

CALIFORNIA ENERGY COMMISSION

Public Interest Energy Research

Research Powers the Future

01 | annual report



GRAY DAVIS, GOVERNOR

March 2002
P500-01-006C





CALIFORNIA ENERGY COMMISSION

**GRAY DAVIS,
GOVERNOR**

March 29, 2002

Members of the Senate Energy, Utilities and Communications Committee
Members of the Senate Budget and Fiscal Review Committee
Members of the Senate Appropriations Committee
Members of the Assembly Utilities and Commerce Committee
Members of the Assembly Budget Committee
Members of the Assembly Appropriations Committee

California State Capitol Building
Sacramento, California 95814

Re: The California Energy Commission's 2001 Annual Report Concerning the Public Interest
Energy Research Program

Dear Members:

In accordance with Public Resources Code Section 25620.8, the California Energy Commission hereby transmits its annual report to the Legislature concerning the Public Interest Energy Research (PIER) Program, for the period January 1 through December 31, 2001. Recent legislation across the nation shows that California's PIER Program is serving as a model for many other states.

This annual report provides the following information: (1) a brief background and overview of the program; (2) a current status of the program, including all funding awards made by the Energy Commission as of December 31, 2001; and (3) the Energy Commission's recommended future direction for the PIER Program. The report specifically includes all required information on the "names of award recipients, the amount of awards, the types of projects funded . . . and recommendations for improvements in the program." However, since some of the projects funded through the PIER Program are multi-year projects and are not yet complete, the required annual "evaluation of the success of [these] funded projects" will be provided in subsequent semi-annual and annual reports on the PIER Program.

Should you have questions or comments concerning this report, please feel free to contact Tim Schmelzer, Energy Commission Director of Governmental Affairs, at (916) 654-4942.

Respectfully submitted,

ARTHUR H. ROSENFELD
Commissioner and Presiding Member
Research, Development, and
Demonstration Committee

ROBERT A. LAURIE
Commissioner and Second Member
Research, Development, and
Demonstration Committee

cc: California Legislative Analyst Office



Public Interest Energy Research

Research Powers the Future

2001 Annual Report

MARCH 2002

GRAY DAVIS, GOVERNOR

The Resources Agency of California

MARY D. NICHOLS, Secretary

California Energy Commission

WILLIAM J. KEESE, Chairman

ROBERT A. LAURIE, Commissioner

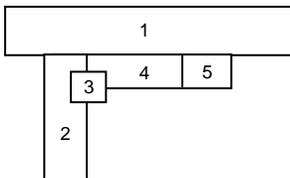
ROBERT PERNELL, Commissioner

ARTHUR H. ROSENFELD, Commissioner

JAMES D. BOYD, Commissioner

STEVE LARSON, Executive Director

Cover images



P500-01-006C

1. PowerLight Corporation – PowerGuard advanced commercial rooftop PV installation on PowerLight Corporation's manufacturing facility.
2. Wind Turbine Company – 500 kW down-wind turbine.
3. Alzeta Corporation – Ultra-low NO_x gas turbine combustor delivering cleaner air solutions.
4. Capstone Turbine Corporation – Capstone MicroTurbines for capacity additions, cogeneration, peak shaving, and stand-by power.
5. Reflective Energies – Residential installation streamlining the complicated distributed generation interconnection process.
(Photo courtesy of Astro Power, Inc.)



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EXECUTIVE SUMMARY



 BACKGROUND

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PIER Program Background

Following the deregulation of California's electric services industry in 1996, the Energy Commission was authorized by the Legislature to conduct public interest energy research, development and demonstration. In accordance with the Public Resources Code (PRC) Section 25620.8, the Energy Commission has developed its fourth annual report to the Legislature concerning the Public Interest Energy Research (PIER) Program, for the period January 1 through December 31, 2001. Legislation across the nation continues to show that California's PIER Program serves as a model for many other states. This annual report provides the following information: (1) a brief background and overview of the program; (2) a current status of the program, including all funding awards made by the Energy Commission as of December 31, 2001; and (3) the Energy Commission's recommended future direction for the PIER Program.

Current Status of the PIER Program

The PIER Program is organized into six program areas:

- Residential and Commercial Buildings End-Use Energy Efficiency
- Industrial/Agricultural/Water (IAW) End-Use Energy Efficiency
- Renewable Energy Technologies
- Environmentally-Preferred Advanced Generation (EPAG)
- Energy-Related Environmental Research

- Energy Systems Integration (ESI), including transmission and distribution and enabling technologies

During 2001, the Energy Commission approved PIER awards totaling approximately \$75 million through competitive awards, sole source contracts, and interagency/intergovernmental agreements. These awards will be matched with approximately \$47.3 million in other cash and in-kind matching funds, thus providing approximately \$122 million in

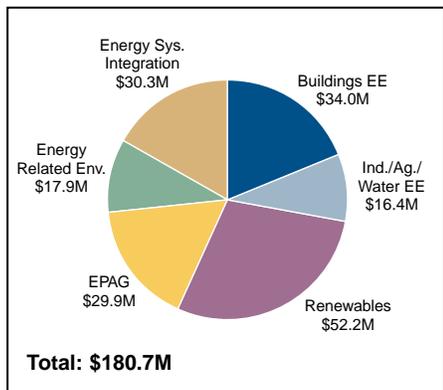


Figure ES1. PIER Program Project Funding 1998-2001 (in millions of dollars)

total funding for PIER projects. The funding and number of projects by program area are shown in Figure ES1.

PIER is entering the stage of early maturity for an RD&D program. A summary of the major accomplishments of PIER during 2001 follows:

- The Energy Commission approved and on March 1, 2001, forwarded to the Governor and the Legislature the *Five-Year Investment Plan, 2002 through 2006*, for the PIER Program.
- Several intermediate goals in staffing, including filling all top supervisory positions, were completed.
- The PIER Program was linked with the Energy Commission’s Renewables Energy Program through the staff of PIER’s Renewables and Energy Systems Integration program areas.
- Collaborative research and commercialization activities were expanded with other RD&D institutions.
- A project and program benefits analysis based on the methodology used by the Gas Technology Institute (GTI) was initiated.
- Preparation of research contracts was consolidated and streamlined.

- Legislation designed to allow streamlining of PIER administrative functions, particularly RD&D contracting, was introduced. The legislation has been reintroduced for 2002.
- A new solicitation for technical support to PIER for the period of September 2001 through September 2004 was completed. The solicitation resulted in contract awards to three strong teams with a total of 510 experts in specific aspects of energy, science, and technology.

2001 PIER Program Highlights

The highlights for each of the program areas are presented below:

In the area of **Residential and Commercial Buildings End-Use Energy Efficiency**, the Alternatives to Compressor Cooling project is shaping up to become a “home run hitter” for the PIER Program. This research has developed energy-efficient home designs and an innovative ventilation cooling system called *NightBreeze*. In 2001, the PIER Buildings Team continued to manage \$25 million in active research contracts. Research was completed in 2001 in air conditioning power electronics, investigation of improved California building framing practices, and improvement of heat pump field performance. The PIER Buildings Team has also been actively involved in facilitating the market adoption of the Berkeley lamp, participating in the Emerging Coordination Council with California utilities and the National Renewable Energy Laboratory (NREL) Industry Growth Forum, and developing an improved market impact assessment methodology. In 2001, projects were initiated in residential water heating, low income housing energy-efficient technologies, and energy-efficient home construction research.

During 2001, the **Industrial/Agricultural/Water (IAW) Energy Efficiency** group sought industry and stakeholder participation in prioritizing technologies and projects for the PIER Program to undertake RD&D activities that are more responsive to industry needs. Based on this input, energy efficiency projects were under-taken for the cast metal industry, California’s oil fields, high-tech and bioscience industry clean rooms, electro-technology applications for potable water production, technology roadmap and partnership for water treatment, food processing ozone and membrane technologies, liquid membrane technology for methyl tertiary-butylether (MTBE) separation, and compressed air systems.

In the area of **Renewable Energy Technologies**, significant inroads were made during 2001 in developing renewables that help meet California’s future electricity needs. Programmatic awards totaling over \$31 million were made that link efforts of renewable technology developers with electricity suppliers to develop renewables that will make California’s electricity more diverse and affordable. Similarly, over \$5 million in targeted research was awarded to continue advancements in wind and geothermal technologies important to the state. If successful, the programmatic and targeted research efforts will open the door to harnessing thousands of megawatts of new renewable electricity supplies. In addition to the programmatic and targeted awards, the Renewables area has developed updated and more accurate assessments of California’s renewable resources, created tools for maximizing benefits from these resources and established forums to

ensure good market connection and deployment of the emerging technologies.

The **Environmentally-Preferred Advanced Generation (EPAG)** Team conducted two solicitations in 2001. Nine awards were made for the first solicitation, which targeted fuel cells, microturbines and small turbine generators, hybrid systems that include a fuel cell or a turbine, and associated technologies. The second solicitation targeted efficiency improvements and atmospheric emission reductions from reciprocating engines. The EPAG team is also co-funding projects with the Electric Power Research Institute (EPRI) and GTI. The installation of fuel cells and other distributed generation technologies is being facilitated through cooperation with other state agencies and governmental entities.

The **Energy-Related Environmental Research** staff prepared research Roadmaps during 2001 to address several high-priority environmental issues related to the generation, distribution, and transmission of electricity in the areas of aquatic resources, land use and habitat, air quality, and global climate change. In addition to developing these Roadmaps, 12 projects totaling over \$5.2 million were initiated to mitigate the environmental impacts of the electricity system. The Spray Enhancement of Dry Cooling Project and a project to study methods to reduce avian mortality associated with utility structure interaction show significant potential for benefits to the California economy and environment.

The **Energy Systems Integration (ESI)** area (formerly Strategic Energy Research) assessed the status of research for grid interconnection, grid effects, and market integration. A series of scoping studies was conducted to determine demand response to electricity prices and system contingencies. The ESI is also responsible for improved efficiency and reliability of the transmission system. In 2001, three awards totaling over \$2.2 million were funded for the intelligent control of distributed generation, technical support for distributed generation interconnection standards, and real-time transmission line ratings for Path 15, one of the most complex gates in the California transmission system.

PIER Five-Year Investment Plan

The *Five-Year Investment Plan* addresses how the Energy Commission will manage the PIER Program from 2002 to 2006 and responds to issues raised by the PIER Independent Review Panel (IRP). PIER continues to move forward to address and solve problems identified in the plan, which include the following:

- Electricity demand has been rising faster than supply.
- Rising peak demand threatens reliability and power quality.
- Balance is needed between energy needs and environmental protection.
- Market uncertainty and price volatility are impacting energy delivery and use.

The PIER Program has adopted a portfolio and budgeting approach to balance the risks, benefits to ratepayers, and timelines for various PIER activities

and investments. PIER will continue to establish partnerships with other energy RD&D institutions to expand the program's effectiveness.

Following major awards for distributed generation technology development, the near-term focus will be on demand-side management.

For fiscal year 2001-2002, the emphasis will be on funding projects in the areas of distributed energy resources and end-use energy efficiency. Funding that has been allotted to date includes \$16 million for end use energy efficiency projects, \$22 million for distributed energy resource projects, and \$6 million for environmental studies. An additional \$31 million remains to be allotted.

Independent Review Panel Findings

PRC Section 25620.9(a) required the Energy Commission to designate an independent panel of experts by January 1, 1999 to conduct a comprehensive evaluation of the PIER Program. PRC Section 25620.9(b) required the IRP to submit preliminary and final reports on its findings to the Legislature. The panel submitted its preliminary report during the first quarter of 2000 and submitted its final report in March 2001 (California Energy Commission Docket Number 96-RDD-1890). The panel held its last meeting in February, 2001 to adopt its final report. The final report offered a set of expectations for the Governor, the Legislature, and the Energy Commission regarding accomplishments needed over the next year to transform PIER into a high-quality research program within the Energy Commission.



OVERVIEW | OF THE PIER PROGRAM ■ ■ ■ ■ ■

A. BACKGROUND

B. FIVE-YEAR INVESTMENT PLAN

C. VISION

D. MISSION

E. OBJECTIVES

F. RD&D AREAS

G. ENERGY INNOVATIONS SMALL GRANT PROGRAM (EISG)

A. Background

In 1996, California adopted far-reaching legislation that deregulated much of the state’s electric services industry (1996 Statutes, Chapter 854, hereinafter referred to as Assembly Bill (AB) 1890). Article 7 of 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. As a result, Public Utilities Code Section 381 requires that, starting on January 1, 1998 and extending through 2001, at least \$62.5 million be collected annually through California’s electric investor-owned utilities (IOUs) to fund energy-related public interest RD&D activities “not adequately addressed by competitive and regulated markets.” In September 2000, the Legislature passed and Governor Gray Davis signed into law Senate Bill (SB) 1194 (Sher) and AB 995 (Wright) extending the PIER

Program surcharge for an additional 11 years from January 2001 to January 2012.

The Energy Commission is authorized in AB 1890 to receive and administer these funds as designated by the California Public Utilities Commission (CPUC) to conduct public interest RD&D, subject to administration and expenditure criteria also established by the Legislature. In 1997, the CPUC determined that at least \$61.8 million annually should be transferred from the major IOUs to the Energy Commission for specified public interest energy research (D.97-02-014)¹. These funds are subject to the administrative and expenditure criteria adopted by the Legislature in 1997 (1997 Statutes, Chapter 905, hereinafter SB 90), which are contained in PRC Section 25620 et seq.

B. Five-Year Investment Plan

On March 1, 2001 the Energy Commission provided the Governor

¹ In 1998, a small IOU, Bear Valley Electric Company (also known as Southern California Water Company), sought and received CPUC authority to contribute \$56,000 annually to the PIER Program.

and Legislature with the *Five-Year Investment Plan, 2002 Through 2006 for the Public Interest Energy Research (PIER) Program* as required by SB 1194 and AB 995, enacted in 2000. The plan addresses how the Energy Commission will manage the PIER Program from 2002 through 2006 and responds to issues raised by the PIER IRP. The following integrated framework for the PIER Program is provided in the plan:

- Fundamental mission, objectives, and vision for implementing the PIER Program.
- Operational definition of public interest energy research.
- The expected “California Energy Context” for the state’s energy RD&D program, including demographics, high-technology sector, social values, air quality, water, and global climate change.
- Energy-related impacts to which this context will give rise in the future.
- Public interest RD&D strategies and activities to address California’s energy problems based on RD&D gaps that need to be filled to meet priority California needs.
- Budget strategy and proposed budget for the PIER Program.

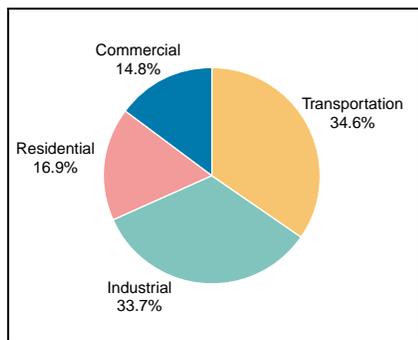


Figure 1. California Primary Energy Use by Sector (2000)

- Steps the Energy Commission has taken and further steps it will take to address the concerns of the PIER IRP.

The design and management of the PIER Program have proceeded as conceived in the plan so that the goals established by AB 1890 and the Energy Commission’s subsequent Strategic Plan (P. 500-97-007, June 1997) will be met.

C. PIER Vision

In the future, California must provide a clean, affordable, reliable, and resilient supply of electricity where “smart,” efficient customers have energy choices that can meet their individual needs, and California’s industries can grow and prosper. The PIER Program will support and catalyze science and technology advancements by providing leveraged funding to establish California as the world leader in energy efficiency and clean, advanced energy technologies and systems.

D. PIER Mission

The mission of the PIER Program is to conduct public interest energy research that seeks to improve the quality of life for California citizens by developing environmentally sound, safe, reliable, and affordable electricity services and products. Public interest energy research includes the full range of RD&D activities that advance science and technology not adequately provided by competitive and regulated markets.

E. PIER Program Objectives

Based on the goals set forth in the PIER Program’s mission and vision, the Energy Commission also adopted specific objectives for the PIER Program, updated in the *Five-Year Investment Plan*. These objectives are to advance science or technology to achieve the public benefits of the following:

- Improving energy cost/value
- Improving the environment, public health, and safety
- Improving electricity reliability, quality, and sufficiency
- Strengthening the California economy
- Providing greater choices for California consumers

F. PIER Program RD&D Areas

The subject areas for the PIER Program are defined in SB 90:

The program shall consist of a balanced portfolio that addresses California’s energy and environmental needs, technology opportunities, and system reliability. To achieve balance, the [Energy] Commission shall actively solicit applications for the under-represented subject areas of end-use energy efficiency, renewable technologies, and environmental enhancements. The portfolio shall include the relevant core subject areas of environmental enhancements, end-use efficiency, environmentally-preferred advanced generation, renewable technologies, and other strategic energy research, including public interest system reliability research, demonstration, and development not adequately addressed by the Public Utilities Commission (PUC).

The Energy Commission’s RD&D strategic plan recommends that planning efforts for the PIER Program be undertaken at levels corresponding to the program’s organizational structure and funding areas. In 1998, the Energy Commission established the following six PIER Program funding areas:

- Residential and Commercial Buildings End-Use Energy Efficiency
- Industrial/Agricultural/Water End-Use Energy Efficiency (Process Energy)
- Renewable Energy Technologies

- Environmentally-Preferred Advanced Generation
- Energy-Related Environmental Research
- Energy Systems Integration

The PIER Program Manager has clear authority to make decisions regarding the PIER Program. Six teams are led by staff experts called Team Leads, who report to the PIER Program Manager. The teams are segregated by each of the six program areas listed above. Each team is responsible for planning and implementing the RD&D activities needed to meet specific PIER goals and deliver results in the program areas in question. As with all aspects of the PIER Program, this effort is conducted with review and input from the Policy Advisory Council (PAC), focus groups, stakeholders, and interested members of the public. Current and future program plans will be periodically reviewed and evaluated—both internally and externally—to recognize the changing roles and scope of the program.

G. Energy Innovations Small Grant Program

The Energy Innovations Small Grant (EISG) Program provides a user-friendly application process to groups that are adversely affected by the high transaction costs associated with the Energy Commission’s standard competitive bid processes. The program offers small businesses, nonprofits, individuals, and academic institutions grant funding of up to \$75,000 for proof-of-concept (POC) research projects that establish the feasibility of new, innovative solutions to California’s energy problems.

The EISG Program was created to meet three needs for the Energy Commission’s overall PIER effort:

- Provide research support for innovative ideas not necessarily covered in the targeted PIER Program area research plans.
- Provide a user-friendly application process to groups such as small businesses, individuals, academics, and non-profits.
- Provide a PIER funding mechanism for early concept feasibility research and development. The mainstream PIER research efforts require that feasibility has already been established.

The EISG Program develops technologies that are not already adequately funded through the competitive and regulated markets. Up to four solicitations per year are conducted, with each solicitation open to all six PIER program areas.

The program is funded at \$2.5 million/year, with \$2 million allocated to grants and \$0.5 million for program administration. In 2001, the Energy Commission conducted three solicitations and approved 24 grants totalling \$1,783,842. From program conception in September 1998, a total of nine solicitations have been conducted, resulting in 81 grants approved by the Energy Commission. Three of these grants were declined, for a net of 78 grants valued at \$5,813,046.

The Energy Commission wanted to design a program with minimal demand on scarce staff resources. To accomplish this, the Energy Commission approved a two-year, \$5 million interagency agreement in September 1998 with the California State University Regents to administer the EISG Program. The Regents contracted with the San Diego State University (SDSU) Foundation to perform the day-to-day administration functions. The foundation, in coordination with the Energy Commission, developed

a simplified funding application process to identify and recommend worthy POC projects to the Energy Commission. The Energy Commission, in turn, participates in the project review process and maintains final authority to approve any projects recommends by the administrator. The Energy Commission extended the interagency agreement with the California State University Regents for another two years in September 2000.

Figures 2 and 3 show how EISG Program awards are distributed among the six PIER program areas and by applicant type.

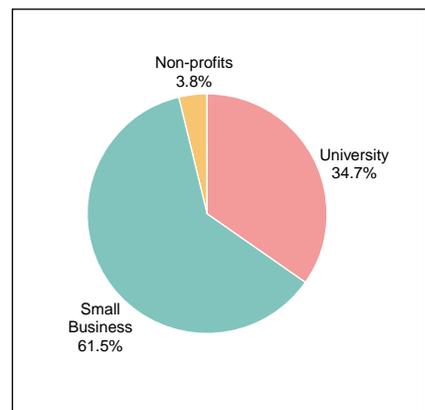


Figure 2. Energy Innovations Small Grant Program Awards Analyzed by Business Type

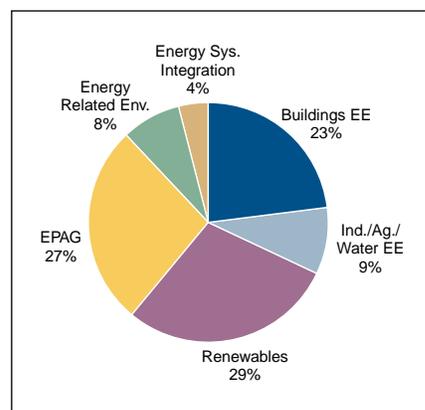


Figure 3. Energy Innovations Small Grant Program Awards Analyzed by Program Area



A. IMPLEMENTATION OF THE
FIVE-YEAR INVESTMENT PLAN

B. 2001 PROGRAM HIGHLIGHTS

C. PROGRAM ADMINISTRATION

- IMPROVING THE PROGRAM
 - INDEPENDENT REVIEW PANEL
 - TECHNOLOGY TRANSFER
 - REPORTING TO THE LEGISLATURE
 - 2001 FINANCIAL STATEMENT
-

The current status of the various functions of the PIER Program, as of December 31, 2001, is set forth below.

A. Implementation of the PIER Five-Year Investment Plan (the “California Context” and the problems identified in the Five-Year Plan)

The PIER Program implements AB 1890, SB 90, AB 995, and SB 1194, the Energy Commission’s RD&D strategic plan, and the *Five-Year Investment Plan, 2002 Through 2006*. These documents identify the essential state policies and objectives for energy-related public interest research. In turn, the results from the PIER Program will provide input for the development of future state energy policies.

The PIER Program has implemented the 2000–2001 recommendations of its IRP and PAC. The IRP, consisting of eminent research experts, completed its review tasks when it issued its second report, *California Public Interest Energy Research, Independent PIER Review Panel Final Report*, in March 2001. The PAC consists of high-

level representatives from industry, academia, research institutions, and various stakeholder associations. Its members provided comments and suggestions to the *Five-Year Investment Plan* in its final stage of preparation.

The topics covered in the *Five-Year Investment Plan* are presented in four chapters that address the following subjects:

- The PIER Program’s fundamental mission, operational definition and related criteria for public interest research, and a guiding vision for California’s energy future
- The California Energy Context
- The major energy-related problems confronting California and a portfolio of integrated RD&D strategies for finding solutions through the PIER Program
- The Energy Commission’s approach and budget for funding future PIER projects and addressing the concerns of the IRP

The plan identifies elements of California’s energy-related circumstances and trends, including deregulation,

demographics, technological advances, economic conditions, social values, political factors, climate, and environmental factors. In particular, the plan highlights the following concerns:

- Rapid growth in demand, particularly peak demand, as a threat to reliability and power quality
- Need for balance in meeting energy needs and protecting the environment
- Market uncertainty and price volatility as they impact energy delivery and use

Four factors increase the necessity to advance science and technology-specific to California's needs under deregulation: reliable, affordable, and clean new supplies; smarter energy transmission and delivery; ways to use energy that are more efficient, clean and economic; and readily available information concerning the status and capability of the system and its environment. The PIER Program is the public interest research response to meet these California needs.

The PIER Program is entering the stage of early maturity for an RD&D program. The following is a summary of the Energy Commission's accomplishments at the program management level of PIER during 2001.

- Approved and on March 1, 2001, forwarded to the Governor and the Legislature the *Five-Year Investment Plan, 2002 Through 2006, for the Public Interest Energy Research (PIER) Program*. The plan was reviewed in a public setting.
- Completed several intermediate goals in its staffing-up program, including filling all top supervisory positions.

- Linked PIER with the Renewables Energy Program through the staff of PIER's Renewables and Energy Systems Integration program areas.
- Expanded collaborative research and commercialization activities with other RD&D institutions.
- Initiated a project and program benefits analysis based on the methodology used by GTI for its public interest RD&D activities.
- Consolidated and streamlined preparation of research contracts in a special process under the title "SPARKEY." The team consists of a contract manager, representatives from the Contracts and General Counsels offices, and a standing member of the SPARKEY group. All issues are identified and resolved in team meetings.
- Introduced legislation designed to allow streamlining the PIER Program administrative functions, particularly RD&D contracting. The legislation has been reintroduced for 2002.
- Solicited technical support to the PIER Program for the period September 2001 through September 2004. The solicitation resulted in contract awards to three strong teams with a total of 510 experts in specific aspects of energy, science, and technology.

During 2001, the PIER Program added to its existing portfolio several major new RD&D projects and program initiatives that substantively address the energy problems and opportunities identified in the *Five-Year Investment Plan*. Their funding is consistent with the budget presented in the *Plan*. The specific achievements of the six PIER program areas, the EISG Program, and

program administration are described in the sections that follow.

B. 2001 PIER Program Highlights

The overall PIER funding objectives are implemented by selecting and supporting projects in the following six PIER Program areas and the EISG.

RESIDENTIAL AND COMMERCIAL BUILDINGS END-USE ENERGY EFFICIENCY

2001 PROGRESS UPDATE

In 2001, the PIER Buildings Team continued managing a growing portfolio comprised of over \$25 million in active research contracts. This portfolio included three general programmatic contracts, three targeted programmatic contracts, approximately 20 project-level contracts, and four memberships involving national collaborative energy research. These memberships continue to provide valuable insights into national research activities and information important to PIER research planning.

The three general programmatic contracts funded in 2000 have made significant progress toward achieving program goals and objectives. In 2001, they were evaluated by an independent contractor; all three contracts are progressing well, and promising research results are anticipated in late 2002 and 2003.

In 2001, research was completed, or nearly completed in the following areas:

- Development of power electronics to improve the energy efficiency of air conditioners.
- Development of alternatives to compressor cooling, including the



The Alternatives to Compressor Cooling

Project is shaping up to be a “home run hitter” for the PIER program. The research has developed energy-efficient home designs and an innovative ventilation cooling technology called NightBreeze, which will help reduce or eliminate compressor-based air conditioning in California’s coastal and “transition” climates.



development of house plans and a night ventilation unit.

- Investigation of framing practices in California homes to determine the appropriate framing factor percentages to use in building energy designs. This information will have national implications in ASHRAE guidelines, as well as specific California applications in Title 24 building energy standards.
- Development of heat pump performance maps to more accurately characterize field performance of equipment.

In addition to the management of ongoing research projects, the PIER Buildings Team has been actively involved in the following:

- Facilitation of the market adoption of research results, including the now commercially-available Berkeley lamp
- Participation in the Emerging Technology Coordination Council with California investor-owned utilities and participation in the NREL Industry Growth Forum, which helps bring emerging technologies to the market-place
- Development of a credible, standardized market impact assessment methodology to more scientifically project the market impact of funded or planned research

2001 RD&D AWARDS

In the *2000 Outlook*, the PIER Buildings Team identified plans to fund three energy research projects targeted to residential buildings. The three projects covered research in the areas of residential water heating, energy-efficient technologies applicable to low-income housing, and research relating to energy-efficient home construction. These three projects were awarded funding in 2001 and successfully initiated. Policy Advisory Committee

meetings have been held for all three projects, and the research scope has been refined based upon valuable input from other technical experts in the field as well as market applicators. Interim results will be available by the end of 2002, and some field demonstrations are planned for 2003.

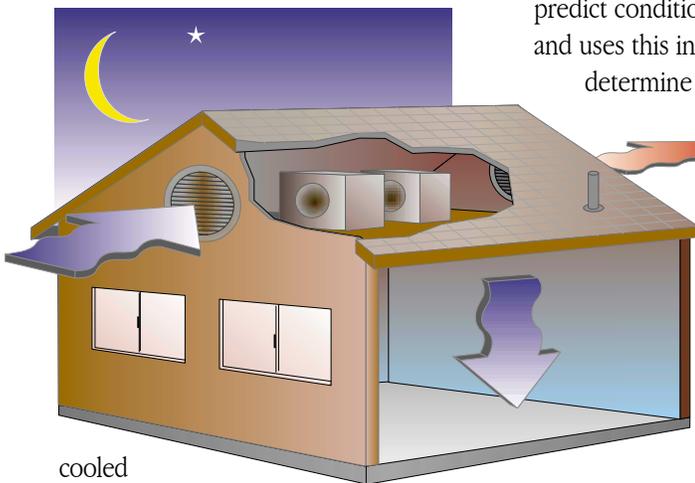
In addition to the larger targeted efforts, several other projects were also initiated in 2001:

- Continuing memberships were funded with the Center for the Built Environment as well as the Lighting Research Center.
- Duct sealant testing was funded to provide information needed to support Title 24 building standards development.
- A sustainable building fiscal/economic analysis was funded in partnership with other state agencies to develop needed metrics for quantifying sustainable building benefits.

SUCCESS STORY

The **Alternatives to Compressor Cooling Project** is shaping up to be a “home run hitter” for the PIER program. This research has developed energy-efficient home designs and an innovative ventilation cooling technology called *NightBreeze*, which will help reduce or eliminate compressor-based air conditioning in California’s coastal and “transition” climates. The research team is collaborating with a manufacturing partner, Enviromaster International of Rome, New York, and is attracting the interest of builders statewide.

The concept behind the technology is as follows: if the mass of a house (concrete floor, walls, etc.) can be



cooled off at night by ventilating the house with outside air, the house will stay cooler during the day, thereby eliminating or reducing air conditioner use. This simple idea is by no means new; people have ventilated their homes by opening windows at night for years. However, for reasons of security, noise, and dust intrusion, many have discontinued this practice, or do not use their windows to best advantage. Work or personal schedules may also interfere with operating windows at the optimum times. Whole-house exhaust fans are effective for increasing ventilation rates, but cannot be automatically controlled, require that windows be opened to let air in, and do not filter the air.

The *NightBreeze* system, developed by Davis Energy Group and other project members, integrates heating, cooling, and nighttime ventilation into a package that provides ventilation with filtered air at optimal times (when cooler outdoors than indoors). An automatically-controlled damper admits fresh outside air through the house's heating duct system and exhausts stale indoor air through the return air vent.

The system's control uses a history of indoor and outdoor temperatures to

predict conditions for the next day and uses this information to determine how much ventilation is needed to maintain comfortable indoor conditions. The easy-to-use thermostat includes a "comfort bar" that displays the predicted range of indoor

temperatures that changes when minimum and maximum desired temperature settings are changed, thus facilitating control of comfort without air conditioning. The thermostat also tells homeowners if their temperature settings are likely to cause the air conditioner to run.

The system's air handler employs a variable speed "ECM" fan motor that assures the right amount of ventilation cooling in summer, and the fan delivers both warm air for heating and fresh air to improve indoor air quality in the winter time. In winter field tests the fan used less than 40 percent of the energy that a standard furnace fan would use under similar conditions.

The architectural firm of Loisos/Ubbelohde Associates, a project team member, incorporated elements such as window shading, high-performance windows, radiant barrier in the attic, and additional mass (exposed floor slab and thicker drywall) to work together with ventilation to reduce air conditioning load for the Alternatives to Compressor Cooling houses. Using these house designs as a guide, two production builders, Clarum Homes of Palo Alto and Centex Homes of Concord, have completed two demonstration

homes that incorporate these features. The first demonstration house, located in Watsonville's Cherry Blossom subdivision, has no air conditioning installed. The second, built in Centex's Los Olivos development in Livermore, uses an air conditioner that is one ton smaller than that used in the same house model without the Alternatives features. Performance, cost, and ease of installation are being verified by detailed monitoring along with interviews of owners and building contractors.

Based on a projected new-home market of 70,000 houses per year and an average reduction in electric power of 2 kilowatts (kW) per house, *California could reduce its residential air conditioning demand by 139 megawatts (MW) through implementing the Alternatives designs*, while improving comfort and indoor air quality. The *NightBreeze* system, which will be commercially available in 2002, makes these goals achievable.

OUTLOOK

In 2002, the PIER Buildings Team will be focusing on initiating several public and private collaborative research efforts. Partnerships will be formed with the Department of Energy (DOE), national laboratories, and other state and federal agencies as well as private sector manufacturers. These collaborations will build upon research already completed by one of the participating entities and will bring together public and private partners to ensure that the resulting research products are responsive to market needs and carried forward into the marketplace. Some of the collaborative activities the Buildings Team anticipates initiating in 2002 include the following:

Development of Cool Colored Roofing Materials. This research will develop blends of different cool materials to produce the colors desired by homeowners. Testing to quantify how cool roofing materials perform over extended periods of time in the field will be conducted to validate performance. Manufacturing partners will be particularly critical to ensure that specific market products are produced. The successful outcome of this research will, therefore, lead to widespread adoption of cool colored roofing materials, which will lower the demand for cooling during the hot season, extend the life of roofing materials, and reduce the rate of smog formation by lowering ambient air temperatures.

Initiation of a Lighting Research Portfolio. The team will be developing a lighting research portfolio (LRP) based upon an assessment of the current lighting research activities throughout the country. The approach of the LRP Program is to work with the research and end-use communities to identify lighting research needs. Gaps in public interest lighting energy research will be identified, with a particular emphasis on applied research and opportunities for short-term energy use reduction. From this, the LRP will be developed, bringing together lighting research experts from across the country in collaboration with private sector partners.

Development of Advanced Windows. Electrochromic glazings offer dynamic and responsive control of the thermal and optical properties of a building's facade. However, significant questions of technical, engineering, architectural, and general public interest remain to be answered. This

proposed effort will be a collaboration supported by the Energy Commission, the DOE, and the U.S. Department of Housing and Urban Development (HUD) to develop, demonstrate, and evaluate integrated electrochromic window systems that will yield benefits of national interest (energy efficiency, peak demand reductions, and comfort). In addition, it will demonstrate, validate, and quantify the technical performance of these systems in buildings, and develop the information products needed to support their effective use with minimal risk and performance uncertainties.

Development of a California Optimized Air Conditioner. In collaboration with the DOE and national equipment manufacturers, this proposed effort will develop an air conditioner that operates efficiently and effectively in California's hot, dry climate conditions.

INDUSTRIAL/AGRICULTURAL/WATER END-USE ENERGY EFFICIENCY

OVERVIEW

Industrial, agriculture, and water sectors in California use 30 percent of all the electricity consumed in the state. These sectors are critical to California's economy and rely on an affordable, reliable, and sustained supply of energy and electricity. Through RD&D, the program seeks to improve the energy efficiency of the industrial processes, agricultural operations, and water and wastewater treatment plants. These sectors are also sensitive to the power quality and reliability of electricity supply. Therefore, besides improving energy efficiency, the program also strives to research, develop, and demonstrate technologies that help

these sectors deal with power quality and power supply reliability issues. The following are the specific RD&D priorities for the coming year in the industrial, water, and agriculture sectors.

Industry. California's industrial base is substantial. The energy reliability of these industries is critical not only for California's economy but for the national economy as well. The major industries—such as food processing, electronics and e-commerce, and petroleum refining and production—all depend on continued low energy costs and reliability. The PIER Program staff analyzed the energy needs of several of these industries, and for the coming year, will work in collaboration with their representatives to identify RD&D options to overcome energy-related problems. PIER-funded projects will focus on RD&D activities that will provide these industries the ability to address the recent energy crisis. Industry is often required to maintain low manufacturing costs while maintaining environmentally-clean and energy-efficient operations. The PIER program will focus its research on activities that will help industry attain this difficult yet critical balance.

Water. The availability of low-cost, clean water is essential to California's economy and continued prosperity. The state depends heavily upon the transportation of a large volume of water across the state. Also important is the treatment of substandard and saline water in large quantities. Both of these activities rely heavily on electricity. RD&D activities that help improve the energy efficiency of processing water for urban, industrial and agricultural consumption and an energy-efficient

treatment of wastewater recovery will remain a focus of this program area. The program will continue to manage the current contracts with the consortium of water utilities and work with them for transferring the technologies developed through these projects to potential end users.

Agriculture. Agriculture forms a large segment of California's economy, export and employment. Agriculture depends highly upon electrical energy for irrigation and post-harvest processing. Electrical costs and power reliability are critical for a successful and sustainable agricultural operation. The PIER Program will continue its RD&D activities in developing techniques for advanced irrigation and other load management practices that will help this sector cope better in the restructured electric market. The program will continue to manage currently funded projects in the area of advanced irrigation practices for water conservation and water recovery.

2001 PROGRESS UPDATE

During 2001, the PIER Program's IAW Energy Efficiency group actively sought industry and stakeholder participation in prioritizing RD&D technologies and projects that would be more responsive to industry needs. Concerned by the uncertainties of the electrical energy supply and the rising costs of electricity in California, the IAW Team found a number of willing industrial, agriculture, and water treatment partners. Several industry organizations and representatives were already engaged in a dialogue to define the specific needs of the stakeholders. The RD&D projects funded by IAW and related activities in

2001 reflect their concerns and are listed below by sector.

Lowering Electricity Consumption for the Cast Metal Industry. A contract with the California Cast Metal Association (CCMA) was successfully completed during this reporting period. The contract involved developing new operating procedures for cast metal foundries that depend heavily on electricity. The best operating practices, tested at the most energy-efficient operations within the industry, were analyzed for electrical load reduction and load shifting ability. An average operation in this industry has a load of 500 kW; 70 percent of this load is for metal melting. If the industry adopts the practices developed through the PIER project, they would reduce load and power consumption 20 percent, thereby reducing the California system load by up to 28 MW and 26 gigawatt-hours (GWh) of electrical consumption.

Improving Oil Field Energy Efficiency. In collaboration with the Petroleum Technology Transfer Center (PTTC) and EPRI, the PIER IAW Team concluded a project entitled *Optimization of Electric Energy Consumption in California Oil Fields*. This project established the baseline measurement for determining electrical energy efficiency of oil wells in California. The data was needed for a uniform methodology for assessing energy efficiency. Establishing this efficiency measurement standard will benefit those interested in identifying wells that need improvement. Specifically, the CPUC contractors hired under SB 5X are using information developed under this project to retrofit

oil wells that need pump and motor replacements.

Improving Energy Efficiency in Clean Rooms for California's High-Tech and Bioscience Industries. In May 2001, the Energy Commission entered into a contract with the Lawrence Berkeley National Laboratory (LBNL) to develop computer-based design tools for building clean rooms. Clean rooms are used in pharmaceutical, chemical, and computer-chip manufacturing facilities. They consume an enormous amount of energy to create an environment that is free of particulate and biological contaminants. The design tool will enable California-based industries to build energy-efficient clean rooms.

In addition, the contract will also enable the development of an energy efficient fume hood. This project would allow the fume hood's electricity consumption to be reduced up to 70 percent with a potential \$30 million annual energy savings in California.

Developing Electrotechnology Applications for Potable Water Production and Protection of the Environment. During this reporting period, the Energy Commission received a final report on eight specific tasks to develop alternative water sources and electro-technologies that could significantly reduce energy use and minimize environmental problems. The report was funded through a \$2.89 million PIER contract with the Metropolitan Water District of Southern California in association with Southern California Edison (SCE) to address potable water issues.²

² Southern California, with its 16 million residents and a dynamic \$450 billion regional economy, depends on a reliable and affordable supply of potable water. Most of the current water supply is imported from Northern California or the Colorado River. Water transfer from the north requires significant energy for pumping and major disturbance to the environment. To address these issues, six innovative water/wastewater treatment process technologies were researched and evaluated.

Water and Wastewater Energy Efficiency Roadmap and Partnership for Funding Emerging Research for Water and Wastewater Utilities.

Treatments for both potable water and wastewater are very energy intensive. The recent energy crisis raised the electric rates of several California water and wastewater utilities and created concern for the availability of electric power. The PIER IAW Team is collaborating with the American Water Works Association Research Foundation (AwwaRF) to develop a Water and Wastewater Energy Efficiency Roadmap to identify and prioritize emerging research priorities related to energy efficiency, cost and reliability affecting water and wastewater utilities. After completion of the Water and Wastewater Energy Efficiency Roadmap, the Energy Commission and the AwwaRF will jointly fund up to three projects identified as the highest priorities from the Roadmap.

R&D to Mitigate Electricity Reliability Problems for California's Electronics and E-Commerce Industries.

The electronics and e-commerce industries are a critical component of California's economy. The recent electricity crisis and its adverse impacts on power availability, reliability, and cost have severely affected the industries' operations. The PIER program has provided \$960,000 to EPRI to work with the electronics industry and the Silicon Valley Manufacturer's Group to develop a technology Roadmap to provide the industries with tools to mitigate the power reliability, availability, and cost issues.

Collaboration with the Food Processing Industry for Energy Efficiency.

California's food processors are major users of energy and are also a critical part of California's economy. The food processing industry consumes about 5.25 percent of all the electrical energy used in California. It is also a major user of thermal energy. Electricity is primarily used for refrigeration, freezing, fluid separation, water treatment, electrical motors, and pumps. In July 2001, the PIER Program contracted with the California Institute for Food and Agricultural Research (CIFAR) to work with the industry to update a 1998 industry energy issues assessment and recommend energy-efficient technology opportunities to mitigate problems created by last year's energy crisis. In November 2001, the industry advisory committee was formed and identified technologies for short-term RD&D opportunities. The PIER Program will fund projects identified under this effort with an active participation by the industry.

Ozone and Membrane Technology for Food Processing.

CIFAR, under a contract with the PIER Program, successfully demonstrated the use of ozone and membranes for disinfecting the water used for cleaning chickens. The use of this technology eliminates the use of chlorine, allowing food processors to re-use water and reduce the amount of electricity needed for cooling every fresh batch of water. The Federal Drug Administration (FDA) and the United States Dairy and Agriculture Administration (USDA) approved this process. When scaled to full plant size, this technology would save 0.2 megawatt-

hours (MWh) of electricity and 8.5 million gallons of water per year. The potential for energy and water savings will be significantly increased when the USDA approves the application of the same technology to other types of food processing plants.

Liquid Membrane Technology. A project demonstrating a new technology for efficiently separating MTBE from water was concluded in December 2001. The technology, developed by Spectrum Laboratories Inc., in collaboration with EPRI, successfully demonstrated the ability of a new liquid membrane technology to separate MTBE from water. Work still needs to be done for further reducing the costs through mass production, extending membrane life, and more effectively using the membrane surface. The public benefit lies in restoring water quality while using substantially less energy.

Compressed Air Systems Efficiency.

Numerous California industries use compressed air as a major component of their manufacturing operations. Although methods are available in the industry to control the efficiency of the compressor, no methods are available at the present time to quantify the compressor central plant efficiency. In some industries, up to 40 percent of energy associated with compressed air systems is wasted. In most plants, there are many opportunities to conserve energy in the generation, distribution, and use of compressed air. In collaboration with California utilities and the Emerging Technology Coordination Council, the IAW Program will develop methodology to quantify

An advanced, energy-efficient laboratory Fume Hood Technology developed by scientists at the Lawrence Berkeley National Laboratory with the support of the Energy Commission promises to save millions in energy costs while protecting workers at all types of laboratory facilities.



Berkeley Lab High Performance Fume Hood. Courtesy of Lawrence Berkeley National Laboratory.

the central plant efficiency and establish procedures for enhancing efficiency of compressed air systems. The project will commence in March 2002 after approval by the Energy Commission.

2001 RD&D AWARDS

The IAW Program awarded the following research contracts in 2001:

California Cast Metal Association.

IAW granted CCMA a \$126,000 award to develop new operating procedures for cast metal foundries that depend heavily on electricity. These new energy-efficient operating procedures are expected to reduce load and power consumption by 20 percent compared to standard practice. The CCMA also sponsored technology transfer workshops in northern and southern California.

Lawrence Berkeley National

Laboratory. This \$652,000 award was granted to develop computer-based tools to help design energy-efficient clean rooms used in pharmaceutical, chemical, and computer-chip manufacturing facilities. LBNL developed an energy-efficient fume hood that uses 70 percent less electricity compared to standard-design fume hoods. Potential energy savings for California are expected to be \$30 million per year.

Electricity Power Research

Institute (EPRI). The IAW Program awarded EPRI for technology development projects to provide California’s electronics and e-commerce industries with the tools needed to mitigate power reliability and cost issues. EPRI is working with the Silicon Valley Manufacturers’ Group and other representatives of the electronics industry on these timely concerns.

California Institute for Food & Agricultural Research.

This award will help CIFAR identify technologies for near-term RD&D opportunities for energy efficiency technology opportunities in the food and agricultural industries. CIFAR organized an industry advisory committee that will develop a technology roadmap addressing the long-term concerns and issues affecting California’s food processing and post-harvest agricultural industry.

Contra Costa Water District.

This \$130,000 award will be used to evaluate chlorine dioxide as a pre-disinfectant when using ozone to treat drinking water. The research is co-funded by AwwaRF.

SUCCESS STORIES

The PIER-sponsored contract with the Contra Costa Water District was recommended by AwwaRF’s Management Division as a featured presentation at the AwwaRF poster session at the 2002 AWWA Annual National Conference. The selection was based on the significant interest to the water utilities, consultants, and regulators. The project evaluates the efficiency of pre-oxidation using chlorine dioxide to reduce treated water. This process replaces or reduces the use of ozone in water. Ozone generation is quite energy-intensive, and this project could potentially save 7 MW of electricity used in California water treatment plants.

About 400 companies comprise the metal casting industry in California, and most have small operations. These companies primarily use electric arc furnaces and electric induction furnaces for their metal melting. The furnaces

range in size from 500 kWh to 10 MW, depending on the size of the operation. Energy is a major cost factor in the operation of these businesses and electric metal melting accounts for 55 percent of energy use in a foundry operation.

The IAW Program cost-shared a research project that evaluated alternative energy practices that would allow load reduction and load shifting, and would result in an overall increase in energy efficiency. The project was completed in record time and was presented at two workshops during summer of 2001.

The industry has already started putting the recommendations in practice. For example, in an operation involving 500 kW of energy, 70 percent of the energy used is for metal melting. By using the measures suggested in the PIER project, the foundry can reduce energy consumption by 20 percent. If these recommendations were widely implemented, ***California could reduce its overall system load by 28 MW***. These reductions would save about \$2.8 million per year, or a 2,200 percent return on the dollars used to invest in these procedures.

The contract resulted in the CCMA publishing two manuals – “Metal Melting Practices and Procedures for Efficiency and Effectiveness” and “Foundry Energy Use Study and Conservation Manual.” Because of the immediate applicability of this work to the industry, the PIER contractor has been invited by the American Foundry Society and Cast Metals Institute to present the findings of this research at the Institute’s Advanced Operations Conference in March, 2002.

OUTLOOK

In the year 2002, the collaborations formed with the water, food, and electronics industries should result in technology Roadmaps and lists of priority energy RD&D projects. This work will facilitate selecting an RD&D portfolio that responds to energy needs and will help these critical sectors of California’s economy to successfully mitigate energy problems. In addition, the IAW Program Area will issue a request for proposal (RFP) for storage technologies in collaboration with the DOE. The technologies demonstrated from these solicitations can help California industry resolve issues regarding energy reliability, load management, and power quality.

RENEWABLE ENERGY TECHNOLOGIES

2001 PROGRESS UPDATE

The PIER Renewables mission is to help develop renewables for California’s electricity system of tomorrow. This mission encompasses four major objectives: (1) maximizing value provided by renewables; (2) lowering the cost of energy supplied by renewables; (3) expanding applications of renewables in California’s electricity system; and (4) pursuing breakthrough opportunities.

The PIER Renewables Team made significant progress during 2001 in meeting the mission. The portfolio of renewable energy research projects started in 2001 at approximately \$16.6 million. A major focus of contracts during 2000 was to target and then solicit renewables research that would make inroads into the major objectives within the next three to five years.

Projects were initiated to update the status, costs, and development pathways for renewable energy technologies and to evaluate the statewide benefits resulting from future deployment of renewables. Based on interim results from those year 2000 projects, the Renewables Team conducted a programmatic solicitation during 2001 that resulted in research contract awards of over \$31 million. In addition, year 2000 activities included developing a California-specific wind forecasting model and expansion of distributed generation renewable applications in the area of small modular biomass systems.

Among the research activities completed in 2001 were the following:

- A renewables technology assessment guide that provides updated information on the performance and costs of renewable energy technologies as well as Roadmaps on development of the technologies.
- A report that provides quantitative estimates of economic, environmental, and electricity benefits resulting from future deployment of renewables. The report also identifies the current status of renewable energy technologies and different approaches taken by renewable energy technology providers to respond to California’s volatile electricity markets.
- Developing and testing of the Wind Turbine Company’s (WTC) 250 kW POC advanced wind turbine. Testing at the National Wind Test Center in Colorado has demonstrated the system’s capability to perform as required under a variety of wind speeds. As a result of this successful demonstration, the WTC is proceeding to demonstrate a 500 kW

system in a commercial setting in the Los Angeles Department of Water and Power (LADWP) service territory.

- In April 2001, PowerLight Corporation opened an 18,000-square-foot manufacturing facility devoted to the producing of building integrated photovoltaic systems (BIPV) capable of contributing 20 MW of electricity. As a result of PIER funding, PowerLight was able to establish and implement innovations that reduced the cost of manufacturing BIPV by up to 57 percent.
- Xantrex Technology (formerly Utility Power Group) and Kyocera Solar, Inc. completed developing and testing of a reduced-cost, higher reliability PV power system for residential electricity customers. Based on the results of the project, Xantrex reduced PV array installation costs by over 40 percent, decreased the power system costs by nearly half, and increased power conversion efficiencies from 90 percent to 96 percent. Presently, over 80 PV systems using the Xantrex advancements have been installed in the greater Sacramento area.

In addition to managing research activities, the PIER Renewables Team has been responsible for the following:

- Establishing and managing a \$10 million Dairy Power Production Program that will use biogas digesters to convert dairy wastes into electricity for on-site use by California dairies. The program goal is to install up to 7 MW of biogas-to-electricity generating capacity at California dairies. The program is receiving national interest, as it represents the single largest dairy biogas effort in the country.
- Working with the U.S. EPA and four state agencies (the California EPA, the

California Integrated Waste Management Board, the California Air Resources Board, and the State Water Resources Control Board) to determine the best ways to develop clean, reliable, and more affordable landfill gas-to-electricity in California. As a result of these activities, a Landfill Gas Primer was prepared and draft copies distributed at a public workshop held in Sacramento in October 2001.

2001 RD&D AWARDS

The PIER Renewables portfolio of research projects rose from \$16.6 million at the end of 2000 to over \$52 million by the end of fiscal year 2001. Major activities included in the following

- programmatic solicitation focused on using renewable resources to help make California's electricity more diverse and affordable;
- targeted solicitations that continue advances being made in wind and geothermal technology development; and
- developing updated resource assessments, evaluation tools, and consortiums that will maximize value from renewables.

Programmatic Solicitation

The bulk of the PIER Renewable funding awards made in 2001 went to "Making California's Electricity More Affordable and Diverse: PIER Renewables Programmatic Affordability Solicitation." Project activities include assessing and targeting the development of new renewable resources; increasing the affordability of existing renewable energy facilities; accelerating the development of renewable distributed generation systems in high-need areas; and using renewables to create a

customer-responsive electricity system of the future. Over \$31 million was awarded to three electricity suppliers. In June 2001, the Energy Commission approved an award of \$13,649,620 to the Sacramento Municipal Utility District (SMUD); an award of \$11,668,572 to Commonwealth Energy Corporation; and an award of \$5,854,582 to the Northern California Power Agency (NCPA) and the Public Power Renewable Energy Action Team (PPREAT).

SMUD Program. Located in the hot Central Valley, SMUD faces a difficult situation of having intense "needle peak" demand, driven primarily by high summer temperatures. In addition, SMUD has traditionally purchased about half of its electricity from outside the district, leaving it vulnerable to volatile market conditions. The current SMUD program focuses on harnessing more of its electricity from renewable resources indigenous to SMUD's service territory. Over the past several years, SMUD has demonstrated a national leadership role in photovoltaics by using a structured manufacturing and installation approach that significantly reduces PV system costs. The SMUD program builds off its successes in the photovoltaic arena by continuing advancements to PV systems targeted for the residential and commercial sectors. However, the new SMUD program expands its PV focus to include wind and biomass resources available in the SMUD territory. Nineteen projects make up the SMUD program, 14 of which concentrate on PV technologies and markets.

Commonwealth Energy

Corporation Program. The Commonwealth program focuses on developing a set of integrated renewable energy resources that will form a micro-grid capable of meeting special requirements of electricity customers in high-need areas. Commonwealth is using California's Chino Basin to demonstrate that a combination of biogas and BIPV technologies can be used to address both environmental and electricity issues.

The Chino Basin is located approximately 40 miles east of Los Angeles and straddles the west ends of San Bernardino and Riverside counties. Like most of southern California, the region encounters hot summers reflecting its abundant supply of sunshine. The Basin also faces significant environmental issues. It is located in the South Coast Air Quality Management District (SCAQMD), which represents an area of 12,000 square miles and a population of over 14 million people. Because of the dense population, high volume of vehicle traffic, and large number of businesses, air quality in the district is among the worst in the country. Although the SCAQMD has taken a number of steps to improve air quality, the district typically violates federal health standards for ozone 120 days out of the year. Groundwater quality is also a concern in the Chino Basin, with one of the highest concentrations of dairies in the world. Home to over 300 dairies, nearly 350,000 cows are located within a 50-square-mile area known as the Chino Basin Dairy Preserve. The high concentration of cows poses special water quality considerations as the dairies generate over 770,000 tons per year of animal manure that has historically been stored on agricultural lands. Runoff from improperly

stockpiled animal manure threatens to contaminate both surface and groundwater supplies.

Electricity service in the Chino Basin is presently provided by the transmission and distribution system of Southern California Edison (SCE). Transmission studies conducted by the California Independent System Operator have identified possible problems with voltage stability in the SCE region by 2005, depending on growth in the region, new generation supplies, and upgrades to current transmission lines. However, the Chino Basin is one of the fastest growing areas in the state, and new generation within the Basin will be critical to ensuring appropriate, adequate power delivery. The Commonwealth program will develop renewable resources that both resolve environmental problems in the Chino Basin and supply the area with clean and sustainable electricity supplies. Under its program, Commonwealth intends to develop a combination of advanced renewable energy systems using biogas and solar resources available in the Chino Basin.

NCPA/PPREAT Program. NCPA represents one of a coalition of California public utilities interested in developing renewable energy resources to meet their future electricity needs. This coalition of over 20 public utilities is known as the Public Power Renewable Energy Action Team (PPREAT). Under the proposed program, PPREAT intends to develop new and advanced renewable energy technology that will enable public power providers to provide thousands of megawatts of clean, renewable resource-based electricity to their customers.

PPREAT's program is a linked research and development program involving

five renewable energy resources: biogas from wastewater treatment plants, landfills, and dairies; solid biomass resources such as forestry and agricultural residues; geothermal; wind; and solar. The research program encompasses nine projects throughout the state. Through these nine projects, the PPREAT will establish a basis for future development of thousands of megawatts of renewable electricity by

- conducting analyses of untapped renewable resources and their accessibility to transmission capacity;
- modifying existing renewable electricity generating facilities located in public utility service territories to improve their technical and cost performance;
- fielding packaged renewable distributed generation options and tools to evaluate their most valuable application; and
- developing advanced renewable energy technologies that will expand public power entities' options for renewable resource acquisition.

Targeted Solicitations

In addition to the programmatic affordability solicitation, over \$5 million in renewable energy research and development awards was released using sole source and interagency agreements to continue advancements in wind and geothermal research.

Wind Turbine Company. The WTC was awarded a sole source contract of \$1.3 million to continue development of its low-cost wind turbine. The goal of PIER's work with WTC is to develop a wind turbine capable of generating electricity from California's wind resources at a cost of less than \$0.035 per kilowatt-hour without subsidies.

Based on earlier funding support provided by the PIER Program, DOE, and NREL, WTC successfully developed and tested a 250 kW prototype wind turbine at NREL's National Wind Test Center. Following the successful tests of the 250 kW unit, WTC entered negotiations with the LADWP to test a 500 kW WTC turbine within LADWP's territory. Fairmont Reservoir was selected as the test site and preliminary agreements reached between LADWP and WTC. The \$1.3 million PIER contract with WTC will support testing of the 500 kW system at the Fairmont site. The project represents a necessary and important step in operating a larger-scale WTC wind turbine in a commercial setting representative of California's wind resources.

Geothermal Targeted Solicitation.

The Energy Commission released a Geothermal Targeted Solicitation in January 2000 providing up to \$4.7 million for geothermal-related projects in California. The goals of the targeted solicitation were to help lower the risks and associated costs of developing new geothermal resources in California and to help reduce the cost and impacts associated with producing geothermal power. The solicitation represented the combined efforts of the PIER Renewables area and the Geothermal Resource Development Account (GRDA) Program. Approximately \$2.7 million of the funds came from the GRDA Program and approximately \$2 million from PIER. Three awards were made on the PIER Renewables portion of the solicitation: Mammoth Pacific, Lawrence Livermore National Laboratory; and Stanford University.

Mammoth Pacific Project:

Geothermal Power Plants with Reclaimed Water. The Mammoth Pacific Geothermal Power Plants are three binary power plants utilizing a working fluid (isobutane) that is heated by geothermal hot water into a high-energy vapor that is then used to turn turbine generator sets. The isobutane is condensed after leaving the turbines by air cooling instead of water cooling. An air-cooled plant produces less power during the warm, dry, summer months than does a water-cooled plant. The power plants have a nameplate rating of approximately 32 MW. Summer on-peak output can be half of the typical winter output. The Mammoth Pacific project will increase power production by 10 megawatts or more during summer months by using reclaimed water from the Mono County Water District (MCWD) for evaporative cooling. As a value-added component, the Mammoth Pacific project will send the heated, reclaimed water back to MCWD for direct use applications.

Lawrence Livermore National Laboratory Project: Co-Production of Silica and Metals from Geothermal Fluids.

The purpose of the LLNL project is to develop methods for cost-effectively extracting silica, lithium and arsenic from geothermal fluids. Silica extraction will be carried out by varying the temperature and pH of the fluid, thereby inducing precipitation of a silica by-product suitable for specific market uses. Lithium and arsenic will be extracted using a new porous silicon nanofilter. If successful, the LLNL project will improve the economics of geothermal

energy production by providing an additional income stream from the sale of mineral by-products. In addition, eliminating silica scaling will allow additional energy and heat to be generated from geothermal brines. Finally, the project will also reduce the environmental impacts associated with geothermal energy production by making it possible to efficiently remove toxic metals from spent geothermal fluids.

Stanford University Project: Improving Energy Recovery at the Geysers Geothermal Field by Delineation of In-Situ Saturation.

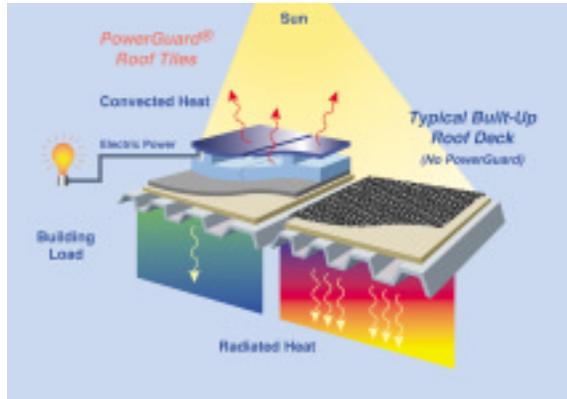
The Geysers geothermal field is the largest in the world and represents an important element of California's electrical power generation capacity. The Geysers is also California's (and the nation's) largest source of renewable energy. Over the past 10 years, energy production from the field had been falling as the reservoir "matures." However, wastewater injection into the Geysers has indicated that it may be possible to slow, if not reverse, the decline in energy production. It is currently not possible to determine the energy production level that will be achieved at the Geysers due to uncertainties in determining the distribution and flow characteristics of the underground geothermal fluids. Similarly, these uncertainties also limit developing an optimal strategy for increased injection of wastewater. The Stanford University project will help determine the in-place fluid saturation at the Geysers by: (1) making laboratory measurements of saturation on rock cores from the Geysers reservoir;

(2) collecting historical field data to infer saturation from model matching; and (3) applying theory and models to estimate saturation from output characteristics. If successful, the project will allow more effective recovery of geothermal energy at the Geysers, while establishing the best strategy to prolong its life for the benefit of Californians.

Resource Assessments, Evaluation Tools, and Consortiums.

California is placing increasing emphasis on renewable resources to help meet the state's electricity needs. However, the appropriate use of renewables requires a good understanding of the state's renewable resource base. Renewable resource assessments were conducted statewide in the 1980s. Much of the resource information is outdated and lacks the detail needed to assess whether sufficient renewable resources exist to help meet electricity needs in problem areas. Similarly, specialized evaluation tools are needed to assess electricity needs at the distribution level, to match the identified needs to supplies of renewable resources, and to evaluate the ability of renewable energy technologies to meet the needed technical and economic performances. Finally, forums are needed to discuss strategies for using renewable energy technologies to meet electricity system needs and to develop partnerships between government and key players to ensure successful market deployment of new and advanced renewable technologies. PIER Renewables made awards in the following areas to help address these needs:

- development of a California wind energy atlas;



- establishment of a renewables strategic value analysis that will combine power flow modeling of the state's electricity system with an already established Geographical Information System and allow comparison of renewable energy options to conventional generation and T&D upgrade approaches; and
- initiation of a California wind energy consortium.

SUCCESS STORIES

California's New Cool: PowerLight's PowerGuard PV System. With the threat of power shortages and higher electricity bills, California's electricity customers are showing increased interest in turning sun-drenched rooftops into a way to cool down the electricity crisis. Rooftops equipped with solar power systems can provide customers the option of generating their own electricity and controlling their electricity bills. Solar power technology is based on PVs that convert sunlight into electricity using semiconductors built into the PV systems. Initially developed in the early 1970s to help power United States spacecraft, the same technology has been used to power solar calculators, watches, freeway call boxes, and now homes and businesses. However,

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*An elegant roofing solution to today's electricity problem, **PowerGuard** is a PV roofing system with patented lightweight modules that insulate the building, thereby reducing heating and air conditioning cost while providing an extended (30 year) roof.*

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PowerGuard advanced commercial rooftop PV installation on PowerLight Corporation's manufacturing facility. Courtesy of PowerLight Corporation.

today's solar power systems are far more efficient and less costly than systems of the 1970s. Because of technology and system research, PV systems today have efficiencies five times greater than the earliest systems while their costs are nearly 20 times lower. In the next step forward, the PowerLight Corporation, a world-leading developer of building integrated PV systems, has discovered an elegant roofing solution to today's electricity problems. The "PowerGuard" is a PV roofing system with patented lightweight modules that insulate a building, thereby reducing heating and air conditioning costs while providing an extended (30-year) roof. In addition, the PowerGuard system generates electricity that offsets peak prices and helps insulate customers from a volatile market.

The partnership between PowerLight and the Energy Commission goes back to the mid-1990s. PowerLight, then a small company called Temenos, applied for research funds to develop a new PV rooftop system. An Energy Commission award in 1994 resulted in the development of the PowerGuard system. Based on inventive changes, PowerLight managed to reduce the manufacturing cost of PowerGuard by over 57 percent. In April 2000, PowerLight opened an 18,000-square-foot manufacturing facility capable of producing up to 20 MW of lower-cost PowerGuard systems per year.

The Energy Commission's involvement in PowerLight has helped grow a PV company capable of bringing solutions to California's electricity system. Based on the success of its PV products, PowerLight has been recognized as one of the top 200 fastest growing privately held companies in the country. From a

one-person firm with annual receipts of \$40,000, PowerLight has grown to a company of over 70 employees and receipts of over \$10 million per year.

Harnessing California's Wind Resources: The Wind Turbine Company's Low-Cost Wind Turbine.

Considered the pioneer of wind energy development in the United States, California is home to over 11,000 wind turbines. In 2000, wind energy represented close to 1,500 MW of the state's generating capacity and supplied over 3 billion kWh of electricity to California consumers. However, existing wind energy systems may be capturing less than 25 percent of the wind energy available in the state. Wind resource assessments indicate that much of the untapped wind resources are lower speed and thus too costly to harness using existing technologies. An innovative approach by the WTC may change that situation. Based out of Bellevue, Washington, the WTC is a small company of wind energy professionals and engineers with industry and technical experience spanning the wind power, turbine generator, and aerospace (helicopter) industries since the early 1970s. Almost all wind turbines used in California are three-bladed European varieties with a robust design approach. While this approach ensures high reliability, it also results in higher capital costs. The WTC's approach involves a two-bladed turbine with lower weight (so lower capital costs) and improved performance. The goal of the WTC project is to develop a wind turbine that produces electricity at market competitive rates in moderate- to low-wind speeds. Achieving that goal opens the way to harnessing California's 5000

megawatts of moderate- to low-wind speed energy resources.

Under a special partnership with NREL, the PIER Renewables Program and WTC, a 250 kW WTC proof-of-concept turbine was successfully tested at the National Wind Test Center in Colorado. Tested under a variety of wind speeds, the test results verify WTC's design approach—an approach that may provide wind energy at less than 3.5 cents per kilowatt-hour in the near term and as low as 2.5 cents per kilowatt-hour. A 500 kW WTC turbine is now being deployed for demonstration in a commercial setting in Fairmont, California.

A higher risk effort, PIER funding is playing a critical role in bringing this new class of technology to market.

OUTLOOK

Much of the 2002 work planned in the PIER Renewables area is to build from the foundation established by the 2001 efforts. Targeted solicitations will be held that focus on specific advances in wind, photovoltaics, and small hydroelectric. Particular emphasis will be placed on expanding applications of renewables to provide high value to the state's electricity customers. In addition, renewable resource and technology assessments will be conducted to ensure up-to-date and accurate information on California's renewable resources is available. Updated resource and technology performance information will be provided to the California Power Authority and the Independent System Operator to help in their decision-making activities. Consortium efforts started in 2001 will be expanded across all renewable energy areas in 2002. In addition, a

consortium will be developed that focuses on utilities actively pursuing renewable energy resources to help meet future electricity needs. PIER Renewables will be better able to target renewable energy research to market needs by participating in these consortia.

ENVIRONMENTALLY-PREFERRED ADVANCED GENERATION

2001 PROGRESS UPDATE

The PIER Environmentally-Preferred Advanced Generation (EPAG) Team is furthering the development of clean and efficient distributed generation technologies. At the end of 2001, the PIER EPAG Team was managing 20 projects and had completed six since 1997.

In 2001 the PIER EPAG Team released two RFPs. The first one targeted fuel cells, microturbine and small turbine generators, hybrid systems that include a fuel cell or a turbine and associated technologies. The RFP set forth technology performance targets and stretch goals that were established in consultation with the energy RD&D community and with those of related federal programs. Subsequently, the RD&D Committee approved nine proposals for funding awards. The Energy Commission approved funding for five contracts in 2001; funding approval for the remaining four will be sought in 2002.

The second RFP targets efficiency improvements and atmospheric emission reductions from reciprocating engines. The installed capacity of reciprocating engines in California may be as high as 8,000 MW, used primarily for standby power. Operational hours are limited because of high nitrogen oxide (NOx) emissions. The Advanced

Reciprocating Internal Combustion Engine (ARICE) RFP was released on December 7, 2001. The performance targets for the RFP were formulated in collaboration with local, state, and federal government agencies, engine manufacturers, fuel suppliers, utilities, universities, national laboratories, and environmental groups.

The EPAG Team is also co-funding projects at EPRI and GTI. The projects provide deliverables that are useful to and consistent with EPAG goals, program plans, and existing projects. They provide information that is of common interest throughout the nation, and they reduce duplication of effort.

In addition, the EPAG Team is facilitating the installation of distributed generation technologies through technical support to several state agencies and is providing technical expertise and assistance to several government entities that will demonstrate and install fuel cells. These entities include the California Environmental Protection Agency (Cal EPA), the California Air Resources Board (CARB), and the South Coast Air Quality Management District (SCAQMD).

2001 RD&D AWARDS

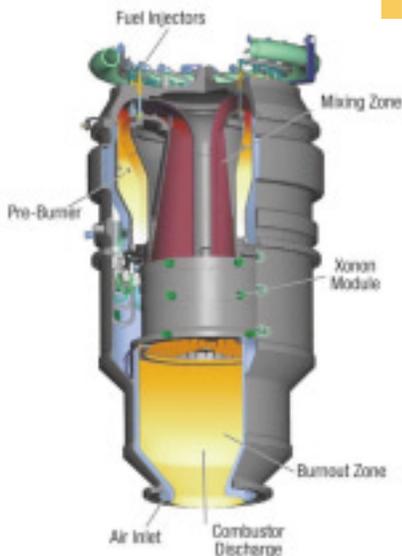
Five contracts were approved following a solicitation for RD&D proposals concerning fuel cells, microturbines, and small turbines. These contracts have the following goals:

- Improve microturbine efficiency by 25 percent. The contractor has a new turbine design that employs a semi-closed cycle. The cycle uses exhaust gas for turbine blade cooling and a new combustion technology that increases efficiency and reduces NOx.

- Reduce NOx emissions in a 13.5 MW gas turbine from 25 parts per million (ppm) to 3 ppm by means of surface stabilized combustion. The contractor will apply atmospheric pressure technology to higher pressure operation at 16.8 atmospheres.
- Advance solid oxide fuel cell and stack technology for high performance (50 percent stack efficiency and 450 MW/cm² stack power density) at reduced temperature, develop materials for the direct oxidation of natural gas at the fuel cell anode, and demonstrate these advances in a 10 kW system.
- Demonstrate high (55 percent) efficiency in a solid oxide fuel cell system. The contractor will optimize stack design for improved radiant heat transfer, even temperature and gas flow distribution, low air-to-fuel ratio, and low pressure drop.
- Demonstrate a high-efficiency, zero-emission, gas-fired, 500 kW power plant using steam and carbon dioxide to drive a steam turbine. The carbon dioxide is separated out for sequestration or commercial sale.

Interagency agreements were signed for microturbine generator-related RD&D. These contracts have the following goals:

- Develop the capability to produce and deliver medium- and low-heat content gas mixtures to microturbines to test their operation on simulated biomass gases; demonstrate the ability of microturbines to utilize these gases while maintaining low NOx and carbon monoxide (CO) emissions.
- Develop a microturbine combustor that produces low NOx and CO emissions over a 50 to 100 percent operating range; determine the cost effectiveness.



A promising technology funded in part through the PIER Program is **Catalytica's Xonon Cool Combustion** system. This revolutionary product can essentially prevent nitrogen oxides from forming in gas turbines as an air pollution prevention measure. The goal is to eliminate the formation of nitrogen oxides (NOx), a primary contributor to smog, while also reducing emissions from other pollutants. Xonon prevents NOx emissions by keeping the temperature of flame and combustion below the level that would form NOx.

Xonon Cool Combustion system.
Courtesy of Catalytica Energy Systems, Inc.

- Improve understanding of combustion and emissions formation in a rich-burn/quench-mix/lean-burn (RQL) combustor. This understanding may lead to improved design of RQL combustors.

The EPAG Team is assisting the California Power Authority in determining the potential of gas turbine inlet air cooling to improve the peak power capabilities of simple-cycle and combined-cycle power plants on the hottest days. On hot days electricity demand is highest but generation capability is diminished because of the lower density of combustion air.

SUCCESS STORIES

Demonstration of Fuel Cell/Gas Turbine Hybrid Systems. The EPAG Team co-funded a solid oxide fuel cell/microturbine generator hybrid POC demonstration. Even though the hybrid component integration was not optimized, the system achieved a fuel-to-electricity efficiency of 52.1 percent, the highest ever achieved in a small (200 kW) system. The EPAG Team will coordinate with DOE on developing ultra-high efficiency distributed generation systems.

Ultra-low Emissions Combustion System for Power Plants. The Xonon Cool Combustion system developed by Catalytica Energy Systems can prevent nitrogen oxides from forming in gas turbines as an air pollution prevention measure. The goal of the project was to virtually eliminate the formation of NOx, a primary contributor to smog, while also reducing other pollutants. This breakthrough technology has been successfully demonstrated on a Kawasaki gas turbine engine, and is ready to enter the California market just when it is most urgently needed.

OUTLOOK

In 2002 the PIER EPAG Team will continue contract management activities, proposal evaluation and contract funding, collaborative activities, and technical support for fuel cell demonstrations. Specific activities are summarized below.

Funding of Advanced Reciprocating Internal Combustion Engine Projects. The ability of existing reciprocating engines to operate in California is limited by their high emissions. The purpose of the ARICE

RFP is to fund projects that meet or exceed California-specific emission requirements, improve fuel-to-electricity conversion efficiency, and lower or maintain current capital and maintenance costs. The desired result will be rapid introduction of clean, distributed generation from a mature technology and manufacturing base. Reciprocating engine improvement is part of the EPAG plan to solve both short-term generating capacity problems and longer-term air quality improvements.

Development of Combined Heat and Power Capabilities. Combined heat and power (CHP), also called cogeneration, is the beneficial use of both the electricity and waste heat from a generating system. Thermodynamic considerations put highest priority on achieving high electrical generation efficiency. The use of waste heat for water, space, or industrial process heating, or for cooling by means of absorption chilling, improves the value of the generating system, reduces emissions, and lowers costs to the system owner. The PIER EPAG team will release an RFP to enhance the

value of EPAG technologies through developing cost-effective CHP designs and systems. This RFP will be coordinated with efforts of the DOE.

ENERGY-RELATED ENVIRONMENTAL RESEARCH

2001 PROGRESS UPDATE

PIER Environmental Area (PIEREA) staff are in the final stages of completing research roadmaps addressing several high-priority environmental issues associated with the distribution, generation, and transmission of electricity. These issues are identified within the four major subject areas of energy-related environmental research: aquatic resources; land use and habitat; air quality, and global climate change. These roadmaps investigate the status and quality of research that has been conducted on each priority issue, identify research gaps, identify possible co-sponsors, and define major goals for resolving the issues. Developing these roadmaps involves intensive stakeholder discussions with major objectives of leveraging limited research funds and facilitating coordination within the research community. These roadmaps will be completed in 2002.

In addition to completing these roadmaps, PIEREA has initiated several projects designed to mitigate environmental impacts of the electricity system. For example, *Spray Enhancement of Dry Cooling* is a project investigating the potential for improving the performance of dry cooling—specifically investigating how introducing a small amount of water spray into the inlet air stream to a dry cooling tower can reduce inlet air temperatures, thereby increasing

electricity generation efficiency. This provides power plant owners with an alternative to traditional wet cooling—a technology that requires large amounts of potable water. At a test facility in northern California, spray enhancement is projected to increase generation by 7–15 MW on hot days. Spray enhancement improves overall efficiency without the high water demands of wet cooling. The millions of gallons of water saved can be utilized by other sectors, such as residential, commercial, and agriculture. Under this project, a prototype was successfully tested, and a full-scale demonstration is anticipated later this year.

PIEREA is also funding projects to reduce avian mortality associated with utility structure interaction. Each year, these interactions kill thousands of protected raptors, causing power outages and estimated economic losses on the order of \$2 billion. PIEREA is developing ways to identify problem areas and help direct retrofitting and mitigation efforts to address these financial, reliability, and environmental issues. Under one project, researchers are designing and testing automated monitors to identify high-fatality areas; the 2001 deliverable, a design specification for a bird strike indicator (BSI), will be available in early 2002. This project is ending its first full year of funding and is expected to continue next year.

2001 RD&D AWARDS

Ultra-fine Particulate Study with Gas Technology Institute. The goal of the PIEREA/GTI collaboration is to develop an accurate particulate matter reference test method or enhance

existing methods for measuring particulate emissions (fine, ultra-fine, and PM₁₀) from combustion sources. This project is also developing realistic mass emissions rates and ultra-fine emissions counts and emissions profiles to provide a basis for developing sound emissions inventories, future regulations, and permit enforcement by local air districts.

Climate Action Registry with Lawrence Berkeley National Laboratory.

In support of a voluntary emissions registry designed to promote early reductions, PIEREA and LBNL are working together to accomplish two goals: to develop methods for measuring emissions rates, and to develop a way to allocate emissions from the production of electricity to consumers. These methods and rules are critical to establishing an early action emissions registry in California. The project will first develop the methods and allocation rules, and then examine their effectiveness through case studies of four California companies.

Mercury, Metals and Organics in Aquatic Environment. The purpose of this project is to improve the scientific basis for California water quality criteria—the basis for standard treatment practices used in power plants. Under this project, multiple studies are being conducted to characterize the impacts of toxic chemicals in California's aquatic environments. Findings can be applied directly to meet specific technical challenges. They are also useful to the regulatory and scientific communities, helping to increase their understanding of critical issues such as water quality, habitat preservation, and public health.

Fish Protection Issues of the Clean Water Act Sections 316(a) and (b) with Electric Power Research

Institute. The purpose of this project is to support cost-effective fish protection and facility operational decision-making. This project provides methods for studying fish mortality and generating results for fish population predictions that will be used to address biological impacts associated with power plants and industrial facilities.

TMDL, Watershed, and Ecosystem Issues with Electric Power

Research Institute. This program delivers scientific information to support the development of strategies for integrated watershed management and ecosystem protection. This information will enable interested parties to assess cumulative impacts on a facility-specific and watershed-wide basis, and to analyze the costs and benefits of management alternatives; such as, examining various erosion control measures to find the optimum strategy to protect water quality.

Facilities Water Management with Electric Power Research Institute.

The purpose of this project is to develop and implement strategies for treating wastewater discharge while minimizing its impact on the environment. This effort will attempt to improve plant performance and reduce a power plant's demand for freshwater.

Rights-of-Way Environmental Issues in Siting, Development and Management with Electric Power Research Institute: Avian

Interactions with Utility Structures. This project's tools and information support new approaches for reducing

negative interactions among birds and transmission and distribution structures, wind turbines, and communication towers. Each year, these interactions kill thousands of protected raptors, such as the federal and state listed golden eagle, and cause significant economic losses from resulting power outages. This project develops and evaluates monitoring approaches to bird deterrents helping direct retrofitting and enhance mitigation.

Environmental Issues Management with Electric Power Research

Institute: Hydropower Relicensing Environmental Issues. This project provides practical information for environmental analysis and operational decision-making in support of Federal Energy Regulatory Commission (FERC) relicensing and environmental management at non-FERC-licensed hydropower projects. This project helps hydropower operators effectively balance environmental protection and water resource demands with power generation by offering solutions to critical hydro issues such as fish mortality, water quality protection, flood protection, and water resource allocation.

PIER Environmental Technical Assistance with UC Regents –

Office of the President. The purpose of this agreement is to continue University of California (UC) technical assistance to support the administration of the PIER Program in the Environmental Area. The UC shall provide the services of faculty, staff, students, and subcontractors to assist PIEREA in program planning and program administration.

Methodology to Assess Air Quality Impacts of Distributed and Backup

Generation with University of California, Riverside (UCR). Backup generators (BUGs) can deliver electricity quickly, which makes them ideal energy sources during short-term power outages; however, emissions from much of this equipment can cause air quality problems. In this project, PIEREA and UCR are developing a methodology to assess and quantify the air quality impacts of BUGs, estimate the air quality impacts of recent rolling blackouts, and identify particulate matter reductions from the use of emissions controls.

Air Quality Impacts of Distributed Generation with University of

California, Irvine. The use of distributed generation (DG) in California could have significant benefits in overall electricity reliability, cost, power quality, and possibly overall emissions reduction. However, a shift from central power to DG would result in significantly different emissions profiles. In this project, researchers will develop a range of possible DG implementation scenarios in Southern California, model the potential regional air quality impact based on those scenarios, and compare the impacts of DG implementation to the impact from central power.

Developing Techniques to Reduce Bird Fatalities in the Altamont Pass Wind Resource Area with

BioResource Consultants. The purposes of this project are to complete fieldwork and develop a tool for wind industry regulators to use to mitigate and reduce bird fatalities at the

Altamont Wind Resource Area. If impacts are sufficiently mitigated, Altamont could increase electricity generation above its current capacity of 583 MW.

SUCCESS STORIES

Spray Enhancement of Dry

Cooling. Dry cooling technologies significantly reduce a power plant's water demand. On average, a 500 MW combined-cycled power plant employing wet cooling technology requires three million gallons of water per day for cooling. The same size plant utilizing dry cooling would reduce water use by approximately 95 percent—a savings of 2.85 million gallons per day. This water saving could satisfy the annual water demands of more than 12,000 people—nearly enough to supply the needs of a city the size of Auburn, California. However, a significant drawback of dry cooling is the inability of facilities using this technology to maintain normal electricity output during the hottest periods of the year. In California, these days of extreme heat occur at the same time that the state's electricity demand is the highest, which can affect electrical system reliability.

A preferred solution is to introduce a small amount of water spray into the inlet air stream to the cooling tower, where it evaporates and cools the air. Studies have shown that reducing inlet air temperature, even by a few degrees, can restore much of the lost capacity. Under this project, the PIEREA and EPRI evaluated the performance, costs, and potential problems associated with using the spray enhancement of dry cooling at an existing dry-cooled power plant, the Crockett Cogeneration Facility—a 240 MW power plant in



Spray Enhancement at Crockett Cogeneration Plant. Courtesy of John Maulbetsch.

Crockett, California. On a hot day, this cooling technique enabled the Crockett plant to operate more effectively, adding an extra 7-15 MW of electricity to the grid. This spray enhancement technique not only drastically decreases power plant water consumption requirements and adds electricity to the grid, but it also has a low initial cost and can be used to retrofit existing units.

Water shortfalls are predicted to reach 2.4 million acre-feet in 2020. Spray enhancement allows for successfully using dry cooling, making valuable water available for other higher uses in the agricultural, commercial, and residential sectors.

Global Climate Change –

Vegetation Maps. California is the largest agriculture producer in the nation. Agricultural production and income yields approximately \$25 billion per year and accounts for nearly one in ten jobs. Production efforts not only help feed our nation, but also much of the world. Because of the abundance of rich agricultural land and a far ranging variety of habitats and ecosystems the Golden State is capable of producing a high volume and variety of fruits and vegetables.

“ *Dry Cooling Spray Enhancement preserves valuable energy resources by meeting California's need for electricity while protecting the environment and conserving precious water supplies.* ”

ARTHUR H. ROSENFELD,
Commissioner

Climate change will likely change average temperatures, rainfall amounts, and location and, therefore, affect the nature and amount of agricultural production. In addition, climate change is predicted to generate harsher weather particular conditions, which will dictate where ecosystems will exist and the level of biodiversity they may shelter. According to hydrological modeling, climate change will increase wintertime stream flow and decrease summertime stream flow, meaning wetter and drier seasons than the agriculture industry is accustomed to.

The PIEREA and EPRI have advanced the analysis of climate change impacts

on vegetation by developing and applying a dynamic vegetation model in California. The modeling uses the highest level of geographic disaggregation ever applied in California, at a 100-square-kilometer (km²) resolution. This study observes the potential changes in location and productivity of terrestrial vegetation. This modeling effort includes a higher number of vegetation types than any previous modeling effort, and is being combined with projections of future land use to explore the collective effect of climate change on ecosystems and biodiversity. The preliminary modeling results show that climate change has the potential to significantly alter the distribution of vegetation in California. If the expected changes in climate are accompanied by reductions in precipitation, the desert areas in the state will expand considerably with a corresponding loss in agriculture land.

While these model simulations should not be taken as exact predictions of the future, the results indicating that all the natural ecosystems in California, whether managed or unmanaged, are likely to be affected by climate change. Changes in temperature and precipitation will alter the structure, composition, and productivity of vegetation communities. Improving our understanding of the relationship between global climate change and vegetation distribution will help us adopt coping and adaptation strategies to help maintain economic output levels and prepare for a changing climate and associated impacts.

OUTLOOK

In defining research priorities, the PIEREA Team assessed how the

generation, transmission, distribution, and use of electricity in the state were affected by market, technological, demographic, and regulatory drivers and trends—a process that resulted in a long list of potential environmental issues. As a result of this analysis, several high-priority environmental issues were selected for targeting future research funding. The following is a discussion of major identified issues and research initiatives planned for the upcoming fiscal year:

Aquatic Resources:

- **Power Plant Impacts on Aquatic Resources.** Power plants that use water for power production or cooling may impact aquatic species through: 1) the impingement (trapping) of aquatic organisms on intake screens; 2) entrainment (passing) of aquatic organisms through cooling systems and turbines; 3) blockage of fish movement and migration; 4) fragmentation of aquatic ecosystems; and 5) alterations in normal stream flows, currents and water temperatures.
- **Water Conserving Power Plant Cooling Technology.** Wet cooling is the conventional technology used in California. A conventional combined-cycle power plant using wet cooling will require about 3 million gallons of water per day. Given the increasing demand on the state's freshwater supplies for domestic use, the development of alternative sources of cooling water supplies or water conserving cooling technologies can minimize impacts on water supplies from electricity generation.

The focus of near-term research addressing impacts to aquatic resources includes evaluation of new

screen technology for small hydro facilities, research on biological impacts of variable flows from hydropower discharges, and enhancement of existing methodologies to assess flows necessary to maintain fisheries and other aquatic resources.

As discussed previously, a prototype hybrid spray enhancement system was successfully tested to reduce water use for power plant cooling. The next phase of research is a full-scale demonstration of dry cooling with spray enhancement. The study will further evaluate design and performance issues inherent in a large-scale application, as well as evaluate different methods for spray production and methods to minimize water loss on heat exchange surfaces. This demonstration should be initiated during 2002. In addition, it is anticipated that a feasibility study using degraded (non-fresh) water supplies for power plant cooling will be conducted.

Land Use and Habitat:

- **Impacts of Power Line Corridors on Environmental Quality in California.** Power lines are thought to have a variety of both negative and positive consequences to environmental quality, particularly with respect to the maintenance of natural biotic diversity.
- **Avian Collision with Power Lines:** Avian fatalities can occur from collisions with transmission line conductors. The data on strike fatalities and studies documenting mortality are lacking in California. Given that there are approximately 40,000 miles of transmission lines in California, (about 6,320 miles in the Central Valley alone, including about 952 miles that transect National Wildlife Refuges, State Wildlife Areas,

and other publicly owned natural resource conservation lands), fatality estimates of avian fatalities are in the several hundred thousands.

- **Avian Electrocution with Distribution Towers.** Avian fatalities can occur from electrocutions with poles used for distribution lines. This impact can also cause costly power outages—about 25 percent of all outages are wildlife- and avian-related. Power outages caused by these interactions result in economic losses approaching \$2 billion each year.
- **Avian Collision with Wind Turbines.** Avian and bat fatalities can occur from collisions with wind turbines and supporting guy wires. Over 1,000 fatalities per year have been recorded at wind farms located in high bird use areas. As a result, new wind farm development proposals have been significantly delayed or denied—resulting in a loss of over 500 MW.

The effects of power line corridors on environmental quality are not well understood. As a means of protecting habitat, it is important to develop information on how to minimize the impacts of power line corridors on the integrity of natural ecosystems and the diversity of the natural biota while providing sound, safe, reliable, and affordable energy services. An example of planned near-term research is to determine the extent of exotic species invasion in transmission line right-of-ways.

To gain a better understanding of the extent and impact of avian collisions, standardized survey protocols incorporating necessary bias factors need to be developed. Surveys should concentrate on areas of high potential

collision risk determined from habitat and high bird use areas. Anticipated research projects include developing automated monitors to facilitate cost-effective determination of high strike/fatality areas. In a second phase of research, funding for devices designed to make conductors more visible and prevent collision will be developed and tested in high strike areas. The data on the statewide significance of electrocution are lacking, but recent studies indicate electrocution-caused fatalities are much higher than initially thought. Information is needed to determine problematic pole designs to help utilities determine a cost-effective retrofitting plan.

The current trend in wind development is to replace smaller, less efficient turbines with larger, more efficient turbines at a ratio of about 7–10:1. The effect of this replacement or “re-powering” effort on birds is not known and, therefore, a concern. Research was recently initiated to develop an avian risk assessment model that will predict low- to high-risk collision potential at various locations within a wind farm. This model can be used to site the newer turbines in low-risk locations.

Outdoor Air Quality:

- **Impacts of Distributed Generation.** The application of DG technologies to the California market could bring about important benefits in overall electricity reliability, cost, and power quality. However, moving from central generation units to localized distributed generation facilities would result in significantly different emissions profiles. Adequate methods, tools, and data are lacking to estimate impacts of DG technologies on air quality.

- **Environmental Justice.** New power plants may increase local emission impacts, and may unfairly burden disadvantaged local communities. This issue is needed to provide accurate information for policy decisions involving power plant siting.
- **Quantify the Air Quality Impacts of Energy-Efficiency Measures.** Adequate methods, tools, and data are lacking to use for preparing air quality management plan baselines and offsets or emission reduction units.

Because generating facilities may be sited near population centers, they can have a significant effect in the communities—particularly those located in the communities where emissions from other industrial facilities mix to create a disproportionately high level of pollution. A field monitoring study in concert with the CARB will begin this year to develop a database of meteorological, emissions, and ambient air quality data to facilitate evaluation of models for short-range dispersion and recommended improvements. In a related project, the Energy Commission, CARB, and New York State Energy Research and Development Authority (NYSERDA) are funding the development of low-cost portable monitors that will make localized ambient air monitoring feasible.

Current emissions measurement methods for source testing and continuous monitoring are inadequate for assessment and enforcement purposes due to reduced emissions concentrations from new combustion sources, especially new gas-turbine power plants. To support validation of the particulate matter reference test

method developed under the ultra-fine particulate study, particulate matter emissions measurements will be made on two to three gas-turbine power plants. Additionally, the Energy Commission will continue to develop methods to measure current and future emission levels including ammonia, CO and volatile organic compounds from combustion sources, especially gas-turbines.

The use of BUGs has been considered as a short-term solution in times of power shortages. However, existing diesel BUGs have almost no modern emission controls and can be the source of significant amounts of particulate matter and NOx. BUGs will be tested this year to measure emissions of criteria and toxic pollutants and to identify emissions reductions realized by adding particulate matter control technology.

Global Climate Change:

- **Application of Global Circulation Modeling to a Regional Level.**

Adequate methods and tools are needed to translate global circulation modeling results to California's regional climates, so that researchers can analyze the impacts of global climate change on California and the electricity system in particular.

- **Estimation of Economic Impacts from Greenhouse Gas Emissions Reduction Efforts.**

Economic modeling and tools are not adequate to estimate economic impacts from efforts designed to reduce greenhouse gas emissions.

- **Address Impacts of Climate Change on Resources and Economy.**

The tools and data sets need to be improved to estimate potential impacts of climate change on California's natural resources and economy.

One of the projects that may be funded in the near future is a quantification of carbon management opportunities on California lands. This project will be coordinated and leveraged with the California Department of Forestry and Fire Protection, the California Department of Food and Agriculture, and other private agencies. Carbon sequestration projects in California may provide substantial benefits such as a reduced threat of fire damage, reduced water pollution and air pollutants, and increased ecological value of the land. Other potential projects include the testing of forecasting tools for the management of water levels in dams, including the optimization of power production under increasing weather variability—an expected outcome of climate change. This work may be sponsored by the National Atmospheric Administration (NAA), NASA, and other state agencies.

Recent climate change impact analyses for California have been hampered by the lack of detailed forecasted climatic data. The lack of statistical predictions of future climates also may preclude the development of robust adaptation strategies. For this reason, the PIEREA is investigating the best strategy for collaborating with other institutions to systematically test of regional models and tools for California. This work will not only benefit work on climate change but will also benefit other activities that rely on medium- and long-term weather predictions. Finally, near-term work will assess new methods designed to estimate emissions of non-carbon dioxide (CO₂) greenhouse gases and start a long-term research program on economic issues as they relate to climate change. The objective of this work is to examine, for example, the co-

benefits of tackling air quality and climate change concerns in an integrated fashion.

ENERGY SYSTEMS INTEGRATION

The Energy Systems Integration program area (formerly Strategic Energy Research Program) conducts crosscutting research critical to the improvement of California's electricity infrastructure. The research focus is on integration of distributed energy resource systems, the customer's response to electricity prices, the improving of efficiency and reliability of the transmission system, and the development of enabling technologies.

2001 PROGRESS UPDATE

Distributed Energy Resources

Integration – *Strategic Distributed Energy Resources Research Assessment Final Report*. The Energy Systems Integration (ESI) program's near-term research efforts are focusing on integrating distributed energy resources into the distribution system. To understand the needed research, the ESI staff assessed the status of research in the following topics:

- Interconnection
- Grid effects
- Market integration

A combination of solicitations and sole-source contracts will be used to address identified research needs in the three topic areas. Research on distributed energy resources will catalyze efforts toward commercialization of distributed energy resources into California's power supply.

Demand Response to Electricity Prices and System Contingencies.

The ESI program has conducted a series of "scoping" studies to determine

current technology baseline and outline research opportunities. The ESI is preparing to launch a new, targeted program creating tools for demand response to both prices and system contingencies.

The **FOCUS I** project is designed to streamline the complicated process involved with interconnection, standardization, certification, and permits needed for the installation of distributed energy resources.



Residential installation streamlining the complicated distributed generation interconnection process. Courtesy of Reflective Energies and Astro Power, Inc.



Improved Efficiency and Reliability of the Transmission System. The transmission research will focus on utilizing and increasing reliability of the existing transmission system in the near term and developing a new generation of automatic control systems in the longer term.

2001 RD&D AWARDS

Intelligent Software Agents for Control and Scheduling of Distributing Generation. In May 2001, the Energy Commission awarded a \$499,970 follow-on contract to Alternative Energy Systems Consulting Inc. to test and prove the concept of using intelligent software agents for control and scheduling of distributed generation assets at multiple sites within California.

Technical Support for Distributed Generation Interconnection Standards. In May 2001, the Energy Commission awarded a \$1,364,787 follow-on contract to Reflective Energies to provide a program of monitoring, data collection and analysis, and reporting for selected distributed energy resource systems. The purpose of this contract is to streamline interconnections of distributed energy resources to the utility distribution system and reduce the associated costs of doing so. Distributed energy resource systems are a key element in the future of California's energy supply.

Real-time Ratings for Transmission Conductors. In February 2001, the Energy Commission awarded a \$367,136 sole-source contract to the Valley Group for continuing research begun under an earlier PIER contract. The research will demonstrate the feasibility of implementing real-time

transmission line ratings for Path 15, one of the most complex gates in the California transmission system. Initial results indicate that the real-time ratings for Path 15 are at times providing for significant increases in power transfer capability when compared to the static line ratings currently employed by the utilities and California Independent System Operator (CAISO).

SUCCESS STORIES

Volt Amps Reactive Management Tool Demonstrated at CAISO. This intergovernmental agreement with the LBNL addresses the transition of California's electricity supply and delivery infrastructures from vertically integrated, regulated, and government-controlled to desegregated, competitive, market-driven institutions.

A new tool, the Consortium for Electric Reliability Technology Solutions–Volt Amps Reactive (CERTS VAR) management adequacy tool, was recently demonstrated at the CAISO. This product provides system operators with immediate access to critical information on wide-area system voltages, and more importantly, to reactive reserve margins at critical grid locations through the use of sensitivity calculations and visual geographically-oriented displays. Maintaining adequate voltages and reactive reserves, which vary according to local conditions, is essential for maintaining system reliability during and immediately after a significant disturbance on the grid. Prior to this tool, system operators received this information in the form of tabular displays or from single line diagrams that suppress the geographic relationship among voltages at various points within the system. Tools such as these could have been instrumental in

alerting operators of dangerously low reactive reserve margins at critical stations and could possibly have prevented widespread outages on the West Coast in 1996. This project provides integrated research and technology development that will produce a quicker and more flexible response to increase the reliability of electricity services delivered to California's customers.

Intelligent Software Agents. This contract demonstrated the simulated use of intelligent software agents for control and scheduling of one or more distributed energy resources in a competitive energy market and will provide demonstration software that can be used to transfer this technology into the energy industry. This enabling technology will make it cost-effective to have a distribution grid-connected generation source available for the CAISO to dispatch. The software can be adopted for curtailing loads. The use of intelligent software agents reduces the level of expertise needed to own and operate distributed energy resources in California's competitive energy industry. The project successfully achieved its goals. The prototype network demonstrated successfully by communicating over the Internet and without direct human intervention the tasks of coordinating and scheduling one or more distributed energy resources. Additional benefits included the development of a demonstration package that will facilitate transfer of the project results into the private sector, and identified potential partners for commercialization.

Streamlining Distributed Generation Interconnection Standards (FOCUS I). Distributed energy resource systems are one of the paths toward greater energy independence in California. The FOCUS I project goal was to streamline the complicated process involved with interconnection, standardization, certification, environmental review regulations, and permits needed for the installation of distributed energy resources. Initially, Rule 21 specified the interconnection, operating and metering requirements for these generators. Rule 21 proved to be too burdensome. The FOCUS I contract team worked to revise Rule 21 through a series of workshops and meetings. Technical issues were resolved for a range of applications. The Energy Commission presented its findings to the California Public Utilities Commission and they were adopted. Standardized interconnection has reduced interconnection costs by approximately 37 percent. "Simplified" interconnection applications cost only \$800. Additionally, the utility review time has been expedited substantially.

Real-time Transmission Line Ratings for Path 15. This follow-on PIER contract with the Valley Group demonstrated the feasibility of implementing real-time transmission line ratings for Path 15, which is one of the most congested lines in California. The cost in the fourth quarter of 2000 from congestion on Path 15 was \$169 million. The Path 15 demonstration indicated greater than 390 MW of increased capacity to the line rating.

Additional benefits can be realized in the future at other highly congested transmission gates, including the positive benefits of avoiding future transmission projects.

OUTLOOK

Microgrids. The CERTS DER Group is initiating a new research activity in distributed energy resource integration. The concept of the microgrid represents a fundamental re-conceptualization of the current challenges faced by distributed energy resource interconnection and integration. The microgrid seeks to control its presentations to the grid such that at worst it does no harm, and at best offers additional reliability to the grid and economic benefits to the customer. It achieves these objectives by postulating a single, controllable point of interface between the microgrid and the distribution grid. The microgrid shows promise as an enabling mechanism for the widespread application of distributed energy resources on the customer side of the meter.

Technical Support for Distributed Generation Interconnection Standards. The FOCUS II contract has two goals. The first is to bring more projects under the "simplified" interconnection umbrella developed in the previous FOCUS I contract; the second is to ease concerns of distributed energy resources' impact on the distribution system. Revised Rule 21 requirements have created a framework for improving the interconnection process and reducing cost. These are

presently defined as installations that use certified equipment, do not export power, and do not generate more than 15 percent of the distribution line's peak load. The next technical challenge for interconnection in the simplified procedures is interconnection applications where the distributed energy resource system operates in parallel with the electrical distribution grid exporting power. These applications currently cost \$1,400 or more. The FOCUS II project will conduct detailed case studies to evaluate the electrical effects of single distributed energy resource units of the distribution system. Furthermore, it will use this data to improve Revised Rule 21.

Distributed Energy Resources Grid Effects. In collaboration with the DOE, the Energy Commission will undertake the first full-scale test of the effects of the integration of distributed energy resources and storage technologies in the United States, including California. The project will include a detailed exercising of variously configured systems with sophisticated monitoring to document the positive and negative interactions of the multiple distributed energy resource units with the electric utility grid. The test is intended to focus on distributed energy resource integration and aggregation issues, not on technology itself.

The project differs from the FOCUS II project in magnitude and scope. Both projects will address issues critical to removing barriers that prevent distributed energy resources from becoming a significant energy resource for California.

ENERGY INNOVATIONS SMALL GRANT PROGRAM

2001 PROGRESS UPDATE

The EISG Program assists the development of technologies that are not already adequately funded through the competitive and regulated markets. Up to four solicitations per year are conducted, with each solicitation open to all six PIER Program areas. To encourage participation in the program, the Energy Commission simplified and streamlined the application and award process than other programs administered by the Energy Commission. During 2001, the Energy Commission cancelled one grant funding cycle to allow time to make improvements in the application process. Nevertheless, with two of the three solicitation cycles complete at the writing of this report, the grant program has processed a total of 178 proposals, compared with 137 total proposals processed in the year 2000.

Of the total 81 active grant projects, 28 are complete and two have succeeded in obtaining follow-on funding in the PIER program. Another nine grants have been recommended for follow-on research due to their success.

2001 RD&D AWARDS

The following projects received EISG Program funding in 2001:

An Innovative Approach to Stabilize the Thermal Conductivity of Air Plasma-Sprayed Thermal Barrier Coatings — Rodney Trice, Purdue University. Proposes to research the feasibility of developing a

microstructurally designed thermal barrier coating that will lower thermal conductivity in turbines, resulting in higher operating temperatures, which can raise the thermal efficiency.

Application Feasibility Study of Gravitational Non-Equilibrium Heat Pumps and Heat Engines — Thomas Smith, Individual. Proposes to research the feasibility of developing an unconventional solar-powered gravitational heat engine using a vapor compression cycle and one moving part.

A PCM Slurry System to Decrease Peak Air Conditioning Loads — Randy Clarksean, Leading Technology Designs Inc. Proposes to research the feasibility of incorporating a liquid slurry phase change material (PCM) to absorb peak air conditioning (A/C) loads while using a ground loop to reject the heat gained in the PCM.

Controlling Fouling with Rice Straw Blends in Biomass Boilers — Charles Lesher, UC Davis. Proposes to research the feasibility of reducing slag deposition from rice straw in biomass combustors by blending the rice straw with wood fuel blends and testing these blends in a subscale vertical quench furnace and a laboratory-scale fluidized bed combustor.

Simple and Reliable Active Power Filter for Energy Efficiency and Power Quality — Keyue Smedley, UC Irvine. Proposes to research the feasibility of developing a fast active power filter capable of responding within one cycle of the frequency. The

design requires fewer components, resulting in lower cost while maintaining performance and reliability. A prototype will be built and tested.

Polymer-Zeolite Nanocomposite High-Temperature Proton-Exchange-Membranes for Fuel Cells — Yushan Yan, UC Riverside.

Proposes to research the feasibility of developing a novel polymer-zeolite nanocomposite proton exchange membrane to allow a proton exchange membrane (PEM) fuel cell to operate at high temperatures.

Development of a PEM Electrolyzer: Enabling Seasonal Storage of Renewable Energy — Peter Lehman, Humboldt State University.

Proposes to research the feasibility of developing a PEM electrolyzer, that will be capable of generating three liters per minute of hydrogen at 2,000 pounds per square inch from one kilowatt of electricity as an input.

Field Validation of a Model of Generation and Migration of Methane and Other Gases in Landfills — Richard Prosser, GC Environmental, Inc. Proposes to research the feasibility of validating a 3-D model simulator for describing gas generation and migration in complex heterogeneous soil and landfills. The model will be validated against actual field data from a California landfill.

An Integrated Anti-Fouling Technology for Energy-Efficient Chillers — Young Cho, J&D ThermoFluid Technology Inc.

Proposes to research the feasibility of developing integrated anti-fouling technology based on an oscillating electric field in conjunction with a side-

stream filter that will mitigate or prevent fouling in chiller tubes, allowing them to run more efficiently.

The Sagebien Project — Richard Ely, Davis Hydro. Proposes to research the feasibility of developing a low-head undershot water wheel, the Sagebien wheel, which will generate power and will be modified to allow for safe fish passage.

Improved Insulation for Buildings and Refrigeration — Jeffrey Zucker, Individual. Proposes to research the feasibility of using a low-cost perlite-based ceramic insulator material to develop a thermal insulating material with high R-value for buildings and refrigeration.

Advanced Generation of H₂ and CO from Improved Methane-CO₂-Steam Reforming Process for Use in Fuel Cell Applications — Zoe Ziaka-Vasilciadou, Individual.

Proposes to research the feasibility of using a catalysis reaction to convert waste gas streams containing CO₂ and methane to CO and hydrogen, allowing the hydrogen to be used in fuel cells.

OTM-Aided, Oxygen-Enhanced Combustion — Theodore Tsotsis, University of Southern California.

Proposes to research the feasibility of using oxygen transport membranes (OTMs) to generate oxygen for oxygen enhanced combustion (OEC) for flame stability and NO_x reduction in power generation systems.

Method of Improving Efficiency of Combined-Cycle Power Plants — Robert Surette, Individual.

Proposes to research the feasibility of using an ejector-diffuser on gas turbine exhaust nozzles to reduce backpressure and provide uniform flow distribution into

the heat exchangers on combined-cycle power plants. Computational fluid dynamics (CFD) analysis will be employed to optimize the design geometry.

Low-Cost Hybrid Inverters Utilizing IGBTs and SCRs — Giri Venkataramanan.

Proposes to research the feasibility of developing a low-cost hybrid inverter/converter utilizing SCRs and IGBTs suitable for use in variable speed drives and DG systems such as PV and wind turbines.

Low Emissions Atmospheric Metering Separator (LEAMS)— Doug Jung, Two-Phase Engineering & Research.

Proposes to research the feasibility of noise reduction strategy for the LEAMS, an environmentally friendly replacement for the Blooie Muffler currently used in geothermal drilling operations. Modeling, fabrication, and testing will be performed.

Use of Waste Flue Gas to Reduce Biofouling of Power Plant Cooling Water Intakes — Greg Rau, UC Santa Cruz.

Proposes to research the feasibility of controlling the biofouling of power plant cooling water intakes that draw water from the ocean by diverting waste flue gas into the water intake.

Biofiltration Abatement of Landfill Gas Energy Exhaust Pollutants — Don Augenstein, Individual.

Proposes to research the feasibility of a biofiltration strategy for cleaning exhaust emissions from combustion-based power generation equipment operating on landfill gas.

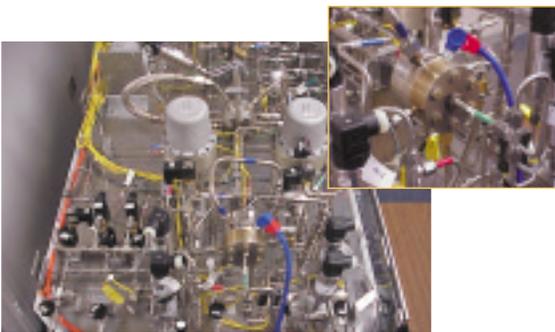
Proof-of-Concept of a Dual-Fired (Solar and Natural Gas) Generator for Use in a Space Cooling System for Residential and Light

Commercial Buildings — Michael Garrabrant, Cooling Technologies, Inc. Proposes to research the feasibility of developing a thermally activated air conditioning system that is fired primarily by solar thermal collectors with natural or propane gas backup capability. Bench scale prototype will be fabricated and tested.

Clean Energy Systems (CES)

110 kW gas generator ...

examines the feasibility of fabricating a combustor for a gas turbine that eliminates the production of NOx, SOx, CO, VOCs, and particulates.



CES 110 kW Gas Generator.
Courtesy of Clean Energy Systems, Inc.

Prototype and Demonstration of a Light Emitting Diode (LED) Alternative to Screwbase Incandescent Lamps — Kathryn Conway, Conway & Silver Energy Associates, LLC. Proposes to fabricate and test an energy-efficient prototype LED lamp based on a U.S. patent issued to the applicant. Lamp has a unique reflector design and adjustable color capability.

Materials for Fast-Response Solid Oxide Fuel Cells (SOFCs) — Lutgard De Jonghe, UC Berkeley. Proposes to research the feasibility of a low-cost composite anode layer in a low-temperature SOFC that would allow rapid thermal cycling.

A Controllably Variable Compression and Displacement Rotary Engine — Geoffrey Deane, Dehlsen Associates, LLC. Proposes to research the feasibility of a rotary engine design that incorporates variable compression and variable displacement capability to achieve greater engine efficiency. A prototype will be fabricated and tested.

Flywheel Energy Storage Units in Power Distribution Networks — John Balachandra, ELCOM. Proposes to research the feasibility of using flywheel energy storage units as a means to maintain power quality when subjected to a variety of power quality disturbances.

Energy Efficient Municipal and Industrial Odor Control Equipment — Bob Richardson, Pacific Rim Design and Development. Proposes to research the feasibility of developing a low-cost municipal and industrial odor control system that uses less energy than conventional odor control equipment.

SUCCESS STORIES

Alzeta Corporation received a \$74,103 EISG award on September 15, 1999, to research the feasibility of using a segmented gas turbine surface burner (GTSB) to reduce air emissions from a gas turbine over a broad operating range. The goal for NOx emissions is less than 5 ppmv (at 15 percent O₂) from 50 percent to 100 percent load. The segmented GTSB will be adaptable to both new engines and those already in service. Alzeta completed proof of feasibility of the segmented combustor in early 2001.

On October 31, 2001, the Energy Commission approved \$2,404,310 in co-funding to Alzeta to develop and demonstrate the segmented GTSB technology in a 13.5 MW gas turbine (Solar Turbines, Inc.). This award is one of nine announced by the Energy Commission under the PIER EPAG solicitation, RFP number 500-00-509.

Solar Turbines, Inc. of San Diego is a major subcontractor in this project, providing the host engine, test facility and related engineering support. The GTSB technology will be integrated into the overall engine control scheme. Tests will confirm the emissions over the operating range of the engine, temperature uniformity at the combustor outlet, combustor stability during load transitions, and combustor durability. Potential product cost will be assessed during this project. Alzeta and Solar Turbines, Inc. are providing project funding and R&D support. The engine tests with the Alzeta GTSB-based combustor will be completed by December 2003. The successful completion of this project could lead to commercial introduction within a year of project completion.

Alzeta Corporation, of Santa Clara, California develops and manufactures combustion equipment, including ultra-low NOx burners for commercial and industrial applications and thermal oxidizers for the control of hazardous air pollutants and other waste gas streams. The gas turbine surface burner is an extension of Alzeta's current ultra-low NOx burner technology.

Clean Energy Systems (CES)

received a \$74,871 grant on November 17, 1999, to research the feasibility of fabricating a combustor for a gas turbine that eliminates the production of NOx, SOx, CO, VOCs and particulates. Drive gas would be produced by combusting methane and pure oxygen. CES achieved the objectives of their feasibility research conducted in the grant program.

On December 19, 2001 the Energy Commission approved \$2 million in co-funding to CES, for a 500 kW zero-emission, gas-fired power plant. This award is one of nine announced by the Energy Commission under the PIER EPAG solicitation, under RFP number 500-00-509. This project will demonstrate the long-term durability of a modified 10 MW gas generator, operated at a low power level to reduce program costs. This small plant will demonstrate the ability to produce power from fossil fuels with zero emissions.

Mirant California is supporting this project by siting the demonstration plant at its Contra Costa Power Plant in Antioch, California, and by providing natural gas, auxiliary services, and operational support. Air Liquide is also supporting the project by providing oxygen and oxygen services along with storage, transport, and marketing of

recovered food-grade CO₂. In addition, Air Liquide is providing project funding and R&D support on the project. This plant is scheduled to be in operation by the end of 2002.

OUTLOOK

The EISG Program will continue to meet three needs for the Energy Commission's overall PIER effort:

- Provide research support for innovative ideas not necessarily covered in the targeted PIER Program area research plans.
- Provide a user-friendly application process to groups that are adversely affected by the high transaction costs associated with the Energy Commission's standard competitive bid processes. These include small businesses, individuals, academics, and nonprofits.
- Provide a PIER funding mechanism for early concept feasibility research and development. The mainstream PIER research efforts require that feasibility has already been established.

SUPPORTING PROJECTS THROUGH COLLABORATIVE RESEARCH

2001 PROGRESS UPDATE

Through collaborative funding with distinguished research organizations, the Energy Commission has leveraged its funds to meet California's energy needs at a lower cost and with greater efficiency. Building on research conducted in 2000, the Energy Commission continued its collaboration with EPRI and GTI in 2001.

The partnership with EPRI enables the Energy Commission to participate in and build on pre-existing collaborative relationships and to continue important

public interest energy and environmental research. EPRI is a public purpose, nonprofit 501(c)(3) California corporation that was established in 1973 as a center for public interest energy and environmental research.

GTI is the national RD&D consortium for the U.S. natural gas industry. It was formed in 2000 from the merging of the Gas Research Institute (GRI) and the Institute of Gas Technology (IGT), two organizations that have delivered over 400 products, processes, and techniques to the marketplace since its inception in 1976.

The Energy Commission believes that collaborative research funding in the six selected program areas will improve the energy cost/value, the reliability and quality, and the public health costs/risks of California's electricity.

2001 RD&D AWARDS

EPRI received \$2,152,651, as part of a two-year agreement, for the Energy Commission's participation as members in 29 collaborative research targets in calendar 2001.

GTI received \$ 354,000, as part of a two-year agreement, for the Energy Commission's participation as members in seven collaborative research programs in calendar 2001.

OUTLOOK

The Energy Commission will continue collaborative research with both EPRI and GTI in 2002. The second year funding agreement with EPRI will be for \$2,152,651. The second year of the agreement with GTI will be for \$292,000 and six research programs, as one of the programs was completed in 2001.

C. PIER Program Administration

IMPROVING THE PIER PROGRAM

An important objective of the Energy Commission is to ensure that the PIER Program is administered in an efficient and effective manner. Year 2001 was the first full year in which the Program was housed completely within the Technology Systems Division, and during which the new PIER Program Manager was in place. Having all of the program staff in one division has greatly improved communications and having a Program Manager with decision-making authority has improved the effectiveness of the program.

The year 2001 also saw the program-wide implementation of contract streamlining procedures, focused primarily on the preparation of contract packages. PIER now has a small team, named SPARKEY, dedicated to the preparation of work statements and associated contract packages. SPARKEY has taken responsibility for achieving the goal contained in the IRP's final report of executing contracts within four months. The team has established templates and procedures that have reduced administrative overhead. One of its most effective procedures has been the contract package review team. This team consists of a contract manager, representatives from the Contracts and General Counsel offices and a standing member from SPARKEY. All issues are identified and resolved in tightly focused team meetings. Since its formation in April, this team has processed 39 contracts.

In January, 2001, the Energy Commission reached agreement with the Department of General Services, Office of Legal Services (DGS-OLS) on a subcontracting policy for PIER projects.

This policy, which was needed to implement the authority contained in PIER's statute, supports PIER's efforts to streamline contracting by giving the program flexibility and control appropriate to different types of contracts.

Another recommendation contained in the IRP's final report was to seek legislative relief from state-mandated limitations on the Energy Commission's procedures. PIER worked closely with the appropriate committees to introduce legislation designed to allow streamlining of PIER administrative functions, particularly those related to RD&D contracting. The bill containing these changes did not get out of committee in the 2001 legislative session and has been reintroduced for 2002.

INDEPENDENT REVIEW PANEL

PRC Section 25620.9(a) required the Energy Commission to designate an independent panel of experts by January 1, 1999, to conduct a comprehensive evaluation of the PIER Program. PRC Section 25620.9(b) required the Independent Review Panel to submit preliminary and final reports on its findings to the Legislature. The panel submitted its preliminary report during the first quarter of 2000 and submitted its final report March 2001 (California Energy Commission Docket Number 96-RDD-1890). The panel held its last meeting in February 2001, to adopt its final report. The final report offered a set of expectations for the Governor, the Legislature, and the Energy Commission regarding accomplishments needed over the next year to transform PIER into a high-quality research program within the Energy Commission.

The members of the IRP are listed in Attachment 3.

TECHNOLOGY TRANSFER

The value of energy RD&D is lost if the results are not made available to potential users, investors, or marketers. Concurrently, many smaller businesses do not have the resources or expertise to launch their own clean energy technology or products. The PIER Program addresses these technology transfer issues through a variety of innovative means.

In November 2001 the Energy Commission, along with NREL, co-sponsored the 14th Industry Growth Forum in San Jose. The Forum focused on bringing together California-based clean energy companies with potential investors and offered some PIER-funded projects the chance to present their business plans to venture capitalists and angel investors. In addition, the PIER Program launched its business incubator program, which assists PIER-funded projects to develop a business plan or marketing strategy that will help them grow a promising business. Applications for incubator assistance will be evaluated in early 2002, and up to 10 successful candidates will receive business consulting assistance through the Environmental Business Cluster (EBC). The EBC is an affiliate of the National Alliance of Clean Energy Business Incubators.

Technology transfer efforts in 2001 also included the production of the first six in an ongoing series of one-page project success stories. Those success stories are highlighted on the new PIER website, which contains all published final reports on research contracts, a program-area information focus, and

information about funding opportunities. The new website “went live” in October 2001.

In addition, PIER co-sponsored technical conferences with other distinguished organizations to leverage PIER funds to more efficiently transfer information and technical knowledge.

PIER PROGRAM REPORTING TO THE LEGISLATURE

In accordance with PRC Section 25620.5(h), the Energy Commission is required to file semi-annual reports with the Legislature for the PIER Program (on or before June 1 and December 1 of each year as requested by the Office of the Legislative Analyst). These semi-annual reports provide the required “evaluation of the progress and a status of the PIER Program’s implementation” for each six-month period, and also provide input for the Energy Commission’s more detailed PIER annual report required pursuant to PRC Section 25620.8. In 2001, the Energy Commission completed and filed both of these semi-annual reports with the Legislature in a timely manner.

2001 FINANCIAL STATEMENT (JANUARY THROUGH DECEMBER 2001)

The financial statement for the PIER Program in 2001 is shown below.

2001 Income		2001 Expenditures	
Payments from Utilities	\$61,800,000.00	Program Funding	\$75,383,286.00
Interest Earnings	<u>\$ 8,058,891.58</u>	Program Administration	<u>\$ 8,958,168.49</u>
Total Earnings	\$69,858,891.58	Total Expenditures*	\$84,341,454.49

* includes carry-over from past funding allocations.



A. FUTURE FUNDING EFFORTS

B. COORDINATED FUNDING EFFORTS

A. Future Funding Efforts

In the current fiscal year, funding efforts will focus on renewed emphasis in developing of technologies and systems for demand-side management and end-use energy efficiency. This is because PIER developed and made awards as part of two large solicitations, which resulted in over \$50 million of funding for supply-side technology development.

Long-term efforts will focus in two areas. There will be a continuing push to develop more efficient end-use energy technologies for buildings, manufacturing, and agriculture. The second area will look to integrate a number of our program activities in Distributed Energy Resources (DER). This will allow for the continued development, demonstration, and deployment of distributed generation in both the renewables and small-scale fossil technology areas. We also intend to fund new development activities in storage technology to address renewable intermittency problems, reliability, and power quality problems for key industrial sectors. Another DER area focus is to considerably expand

our funding of enabling technologies. This would lead to additional development, demonstration, and deployment of advanced sensors, controls, data collection, and software systems. The integration of these technologies into our electricity system will provide consumers greater choice in generation technologies and may also lead to more efficient approaches to demand-side management and demand response. Finally, these technologies will better facilitate the opportunities presented by real-time pricing.

The PIER will also continue to fund environmental research and assessment activities. These efforts will focus on the evaluation of technology impacts and methods to ameliorate those impacts. We will also develop and fund regional climate change programmatic activities in order to address California-specific concerns.

B. Coordinated Funding Efforts

In 2002, the Energy Commission plans to continue collaborative research projects with major national and international RD&D institutions such as the U.S. DOE, UC, EPRI, GTI, and the

Air Conditioning and Refrigeration Technology Institute (ARTI). Each of these institutions has both funding and intellectual resources in major energy research and development programs. These institutions are partners with the Energy Commission through PIER to target research and development for providing significant public benefits for California's future.

This coming year a major new program at EPRI, called the Electric Innovation Institute (E2I), will begin in response to growing public interest R&D needs in the United States. The Energy Commission will assist and monitor E2I as it expands on the support already provided by California to begin new R&D programs led by a prestigious public interest Board. The UC also is creating several new research institutions through state and other private funding. The Energy Commission is investigating areas of cooperation and coordination with one of these new organizations. The PIER Program staff have been in discussions with representatives with the new UC Center for Information Technology Research in the Interest of Society (CITRIS) regarding advanced electronics and sensors research that could significantly improve the energy efficiency and control of many different types of electricity generation and other end-use equipment and systems.

Based on the active participation of the Energy Commission, a new coordinated funding effort at the national level is developing through the Association of State Energy Research and Technology Transfer Institutions (ASERTTI).

ASERTTI is an organization of growing state and regional energy research and deployment institutions with support from the states such as New York, California, North Carolina, South Carolina, Massachusetts, Florida, Wisconsin, Illinois, Connecticut, and Washington. The new ASERTTI program is called the State Technologies Advancement Collaborative (STAC) and it is being designed to jointly plan, fund, and conduct a federal/multi-state research and deployment agenda consistent with the strategies of both the federal government and the states. The ASERTTI is working with the National Association of State Energy Officials (NASEO) and the DOE to request funding for this program through Congress during 2002.

The coming years will also see a continuation of our efforts to collaboratively fund a number of programmatic activities with federal agencies, primarily the DOE. In the area of end-use energy efficient technologies for buildings, we will continue to expand our collaboration with DOE's Office of Building Technology. Where possible, we will also collaborate with DOE's Office of Industrial Technology to support advances in energy efficient manufacturing processes and technology. We also have (and are expanding on) a number of activities with the DOE's Office of Power Technology (OPT) in the areas of renewable electricity generation (geothermal, wind, photovoltaics) and distributed energy resources (emphasizing demand response, reliability, and power quality). All of

these offices are within DOE's Office of Energy Efficiency and Renewable Energy. In addition, we will also be working with OPT and DOE's Office of Fossil Energy in fuel cell and microturbine technology development. We plan to develop a regional climate change program activity by working both with DOE's Office of Science and Department of Commerce's National Oceanographic and Atmospheric Administration.



Acknowledgments



The Energy Commission wishes to acknowledge the invaluable contributions made to the PIER Program by the Energy Commission’s staff, the members of the PIER Policy Advisory Council, and the many concerned citizens who have actively participated in PIER-related advisory groups, planning focus groups, and other program forums to date. This participation has provided essential input throughout the program’s development, and the Energy Commission will continue to seek such input and assistance in the future as we strive to further develop and improve the PIER Program. The Energy Commission also wishes to acknowledge the individuals who have agreed to serve on the Independent PIER Evaluation Panel authorized by the Legislature. Finally, the Energy Commission wishes to acknowledge the many highly talented and creative researchers and research organizations that are participating in the PIER Program. Without the team effort of these various dedicated participants, the important public benefits of the PIER Program could not be achieved.



**PIER Oversight
Research, Development, and
Demonstration Committee**

Arthur H. Rosenfeld, Commissioner
and Presiding Member
Robert A. Laurie, Commissioner
and Second Member

PIER Program Management

Terry Surles, Program Manager
and Division Chief
Mike DeAngelis
Ron Kukulka

PIER Program Area Team Leads

Mike Batham, Environmentally-Preferred Advanced Generation
Kelly Birkinshaw, Energy-Related Environmental Research
Nancy Jenkins, Residential and Commercial Buildings End-Use Energy Efficiency
Pramod Kulkarni, Industrial/Agriculture/Water End-Use Energy Efficiency
George Simons, Renewable Energy Technologies
Laurie ten Hope, Energy Systems Integration
Philip Misemer, Energy Innovations Small Grant Program

PIER Annual Report

Susan Patterson, Project Manager and Contributing Author
David Navarro, Contributing Technical Author and Editor
Art Firebaugh, Production Manager
Rita Champion, PIER Information Management System (PIMS) Project Manager
Sunni Chacon, PIMS Project Lead
Lawrence Kinser, PIMS Database Consultant
Elizabeth Parkhurst, Editor, Media and Public Communications Office

Contributing Authors

David Abelson
Sherri Guzman
Gary Klein
Alec Jenkins
Nancy Libonati
Julie Talbert
Bert Fegg

Science Applications International Corporation

Rob Taylor, Contributing Technical Author
Gail Fink, Editor
Peter Wetzel, Designer
Hang Hennessey, Designer
Rush Press



Members of the PIER Policy Advisory Council

Sheryl Carter

Natural Resources Defense Council
71 Stevenson, Suite 1825
San Francisco, CA 94105

Rotating Member

California Utility Research Council

Rich Ferguson

Center for Energy Efficiency
& Renewable Technologies
1100 11th Street, Suite 311
Sacramento, CA 95814

Steven Kelly

Independent Energy Producers
Association
1112 I Street, Suite 380
Sacramento, CA 95814

Karen Mills

California Farm Bureau Federation
2300 River Plaza Drive
Sacramento, CA 95833

Joe Raguso

Trade & Commerce Agency
Division of Science, Technology,
& Innovation
801 K Street, 17th Floor
Sacramento, CA 95814

Bob Rivinius

California Building Industry
Association
1215 K Street, Suite 1200
Sacramento, CA 95814

Lawrence Coleman

Office of the President,
University of California
1111 Franklin St., 11th Floor
Oakland, CA 94607-5200

Dorothy Rothrock

California Manufacturers Association
980 Ninth Street, Suite 2200
Sacramento, CA 95814-2742

Alan Sweedler

Center for Energy Studies
San Diego State University
San Diego, CA 92182-1233

Gerald Harris

Global Business Network
P.O. Box 8395
Emeryville, CA 94662

Hal Harvey

The Energy Foundation
P.O. Box 29905
San Francisco, CA 94129-0905

Vacant

California Environmental Protection
Agency/California Air Resources Board
P.O. Box 2815
Sacramento, CA 95812

Elena Schmid

Independent System Operator
P.O. Box 639014
Folsom, CA 95763

Vacant

California Public Utilities Commission
505 Van Ness Avenue
San Francisco, CA 94102-3298



Members of the PIER Independent Review Panel

Dr. Harold M. Agnew is the retired President, General Atomics, and past Director of Los Alamos Scientific Laboratory. He was Science Advisor to the Supreme Allied Commander in Europe (1961–64) and a New Mexico State Senator from 1955 to 1961. Dr. Agnew's honors and awards include: recipient of the Ernest Orlando Lawrence award, 1966; and the Enrico Fermi award, 1978. He is an elected member of the National Academy of Sciences and the National Academy of Engineering and Fellow of the American Association for the Advancement of Sciences.

Dr. Richard E. Balzhiser retired in August 1996 as President and Chief Executive Officer of the Electric Power Research Institute (EPRI) in Palo Alto, California. He remains active in a President Emeritus role at EPRI in addition to serving on several industry boards and technical advisory committees. Dr. Balzhiser currently serves on a variety of boards and committees including the Energy Subcommittee of the President's Council of Advisors on Science and Technology, the Mobil Technical Advisory Committee, the Pacific Northwest Laboratory Advisory Committee, the Technical Advisory Board of the Massachusetts Institute of Technology Energy Laboratory, the Board of Directors for the Aerospace Corporation, the Board of Directors for Reliant Energy, and the Board of Directors of Nexant, LLC.

Dr. Patricia A. Buffler is Dean Emerita and Professor of Epidemiology and Public Health at the School of Public Health, University of California, Berkeley. Dr. Buffler's research interests include epidemiology of cancer, specifically childhood leukemia and the effects of environmental exposures and genetic susceptibility. She serves on the Board of Directors, U.S.-Japan Radiation Effects Research Foundation, Hiroshima, Japan; the World Health Organization, Expert Advisory Panel on Occupational Health; the Board of Scientific Counselors for the National Center for Infectious Diseases; the U.S. Public Health Service Centers for Disease Control and Prevention, Task Force on Community Preventive Services; and the National Institutes of Health, National Advisory Council on Environmental Health Sciences. She is a fellow for the American Association for the Advancement of Science and the American College of Epidemiology and a member of the Institute of Medicine/National Academy of Sciences.

Dr. Linda R. Cohen is Professor and Chair for the Department of Economics at the University of California, Irvine. Her fields of study are political economy, government regulation, government policy for science and technology, and positive political theory and law. Dr. Cohen has advised numerous federal departments and agencies on science policies, including the Departments of Energy and Commerce, the Office of Technology Assessment, and the Congressional Research Service, and has served on several committees for the National Research Council. She has testified before state agencies and commissions, including the California Energy Commission and the California Constitutional Reform Commission.

Dr. John S. Foster, Jr. is a retired Vice President of Science and Technology of TRW Inc. and former chairman of the Defense Science Board. Dr. Foster is currently Chairman of the Board of Directors of Pilkington Aerospace, chairman of Technology Strategies and Alliances, and consultant to TRW, United Technologies Corporation and Defense Group, Inc. His field of specialization is Industrial Manufacturing and Operating Systems Engineering and he is recognized for his work in technological leadership in defense research and engineering. Dr. Foster was the director for the Lawrence Livermore National Laboratory from 1961 to 1965. In 1965, Dr. Foster left the LLNL for Washington and became Director of Defense Research and Engineering.

Dr. T. Kenneth Fowler is Professor Emeritus in the Department of Nuclear Engineering, University of California, Berkeley. Dr. Fowler was chair of the department from 1988 to 1994 and helped establish the multi-disciplinary Center for Nuclear and Toxic Waste Management at UC Berkeley. His honors and awards include elected membership in the National Academy of Sciences; Fusion Power Associates Distinguished Career Award, 1995; and The Berkeley Citation, 1995. Dr. Fowler's areas of interest include fusion energy and energy research funding and the appropriate role of government in anticipating problems of energy-associated pollution and energy-associated competition for resources in its research funding policies.

Fred W. Kittler is co-founder and co-president of Velocity Capital Management, an investment firm based in Palo Alto that provides equity funding for public and private technology and communications companies. Mr. Kittler was a research analyst and portfolio manager for J.P. Morgan Investment Management where he managed their portfolios of small technology and health science company stocks. He serves on the Visiting Committee on Advanced Technology for the National Institute for Standards and Technology.

Peter M. Miller is a scientist with the Natural Resources Defense Council, Inc., a nonprofit national environmental organization. He is part of NRDC's energy project, which promotes the increased development of energy efficiency and other environmentally sound and cost-effective energy resources. His work involves research, analysis, and advocacy at the state, national, and international levels. He has participated in utility advisory committees in California, Hawaii, and the Pacific Northwest, in numerous proceedings before the California Energy Commission, the California Public Utilities Commission, and the Northwest Power Planning Council, and in rulemakings before the U.S. Department of Energy. He was appointed to the California Board for Energy Efficiency in April 1997.

Dr. Esteban Soriano established his own market research and program assessment company (The Resource Group), specializing in educational and economic assessments. He currently serves as Vice President for University Advancement at California State Polytechnic University, Pomona. He is an expert in communication strategies, economic impact studies and assessments, methodology and research design, and has extensive experience relating to electric and water utilities.

Dr. James L. Sweeney is Professor of Management Science and Engineering, Stanford University. Dr. Sweeney has over 25 years of experience working in energy and environmental economic issues, having worked at the federal level in the Federal Energy Administration in the 1970's. Dr. Sweeney has a long history of research and analysis in energy economics and technology issues. He has also contributed to a number of National Energy Plans, has been a member of numerous National Research Council committees, and was one of the founding members of the International Association for Energy Economics.

Dr. Mary L. Walshok is Associate Vice Chancellor – Extended Studies and Public Programs and Adjunct Professor in the Department of Sociology at the University of California, San Diego. She is the recipient of many awards and honors, among them a Kellogg Foundation national fellowship. Dr. Walshok serves on the board of the California Council for the Humanities and is a member of numerous community boards and professional associations including the San Diego Community Foundation, Girard Foundation, Eureka Communities, Foundation for Enterprise Development, and ACCION.

Carl J. Weinberg is currently a private consultant after retiring from Pacific Gas and Electric Company, where he worked for almost 20 years including eight years as Manager of Research and Development. Mr. Weinberg has been a contributor to the development and implementation of corporate, industry, and national energy policies and strategies through research program management. He has extensive understanding of energy technologies, including commercial and potential renewable and conservation technologies, and has demonstrated effectiveness at accelerating technology readiness and proving technology benefits.



California Energy Commission
1516 Ninth Street, MS 43 • Sacramento, California 95814
www.energy.ca.gov/pier