{10})
    - 24 hour – 50 micrograms/m3
    - Annual Arithmetic Mean – 20 micrograms/m3
  - Fine Particulate Matter ($PM_{2.5}$)
    - Annual Arithmetic Mean – 12 micrograms/m3

- National Ambient Air Quality Standards
  - Ozone (O3)
    - 8 hour – 0.08 ppm
  - Respirable Particulate Matter (PM_{10})
    - 24 hour – 150 micrograms/m3
    - Annual Arithmetic Mean – 50 micrograms/m3
  - Fine Particulate Matter ($PM_{2.5}$)
    - 24 hour – 65 micrograms/m3
    - Annual Arithmetic Mean – 15 micrograms/m3

Biological and Land Use

- *Energy Policy Report* – avian mortality issues related to wind facilities.
- Federal Endangered Species Act – Protection of endangered and threatened animal and plant species and their habitats. Regulated activities include power generation and transmission.
- Migratory Bird Treaty Act – Protects migratory birds, prohibits death by electrocution (mainly distribution poles) and collision (wind turbines and conductors).
- Bald Eagle Protection Act – Protects bald and golden eagles, prohibits death by electrocution by and/or collision with power infrastructures.
- Invasive Species Executive Order (February 1999) – Requires prevention, response and control, monitoring, and restoration programs to reduce invasions by non-native species. Applies to terrestrial and aquatic habitats.
- California Fish and Game Code – Requires state permits for any activities that might cause mortality of native wildlife (not just rare species). Also protects all nesting birds.
- California Endangered Species Act – Prohibits taking of plant and animal species designated by the state as threatened or endangered or candidate species petitioned for listing. Regulated activities include power generation and transmission.

Water Resources

- *Energy Policy Report* – Hydroelectric power can have significant ongoing impacts to California's rivers and streams, native salmon and trout populations, and water quality. The restoration of imperiled salmon and trout fisheries is one of California's environmental policy objectives.
- *Energy Policy Report* – Supports research on improving runoff forecasting and decision support modeling to improve hydropower generation.
- *Energy Policy Report* – Supports research on improving tools and methodologies for determining instream flows for hydropower projects.
- *Energy Policy Report* – Assess potential of once-through cooling technology.
- *Energy Action Plan* – Development of dry-cooling techs to minimize impact on water resources.

- Clean Water Act prohibits impacts to wetlands and 'water of the U.S.' without a permit. Regulated activities include power generation and transmission, construction, and maintenance.
- California Ocean Protection Act of 2004 establishes the Ocean Protection Council and the California Ocean Protection Trust Fund. Encourages protection, conservation and maintenance of healthy coastal waters and ocean ecosystems. Includes once-through cooling for electrical generation.
- Ocean Protection Plan – Has several goals and action items that include increasing the abundance and diversity of California's oceans, bays, estuaries and coastal wetlands and make water in these bodies cleaner. Eliminate adverse impacts of offshore oil and gas development.
- California Ocean Protection Council: Ocean and Coastal Information, Research, and Outreach Strategy – This action plan identifies that information and research is needed to protect and restore ocean and coastal organisms, ecosystems, and habitats, including study the stressors on marine life of current and potential ocean uses such as once-through cooling for coastal power plants.
- Clean Water Act Section 303 protects water quality; regulated activities: power generation and transmission, construction and maintenance.
- Clean Water Act Section 316a&b – Protects water quality through regulation of the withdrawal and discharge of power plant cooling water.

Goals

- By 2010, 2020, and 2050 reduce greenhouse gas emissions to 2000 levels, 1990 level and 80 percent below 1990 levels respectively.
- All facilities are required to reduce impingement mortality (IM) of all life stages of fish and shellfish by 80-95 percent from the calculation baseline. Some facilities are also required to reduce entrainment (E) of all life stages of fish and shellfish by 60-90 percent from the calculation baseline (Clean Water Act 316b).
- Other environmental policy goals.

Appendix F: Governor's Ten Point Electricity Plan

The Governor's electricity plan is designed to ensure an adequate, stable supply of electricity at reasonable prices. The plan encourages the use of emerging technologies to preserve and protect California's environment and promote economic growth.

1. Resource Adequacy
- Minimum 15% reserve margins for all suppliers of electricity, by 2006

2. Competitive Procurement
- Open, transparent procurement process ensures best value to ratepayers in terms of price, risk, reliability and environmental impact
- Cost recovery for utilities encourages long-term contracts

3. Transmission
- Legislation to establish transmission corridors
- Encourage investment to reduce congestion, increase grid reliability

4. Rate Relief
- Encourage PUC to implement equitable rate designs for allocating system costs
- Reduce rates for all customers from FERC refunds and DWR contract renegotiations

5. Natural Gas
- Increase in-state gas storage, production and natural gas import capability to ensure adequate supply and stable prices

6. Renewable Energy
- Accelerate renewable mix of 20% by 2010
- Million Solar Roofs Initiative
- Western Governor's Association Clean and Diversified Energy Resolution: 30,000 MW by 2015

7. Energy Efficiency
- Increase State's energy efficiency 20% by 2010
- Energy efficiency prioritized in the Energy Action Plan's loading order
- Green Buildings Executive Order – State will lead by example
- WGA Clean Energy Resolution: 20% gain by 2020
- Zero energy homes, building codes, appliance standards

8. Dynamic Pricing/Advanced Metering
- Encourage technology, rate designs and consumer behavior to reduce power usage during peak hours
- Deploy advanced interval meters to all customers

9. Core/Non-core
- Allow large customers to choose their electricity supplier

10. Research & Development
- Invest in emerging technologies that improve the efficiency, effectiveness and environmental impact of energy supplies and infrastructure

Appendix G: Executive Order S-3-05 by the Governor of the State of California

WHEREAS, California is particularly vulnerable to the impacts of climate change; and

WHEREAS, increased temperatures threaten to greatly reduce the Sierra snowpack, one of the State's primary sources of water; and

WHEREAS, increased temperatures also threaten to further exacerbate California's air quality problems and adversely impact human health by increasing heat stress and related deaths, the incidence of infectious disease, and the risk of asthma, respiratory and other health problems; and

WHEREAS, rising sea levels threaten California's 1,100 miles of valuable coastal real estate and natural habitats; and

WHEREAS, the combined effects of an increase in temperatures and diminished water supply and quality threaten to alter micro-climates within the state, affect the abundance and distribution of pests and pathogens, and result in variations in crop quality and yield; and

WHEREAS, mitigation efforts will be necessary to reduce greenhouse gas emissions and adaptation efforts will be necessary to prepare Californians for the consequences of global warming; and

WHEREAS, California has taken a leadership role in reducing greenhouse gas emissions by: implementing the California Air Resources Board motor vehicle greenhouse gas emission reduction regulations; implementing the Renewable Portfolio Standard that the Governor accelerated; and implementing the most effective building and appliance efficiency standards in the world; and

WHEREAS, California-based companies and companies with significant activities in California have taken leadership roles by reducing greenhouse gas (GHG) emissions, including carbon dioxide, methane, nitrous oxide and hydrofluorocarbons, related to their operations and developing products that will reduce GHG emissions; and

WHEREAS, companies that have reduced GHG emissions by 25 percent to 70 percent have lowered operating costs and increased profits by billions of dollars; and

WHEREAS, technologies that reduce greenhouse gas emissions are increasingly in demand in the worldwide marketplace, and California companies investing in these technologies are well-positioned to profit from this demand, thereby boosting California's economy, creating more jobs and providing increased tax revenue; and

WHEREAS, many of the technologies that reduce greenhouse gas emissions also generate operating cost savings to consumers who spend a portion of the savings across a variety of sectors of the economy; this increased spending creates jobs and an overall benefit to the statewide economy.

NOW, THEREFORE, I, ARNOLD SCHWARZENEGGER, Governor of the State of California, by virtue of the power invested in me by the Constitution and statutes of the State of California, do hereby order effective immediately:

1. That the following greenhouse gas emission reduction targets are hereby established for California: by 2010, reduce GHG emissions to 2000 levels; by 2020, reduce GHG emissions to 1990 levels; by 2050, reduce GHG emissions to 80 percent below 1990 levels; and

2. That the Secretary of the California Environmental Protection Agency ("Secretary") shall coordinate oversight of the efforts made to meet the targets with: the Secretary of the Business, Transportation and

Housing Agency, Secretary of the Department of Food and Agriculture, Secretary of the Resources Agency, Chairperson of the Air Resources Board, Chairperson of the Energy Commission, and the President of the Public Utilities Commission; and

3. That the Secretary shall report to the Governor and the State Legislature by January 2006 and biannually thereafter on progress made toward meeting the greenhouse gas emission targets established herein; and

4. That the Secretary shall also report to the Governor and the State Legislature by January 2006 and biannually thereafter on the impacts to California of global warming, including impacts to water supply, public health, agriculture, the coastline, and forestry, and shall prepare and report on mitigation and adaptation plans to combat these impacts; and

5. That as soon as hereafter possible, this Order shall be filed with the Office of the Secretary of State and that widespread publicity and notice be given to this Order.

Appendix H: Trends and Drivers Description

	Driver	Definition
Demand Trends	**Increasing Population Growth**	Growth of western region population increases demand for electri city, natural gas, and transportation fuels, and will put pressure on the infr astructure unless growth can be mitigated by decreased per capita consumption.
	Increasing Economic Activity	Economic growth increases overall energy consumption; shifts fro m industrial to information economy and changing standards of living will cha nge consumption patterns and increase energy demand unless mitigated by decreased per capita consumption.
	Growth in Hot Inland Areas	Population and economic development in hot/cold inland areas req uires new energy infrastructure, increases home energy consumption, increa ses peak demand spikes, and increases driving distances, traffic congesti on, and use of transportation fuel.
	Growth in Consumer Energy Demand	Growth in per capita use of energy consumption devices including an increased use of electronic devices and consumer comfort expecta tions (multiple AC units).
	Changing Weather Patterns	Changing temperatures will lead to increased demand for natural gas and electricity.
	Increasing Need for Consumer Choices	Increasing pressure from consumers to select their energy servic es from a set of energy products and services options (DG, DR, EE, Premium Pow er).

	Driver	Definition
Resource Availability	**Increased Global Oil Demand**	Increased global competition for oil from China and India will i mpact the prices and increase price volatility of gasoline, diesel, LNG an d propane.
	Constrained and Unreliable Petroleum Transportation Fuels Supply	In-state production capacity and export to western states of gasoli ne, diesel, and propane, distribution infrastructure will impact pri ces and increase price volatility.
	Constrained Natural Gas Supply	Availability and stability of natural gas supply, including in -state production and storage, import of natural gas from other states and Baja, i mport of LNG, reliance on NG for electricity generation in the Western Re gion will impact prices and increase price volatility.
	Constrained Electricity Supply	Availability and stability of electricity supply, including in -state generation and import from other western states (coal, renewables, hydro po wer from Northwest) and Baja will impact prices and increase price volati lity.
	Changing Weather Patterns	Changing weather patterns likely to impact water resources (redu ce the available snow pack to be used for hydroelectricity).
	Degrading/Dwindling Habitat, Air Quality and Water Quality	Urban development and pressures of growing economy and populatio n are significantly impacting sensitive habitat, air quality and water quality.
	Increased Use of Natural Gas for Electricity Generation	Urban development and pressures of growing economy and populatio n are significantly impacting sensitive habitat, air quality and water quality.

	Driver	Definition
Regulatory Framework	**Uncertain Electric Market Regulations**	There is uncertainty in the direction of regulatory control and the effects in electric prices and the competitive markets. This includes but is not limited to tar iff structures and the fact that current approaches to calculate life cycle costs do not consider fuel costs.
	Aging and Inadequate Electricity Infrastructure Constraints	The poor state of current infrastructure, lack of collaboration, and constraints to develop new infrastructure for electricity (generation, T&D) results in redu ced capacity and higher energy prices. Contributing factors include current permitting process challenges (environmental siting rules), costs, and benefits.
	Aging and Inadequate Natural Gas Infrastructure Constraints	The poor state of current infrastructure, lack of collaboration, and constraints to develop new infrastructure for natural gas (pipelines, storage, LNG terminal s), results in reduced capacity and higher energy prices, with impacts on the environment, cost, and benefits.
	Aging and Inadequate Transportation Infrastructure Constraints	The poor state of current infrastructure, lack of collaboration, and constraints to develop new infrastructure for transportation (drilling, refining) results i n reduced capacity and higher energy prices, with impacts on the environment, cost, and benefi ts.
	Global Climate Change	There is an impact to the state from climate change, as well as consumer and government support for regulations and incentives to reduce emissions of gr eenhouse gases. The state 's organizations will also have to adapt to the new conditions (ope rations).
	Increasing Public Focus on Environmental, Public Health, and Safety Concerns	The application for existing regulations and consumer and govern ment support for new regulations to protect the environment (RPS, efficiency standard s, local air quality emission regulations) will have implications to infrastructure constraint s, energy prices, and protection of the environment, public health, safety and environmental justice .
	Increasing Focus on Energy Security	Concern and protection against natural and terrorist threats to energy infrastructure and supply will result in more and better security and response meas ures be developed and implemented to improve the state 's economic resiliency and energy security.
	Uncertain Regulatory Market Structure for Emerging NG Markets	There is uncertainty around how to regulate new natural gas mark ets and NG quality that will affect development of the market and the infrastructure.
	Increasing Local Resistance to New Infrastructure Projects	There is increasing resistance from communities to building new energy infrastructure projects in their areas (not in my back yard – NIMBY). This trend is contributing to the infrastructure constraints.
	Aggressive Policy Goals and Increased Urgency for Solutions	With high costs of energy, the poor state of the energy infrastr ucture, local resistance to new projects and increased public focus on environmental concerns, t he state energy policy makers have established a series of aggressive and urgent policy goals.

	Driver	Definition
Technology	**Improved and More Cost - Effective Renewable Energy**	Increased availability and wide adoption of technologies to gene rate electricity from renewable resources (solar, wind, biomass, geothermal, hydroelec tric) will provide additional supply options, and the related environmental benefit s and life cycle cost implications.
	Improved and More Cost - Effective Advanced Generation Technology	Technology breakthrough in performance and cost, and wide adopti on of advanced generation technology for transportation and stationary applicat ions (distributed, modular) will provide additional supply options, and the related environmental benefits and life cycle cost implications.
	Improved and More Cost - Effective Advanced and Hybrid Propulsion Systems	Wide adoption of advanced and hybrid propulsion systems (gasolin e/electric, diesel/electric, plug -in hybrids, fuel cells) for transportation applications (includi ng mass transit and the transportation of goods) will provide addit ional supply options, and the related efficiency benefits and life cycle cost implicat ions.
	Increased Availability of Alternative Fuels for Transportation	Technology breakthrough in performance and cost, and wide adopti on of alternative fuels for transportation applications (ethanol, GTL, FT diesel, hydrogen), will provide additional supply options , the environmental and efficiency benefits, and life cycle cost implications.
	Improved and Cost -Effective Advanced Meters, Information Technology, Communications	Technology breakthrough in performance and cost and wide adoptio n of advanced functionality meters (time of use, power line communications), b roadband communications, and IT will provide increased throughput from in frastructure.
	Improved and Cost -Effective End-Use Technologies	Wide adoption of real -time energy management and dynamic control systems with advanced capabilities (efficiency, demand response, dynamic rate s), will provide efficiency benefits.
	Pollution Control	Emerging electro technology could provide performance and cost i mprovements to restore environmental quality.

Appendix I: Acronym List

AB	Assembly Bill
ARB	Air Resources Board
BIPV	Building Integrated Photo Voltaic
CARB	California Air Resources Board
CCHP	Combined Cooling, Heating and Power
CIEE	California Institute for Energy and Environment
CIWMB	California Integrated Waste Management Board
CHP	Combined Heat and Power
CPUC	California Public Utilities Commission
DG	Distributed Generation
DOE	United States Department of Energy
EPA	Environmental Protection Agency
ETCC	Emerging Technology Coordinating Council
GCC	Global Climate Change
GHG	Greenhouse Gas
HVAC	Heating, Ventilation, Air-Conditioning
ICLS	Integrated Classroom Lighting System
IJE	Inter-Jurisdictional Exchange
IOU	Investor Owned Utilities
ISO	Independent Service Operator
LBNL	Lawrence Berkeley National Laboratory
LLNL	Lawrence Livermore National Laboratory
LNG	Liquefied Natural Gas
NREL	National Renewable Energy Laboratory
PIER	Public Interest Energy Research
PUC	Public Utilities Commission
PY	Person Years
RD&D	Research Development and Demonstration
RPS	Renewable Portfolio Standard
SB	Senate Bill
SMUD	Sacramento Municipal Utility District
T&D	Transmission and Distribution
UCOP	University of California Office of the President
WTC	Wind Turbine Company
ZENH	Zero Energy New Home

Appendix J – Summary Tables

Affordable, Comfortable and Energy -Smart Choices for Daily Life and a Strong Economy	
PIER Strategic Objectives	1. Reduce energy cost and improve performance of efficiency end use systems (residential, commercial, industrial, agricultural) 2. Develop energy -efficient technologies for unique California conditions and indu stries 3. Reduce water use and improve efficiency of alternative water sou rces, treatment and delivery 4. Develop end -use cost -effective load management and demand response technologies that support peak reduction goals 5. Develop knowledge base for future decision -making and informed end use policy relative to electricity
Primary Solutions	• Reduce first costs and operational costs of energy efficient tec hnologies and systems for buildings and industries. • Increase efficiency of existing building systems and industrial processes (develop replacement/retrofit products, improve operat ional strategies, identify intervention tactics). • Develop energy efficient end use technologies and strategies for unique California conditions and industries (climate, construct ion practices, state standards). • Understand linkages between water and electricity to reduce wate r use, improve the energy efficiency of treatment and delivery o f alternative water sources, and develop water related energy stor age.
Secondary Solutions	• Develop technologies and strategies that reduce peak demand (Zer o Energy New Homes, low -energy cooling, and industrial refrigeration systems). • Develop end use load management and demand responsive technologi es that support power reliability and dynamic tariffs, as well a s the integration of advanced metering (programmable communicating thermostats, lighting controls, analysis tools). • Develop sustainable building technologies, designs, and systems, including sustainable building construction practices, and integration of environmental and generation issues in efficient building design.
Tertiary Solutions	• Develop improved (more energy -efficient) information systems and consumer electronic technolog ies. • Develop advanced irrigation practices related to water conservat ion and recovery. • Develop commissioning, benchmarking, diagnostic tools, standard practices, and specifications for energy efficiency. • Develop technologies to further the understanding of consumer be havior and market issues.

Clean and Diverse Electricity Supply that Optimizes California 's Resources	
PIER Strategic Objectives	1. Reduce cost and improve system and environmental performance of solar, wind, biomass, geothermal and hydroelectric technologies. 2. Reduce cost and improve system and environmental performance of alternative generation systems. 3. Develop adequate generation resources that are diverse and flexi ble. 4. Develop knowledge base for future decision -making and to inform electricity supply policy.
Primary Solutions	• Reduce life -cycle cost of electricity from renewable resources (biomass, geo thermal, wind, solar & hydroelectric) by reducing capital, operational, and maintenance costs and by improving performance. • Improve renewable energy reliability, quality, and environmental performance. • Improve cost effectiveness, thermodynamic efficiency, and fuel f lexibility, as well as the reliability, availability, maintainab ility, durability, and environmental compliance of alternative generati on systems (advanced reciprocating internal combustion engines, advanced turbines, fuel cells, and fuel cell/turbine hybrids). • Support development of advanced coal technologies, including cap turing and storing CO2. • Develop technologies to utilize waste fuels, heat, and pressure. • Improve existing renewable energy facilities to increase peak ca pacity and improve system reliability. • Support the environmentally sound re -powering of aging wind facilities and aging power plants.
Secondary Solutions	• Expand distributed generation to help provide generation in area s of highest value (high demand, high grid congestion areas, net work peak demand). • Evaluate and facilitate capture of environmental benefits and ad verse impacts from renewable energy production. • Develop improved combined cooling, heat, and power (CCHP) system s (industrial applications, modular systems) • Develop and demonstrate innovative generation technologies: hybr id combinations, novel cycles, mixed fuels, co -firing, and biomass gasification. • Explore and implement electric energy storage technologies to ma ke renewable energy more dispatchable .
Tertiary Solutions	• Develop co -production technologies (fuel and electricity). • Develop improved technologies for exploration and utilization of geothermal resources.

Clean and Diverse Transportation System

PIER Strategic Objectives

1. Identify advanced transportation research opportunities that optimize the goals of reducing petroleum dependence, enhancing energy, and economic security, and expanding environmental and public health benefits.
2. Develop and demonstrate technologies to improve efficiency within the transportation system.
3. Develop and demonstrate alternative fuels, vehicles, and fueling infrastructure.
4. Develop the knowledge base and advanced analytical tools for future decision-making and informed transportation policy.

Solutions

- Develop and demonstrate advanced fuel efficient transportation technologies and fuel switching strategies that result in a cost-effective reduction of on-road and off-road petroleum fuel use in the short and long term.
- Develop and demonstrate alternative transportation fuels that can augment available transportation fuel supplies with non-petroleum sourced fuels, can optimize their efficiency, environmental and public health benefits, and commercial viability over the mid and long term.
- Develop and demonstrate technologies for the in-state production of renewable and non-petroleum transportation fuels that can augment transportation fuel supplies, provide state economic and ratepayer benefits, reduce air pollutant and greenhouse gas emissions, and increase on- and off-road transportation fuel diversity.
- Develop and demonstrate options for alternative fuel distribution, infrastructure development and deployment, and examine technologies such as plug-in hybrids, truck stop, marine port and airport electrification and accelerate storage and distribution technology development for non-petroleum alternative fuels.
- Develop and demonstrate mitigation strategies that address the environmental and economic impacts of non-petroleum alternative fuel production, distribution and utilization, and accelerate the deployment and refinement of highly efficient transportation technologies.
- Develop and demonstrate advanced planning tools, processes and regulatory models that integrate fuel choices and demand considerations and innovative mass-transit strategies in local land-use and transportation planning.
- Develop technologies and tools to further understand consumer behavior and preferences and how these are affected by fuel choices and market conditions.

Integrated Electricity System that is Reliable and Secure

PIER Strategic Objectives

1. Enable optimal integration of renewables, distributed generation, demand response, and storage to the power system.
2. Improve capacity, utilization, and performance of transmission and distribution system.
3. Improve cost and functionality of components to integrate demand response, distributed generation, and electricity storage into the system.
4. Improve security and reliability of electricity system.
5. Support improvement of tariffs and regulations for demand response, distributed generation, storage, and renewables.
6. Facilitate transmission siting process.
7. Develop knowledge base for future decision-making and informed delivery, integration, and infrastructure policy relative to electricity.

Primary Solutions

- Increase the intelligence and responsiveness of the transmission and distribution system to more effectively enable optimal integration and use of renewables, demand response, distributed generation, and storage.
- Support integration of intermittent and remotely located renewables into the system.
- Improve cost and functionality of demand response, storage, and distributed generation integration components.
- Analysis of appropriate market mechanisms for renewables, demand response, distributed generation, CCHP, storage, transmission, distribution, and security (rates and tariffs, markets and utility planning, incentives, regulation, financial).
- Provide new technologies and tools to expand capability of existing transmission and distribution (real time ratings and operations, better asset utilization).
- Develop an electric system (cyber and physical) that is resilient to natural and man-made events, self-diagnosing and self-healing.

Secondary Solutions

- Develop a regulatory business case for increased utilization of automation, demand response, renewables, and distributed generation on the distribution system that promotes efficiency and reliability while reducing cost.
- Provide new planning tools and processes for technical and policy participants, which will result in successful and timely expansion of the transmission system through existing and new corridors (economic transactions that result from transmission congestion).
- Develop the analysis and enabling technologies to provide varying levels of electricity service.

Tertiary Solutions

- Analyze the environmental and economic implications of shifting from solely central station power to distributed generation and central station power.
- Analyze technical and economic interdependencies between electricity and natural gas infrastructure.
- Develop new transparent distribution planning models.

Environmentally Sound Electricity System

PIER Strategic Objectives	1. Understand the nature/significance of climate change; its relationship to electricity generation and use; development of strategies for GHG reduction; and strategies for mitigation/adaptation of impacts. 2. Improve the understanding of, and develop solutions for, reducing biological, land use, air-quality, and water related impacts of the electricity system and contribute to a sustainable energy future. 3. Develop knowledge base for future decision-making and informed environmental policy relative to electricity.
Primary Solutions	• Develop strategies and technologies to reduce direct and indirect GHG emissions associated with electricity in California. • Create tools for assessing impacts of global climate change (GCC) on key sectors (ecosystems, energy, and infrastructure) and develop robust mitigation and adaptation strategies. • Improve understanding and develop solutions to reduce air quality, biological, land-use, public health and water impacts of electricity generation, transmission, distribution, and use, and contribute to a sustainable energy future. • Develop methodologies (indoor emissions testing protocols) to improve regulatory processes (transmission siting) and inform future State environmental/energy policy.
Secondary Solutions	• Improve understanding of State-specific environmental and economic tradeoffs resulting from emerging (renewable, distributed generation) energy technology. • Develop methodologies for designing and establishing sustainable communities. • Improve methodologies for assessing the environmental and economic implications of fuel choices and interdependence (conventional and alternative) in electricity, natural gas and transportation. • Develop tools for assessing and improving indoor environmental quality.
Tertiary Solutions	• Support technological performance and cost improvement research for air/water pollution control. • Develop innovative electro-technologies (soil remediation) for mitigating impacts and restoring environmental quality. • Develop life-cycle analytical techniques for assessing site-specific environmental impacts from energy facilities. • Develop methods for assessing the environmental and economic tradeoffs of conventional and alternative energy and transportation infrastructure. • Support national research initiatives (implementation of 316(a) and (b) regulations of the Clean Water Act) designed to protect and restore critical environmental resources.